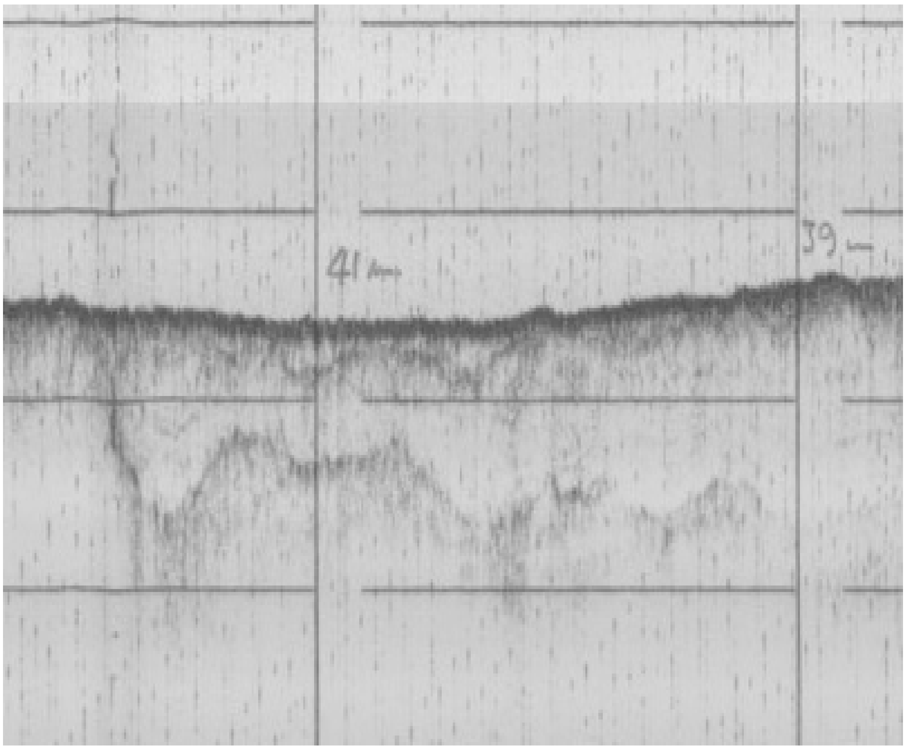
WEST COAST PALAEOLANDSCAPES SURVEY PILOT

(WCPS-P)

5238



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West Coast Palaeolandscapes Project
(Pilot Project)

Report

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Summary

The West Coast Palaeolandscapes Project builds upon the results of comparative work carried out within the Southern North Sea as part of the North Sea Palaeolandscape Project (NSPP). The results of that project, and the associated data audit variation, suggested that several other areas existed within the UK where sufficient data could support similar work. The west coast of Britain was identified as one area where any information derived on existing palaeolandscapes would have a significant impact on our understanding of the Mesolithic and, potentially, the Palaeolithic in England and Wales, whilst also informing the archaeological records of Ireland, Scotland and the Isle of Man. This project was commissioned to develop a methodology to support the heritage management objectives of this region with respect to aggregates extraction.

The specific outcomes of the pilot project are:

1. A methodology to utilise existing 2D seismic and related data to improve the understanding of the submerged prehistoric resource.
2. Refinement of existing methodology for 3D datasets (where available) to suit the prevailing conditions of the Irish Sea.
3. Use of these datasets to investigate and explore the Late Palaeolithic and Mesolithic landscapes within the pilot study area.
4. Identification of other areas within UK territorial waters where sufficient data of similar quality exists, and which might benefit from similar research.

Acknowledgments

This project was commissioned by English Heritage through ALSF funding. Data was provided by the BGS, SeaZone Solutions Ltd, UK Hydrographic Office, the UK Onshore Geophysical Data Library, UK DEAL, and Phoenix data solutions (DECC/UKCS seismic).
VISTA would specifically like to thank Centrica UK Ltd. who donated the 3D seismic dataset for this research project. VISTA would also like to thank the staff of all the organisations involved for their assistance and co-operation during the production of this report.

Data Usage and Copyright

Co-ordinate Systems utilised within this project.

UTM Zone 30N Projection System was utilised within the GIS project throughout this assessment a positions and GIS shapefiles obtained from other institutions were converted to this projection using the Geospatial tools provided within ArcGIS 9.3.

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1. INTRODUCTION TO PROJECT

1.1 In 2007 the results of the North Sea Palaeolandscape Project (NSPP) were published providing information on the extent and nature of the submerged Mesolithic landscape contained within the Southern North Sea. The results of this project and the associated data audit identified several other areas within the UK where sufficient data, often in the form of older 2D survey, could support similar a similar study. The west coast of Britain was identified as one area where any information gleaned on the existing palaeolandscapes might contribute significantly to our understanding of the development of the Mesolithic and, potentially, Palaeolithic periods in England and Wales, Ireland, Scotland and the Isle of Man. This project was commissioned to undertake a pilot project within the west coast region (see Figure 1) and to provide a methodology to support the heritage management within the region with respect to aggregates extraction. The work was specifically linked with ALSF priorities 2.1 and 2.2.

1.2 The specific outcomes of the proposed pilot project were:

- To develop a methodology to utilise existing 2D seismic and related data to improve our understanding of the submerged prehistoric resource.
- To refine the existing methodology for 3D datasets (where available) to suit the local prevailing conditions of the Irish Sea.
- To use these datasets to investigate and explore the Late Palaeolithic and Mesolithic landscapes within the pilot study area, and where possible map landscape features.

1.3 The situation of the Irish Sea is comparable to that of the North Sea in the existence of a significant areal coverage of traditional 2D and high-resolution 2D seismic lines, but differs with respect of the lesser availability of 3D data. It therefore provides an ideal test bed to develop a methodology for investigating coastal areas with similar data availability.

1.4 The overall aim of the pilot study was therefore to develop a methodology that might be utilised in areas where existing 3D seismic data coverage may be limited or absent. Such a methodology should be able to provide baseline data to facilitate future management of the submerged prehistoric resource, through the limited mapping and identification of such features within the pilot area.

1.5 The main aims of the project are therefore:

Aim 1: To develop a methodology for utilising existing 2D and related datasets, where 3D seismic datasets are unavailable.
Aim 2: To refine the existing methodology for 3D datasets (where available) to suit the local prevailing conditions.
Aim 3: To use the existing 2D and 3D seismic and related datasets to investigate and explore the Late Palaeolithic and Mesolithic landscapes within the pilot study area, and where possible map the landscape features of the region.
Aim 4: To utilise the results of Aims 1 to 3 to assess the viability of an extensive project to improve our knowledge of the Late Palaeolithic and Mesolithic landscape contained within the Irish Sea and Bristol Channel.

2. OBJECTIVES

2.1 The academic aims defined above may be formulated as a series of explicit objectives that may be addressed through the use of specific methods.

Aim 1: To develop a methodology for utilising existing 2D seismic and related datasets
Objective 1.1: To locate and acquire appropriate 2D seismic and related datasets where available.
Objective 1.2: To assess the density of 2D seismic coverage and to identify any gaps of coverage within the pilot study area and to assess the impact of such gaps upon the production of an archaeological landscape determination.
Objective 1.3: To identify any additional data that may be required to facilitate the use of the 2D seismic data in mapping the submerged archaeological landscape.
Objective 1.4: To determine an appropriate methodology to obtain landscape-scale data utilising the extant petroleum industry 2D seismic data contained within the pilot area and consider its application to other areas of the UK and English territorial waters.
Objective 1.5: Investigate the interface between the new methodology for production of landscape data from 2D seismic data and that generated by the existing methodology for 3D seismic data.

Aim 2: To refine the existing methodology for 3D datasets
Objective 2.1: To locate and acquire 3D seismic datasets where available.
Objective 2.2: To assess the available 3D seismic coverage in relation to its ability to produce information pertaining to the archaeological landscape.
Objective 2.3: To assess the existing methodology and define any changes required to support its application within the study area.

Aim 3: To use the existing 2D and 3D seismic and related datasets for the investigation of the Late Upper Palaeolithic and Mesolithic Landscape
Objective 3.1: Collate all the data described within Aims 1 and 2.
Objective 3.2: To utilise the 2D and 3D seismic datasets, in conjunction with any associated datasets, to provide a baseline map of the submerged Late Upper Palaeolithic to Mesolithic landscapes of the pilot area.
Objective 3.3: To provide a brief archaeological interpretation of the features identified within the pilot study area.

Aim 4: To utilise the results of Aims 1 to 3 to assess the viability of an extensive future project to improve the archaeological knowledge of the Late Palaeolithic and Mesolithic Landscape contained within the Irish Sea and Bristol Channel
Objective 4.1: Assess the viability of an extensive project utilising the generated methodology.

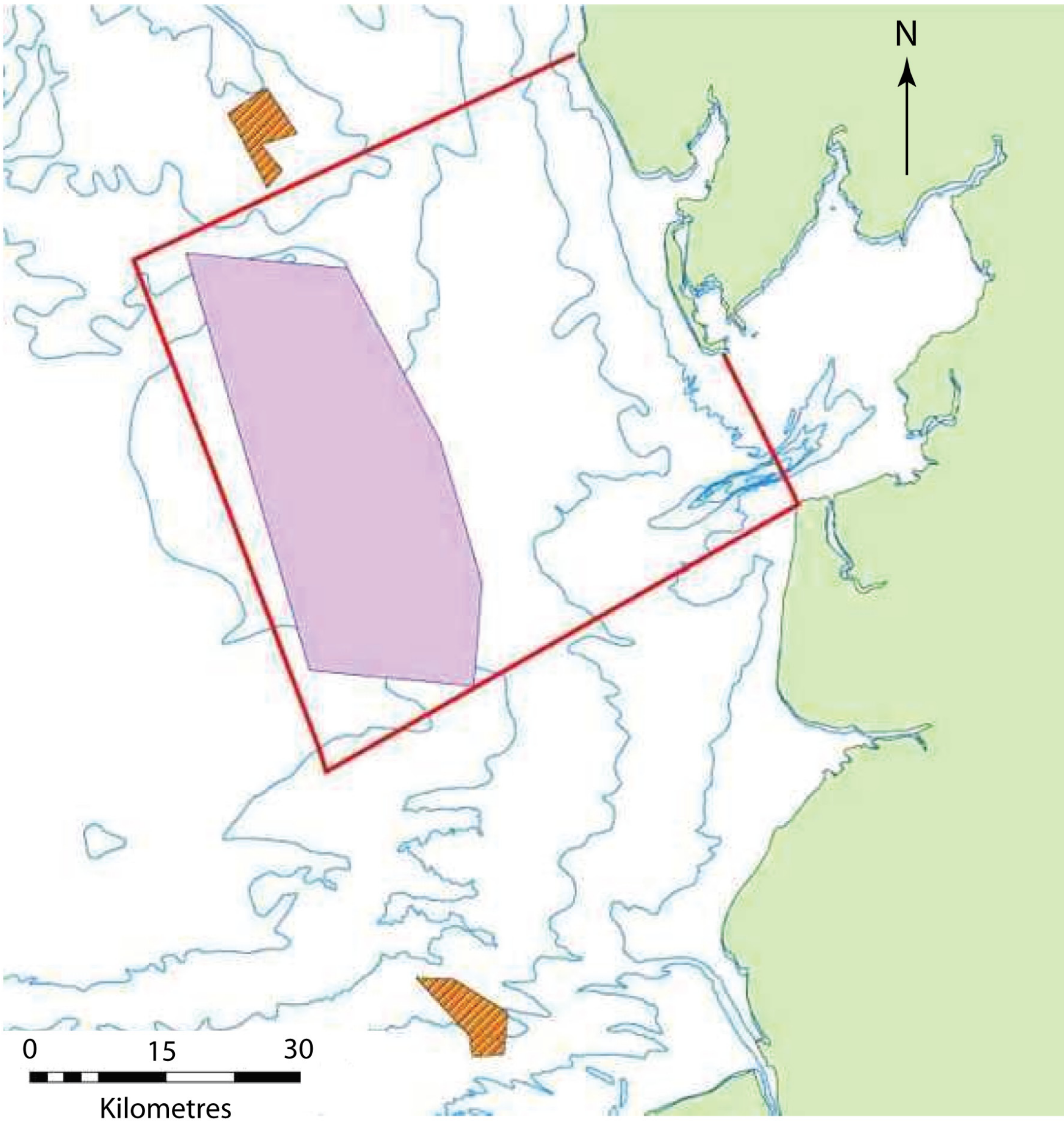

Figure 1: Location of the pilot area (red outline), shown in relation to the coast of England and its position in UK Offshore waters. Active aggregates extraction areas are shown here in orange. The location of the 3D dataset utilised within this study is shown here in pink.

3. SUMMARY OF RESULTS OF PREVIOUS WORK

3.1 The pilot study area was identified by Coles (1998) as part of the palaeolandscape which facilitated the connection of the Isle of Man to the British mainland. However the lack of detailed information prevented a more detailed description or assessment of the potential and significance of the area. Despite this, Coles produced a series of extensive but speculative maps which included the area (Figure 2) and these clearly indicate the region as an extensive emergent landscape well into the early Holocene.

3.2 Attempts to rectify this lack of information have frequently involved the use of isostatic rebound models to provide outline representations of the former landscape in this area and examples include those produced by Shennan 2000 and Lambeck (2001). Unfortunately, the scales at which these coarse models operate make them unsuitable for the purposes of archaeological interpretation. Even though higher resolution local models are utilised in other areas of the British Isles, the analytical cell size (1.2km x 1.2km, Shennan 2002: 513) is still too large for the majority of archaeological purposes. This factor, combined with the exclusion of important oceanographic and geological factors including burial and erosion, make these models far from ideal (Bell et al 2006, Box 1, 14). Essentially, the issues associated with isostatic modelling and its use in archaeology demand that novel methodologies must be developed if the marine prehistory of this region is to be understood and protected adequately.

3.3 In January 2005 Wessex Archaeology undertook to produce a pilot study of the 'seascape' within part of the Liverpool Bay area (extending to the 12 nautical mile limit). Mapping, themed by period and broad headings reflecting modern use of the region, define a series of polygons representing 'Character Areas'. However, it is important to note that the lack of detailed information concerning the submerged landscape in the region meant that this study was obliged to use a model of coastal change to provide an assessment of potential for the presumed, submerged prehistoric landscape. Whilst such observations do not invalidate the larger rationale of such a project it still remains true, for the reasons highlighted by Bell (2006) and those cited above, that the method is less than ideal if the intention is to understand these early, inundated landscapes. The arguement is clear to provide further, detailed mapping of the actual landscape and any surviving features in order to enhance these earlier projects and to assist strategic marine planning.

3.4 The potential for petroleum industry data to inform submerged archaeological prospection has been noted for some time (e.g. Kraft et. al. 1983, Coles 1998). However, the methodologies and the technology needed to implement such studies have been unavailable until relatively recently. The use of extracted datasets for archaeological purposes was pioneered by Birmingham University for the palaeolandscapes of the southern North Sea (Gaffney et al. 2007) as part of the ALSF funded North Sea Palaeolandscape project. The project employed the latest visualisation and computer techniques available to both the archaeological and petroleum industries to explore a 3D dataset provided by PGS UK Ltd. This revealed a submerged Mesolithic landscape in unprecedented detail. The resolution was sufficient to perform a detailed analysis using the data to reveal the presence of the coastlines, estuaries and major fluvial features active in prehistory.

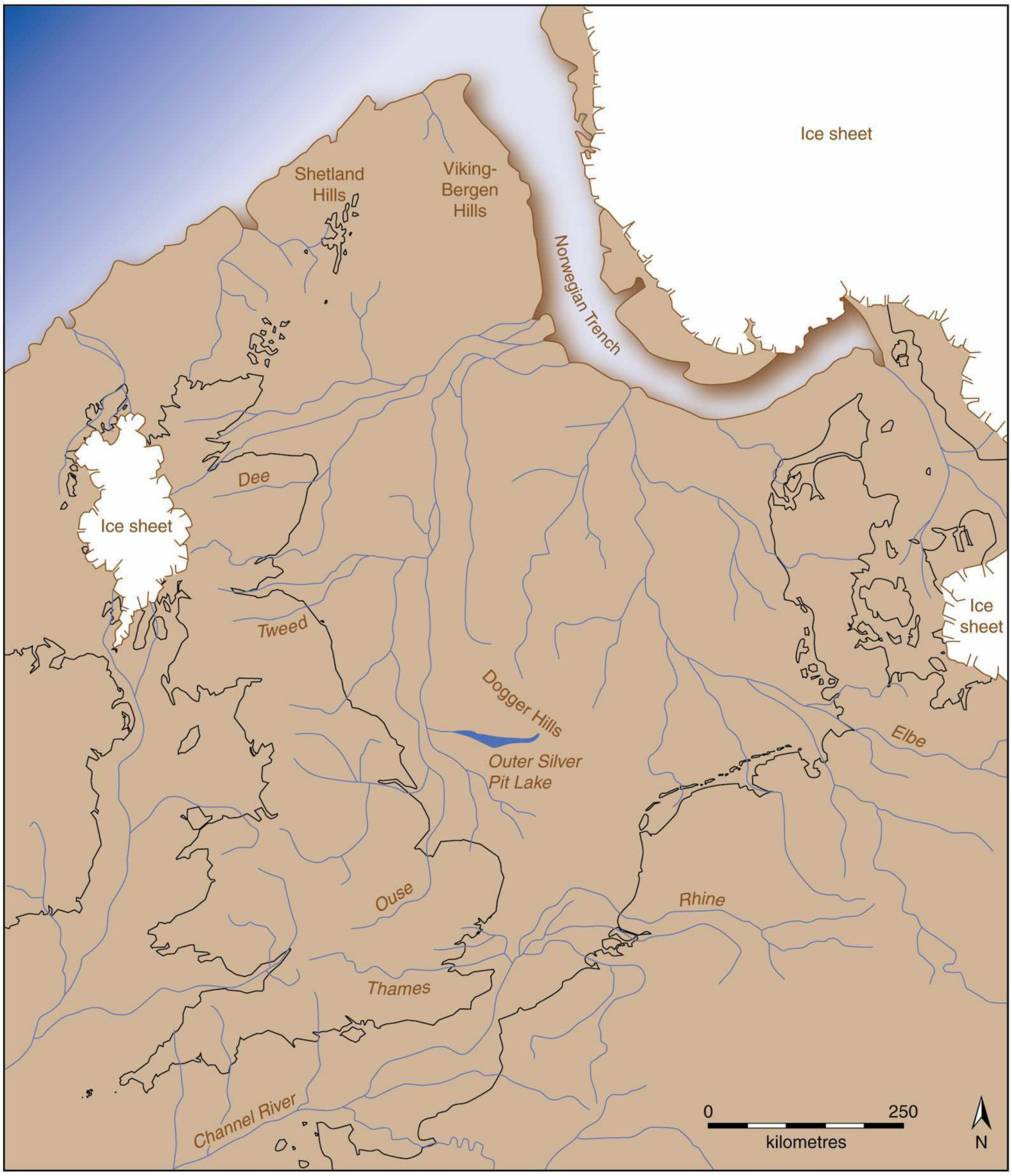

Figure 2: Late Upper Palaeolithic Landscape of the British Isles (After Coles 1998)

4. METHODOLOGICAL INTRODUCTION

4.0.1 In 2007 a methodology was pioneered by Birmingham University, as part of the ALSF funded North Sea Palaeolandscape project, which derived landscape information from large scale 3D petroleum industry datasets for archaeological purposes (Gaffney et al. 2007). The methodology utilised 3D reflection seismic data acquired through the use of multiple streamers. These data were then placed into a binned dataset with, in the case of data acquired for hydrocarbon exploration, a spacing of 12.5m x 12.5m x 4 milliseconds, or multiples thereof. However, 3D seismic is versatile and can be interrogated in a number of ways. Instead of relying on vertical profiles, the volume can be sliced in any direction. Of particular importance to the North Sea Palaeolandscape Project was the utilisation of horizontal slices (timeslices) through the data to produce an image of relatively shallow, and flat, Holocene features (Thomson et al. 2007). The image, in many cases, could be interpreted as a map showing a range of sedimentary features and thus subsequently produce a map of the inundated landscape.

4.0.2 Given that the methodology had been so successful, it is appropriate to consider why this is not directly applied to the area of the pilot study area. The simple answer is that there is considerably less 3D seismic data located around the west coast of England. Whilst the southern North Sea represents the ideal situation, with "wall to wall" coverage of 3D datasets, the situation in the Irish Sea, and indeed the whole of the west coast is less satisfactory. Large blocks of data, covering the main reservoirs and prospects can be found, they are however often unlinked and large areas remain without coverage (see Figure 3). For example, the archaeologically significant Severn Estuary area contains no 3D seismic coverage at all. Application of the North Sea Palaeolandscapes methodology to available datasets could provide valuable landscape information for these isolated areas. However, their use would be limited as they would effectively be islands within a background of limited or no data. This situation would therefore be of limited use to strategic marine planning, since the significance of the landscape as a whole and that of the features identified would remain to be fully determined.

4.0.3 Clearly it would be advantageous situation to utilise these 3D datasets to provide landscape data for the areas available, whilst using some other means to determine the background landscape information between the 3D surveys with data. The most obvious data that could be used are the standard petroleum industry 2D seismic datasets which cover the area. These are traditional seismic reflection surveys, usually referred to as 2D because the data is collected via a single cable or streamer and the information displayed is effectively a vertical slice through the earth. Consequently, specific features, such as river channels, may be located with a vertical profile. Shallow 2D seismic surveys therefore aid the detection of palaeogeographic features which may possess archaeological potential.

4.0.4 The use of such surveys could permit the location and possible mapping of buried Holocene landscape features. Traditional 2D seismic reflection data is often acquired as a series of discrete vertical profiles using a single streamer towed behind the vessel. This acquisition pattern results in the collection of several profiles with the spacing between profiles being several orders of magnitude greater than the trace spacing (i.e. the horizontal sampling interval along the profile).

4.0.5 This method of acquisition has two main disadvantages. Firstly, the reflected seismic energy is assumed to have originated from a point directly beneath the profile even though it could have originated from a point laterally offset from the profile. This aliasing means that the location of a feature cannot be accurately constrained, as the spacing between lines is too wide to correct this error. Secondly, the spacing between lines is sufficiently wide that it can be difficult to map the position of a morphological feature across the region of interest. For example, Figure 4 (a-d) demonstrates how wide line spacing can lead to several equally valid interpretations. It is important to consider therefore that whilst these datasets could provide the structural framework of the interpretation, other datasets may be required to provide additional data in areas where the 2D data coverage is insufficient to resolve interpretation issues.

4.0.6 The value of 2D seismic data to map buried palaeochannels has long been understood, however this has tended to focus on the utilisation of data from higher resolution 2D seismic systems (e.g. Velegrakis et al. 1999). However, if such data could be utilised the relative density and spatial coverage of these 2D datasets (see Figure 5) may offer a potential solution to the issues of developing an archaeological landscape understanding of the submerged areas of the West Coast.

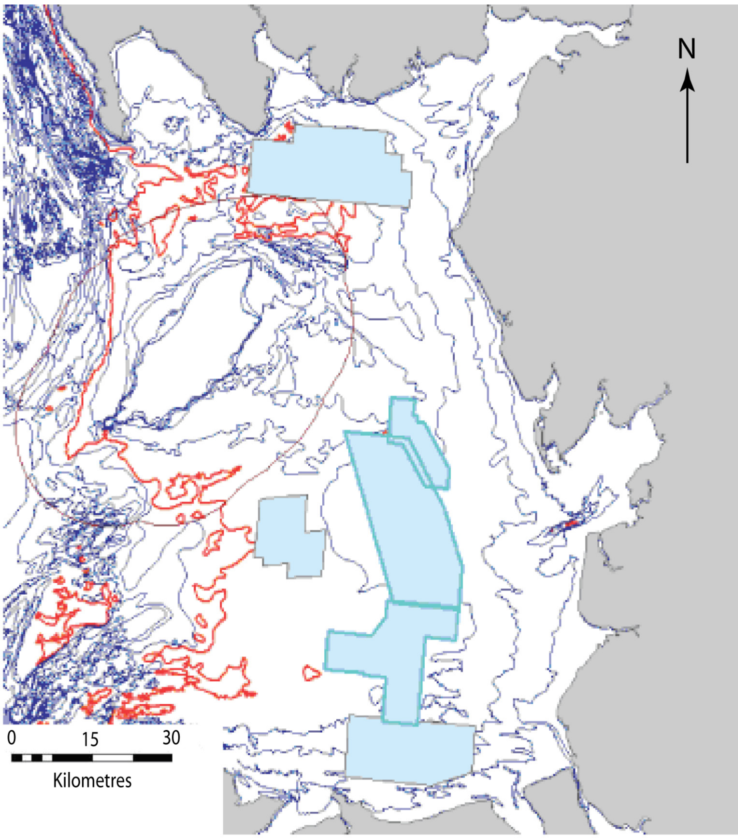

Figure 3: Coverage of 3D seismic surveys in the Irish Sea region (data blocks are shown here in blue)

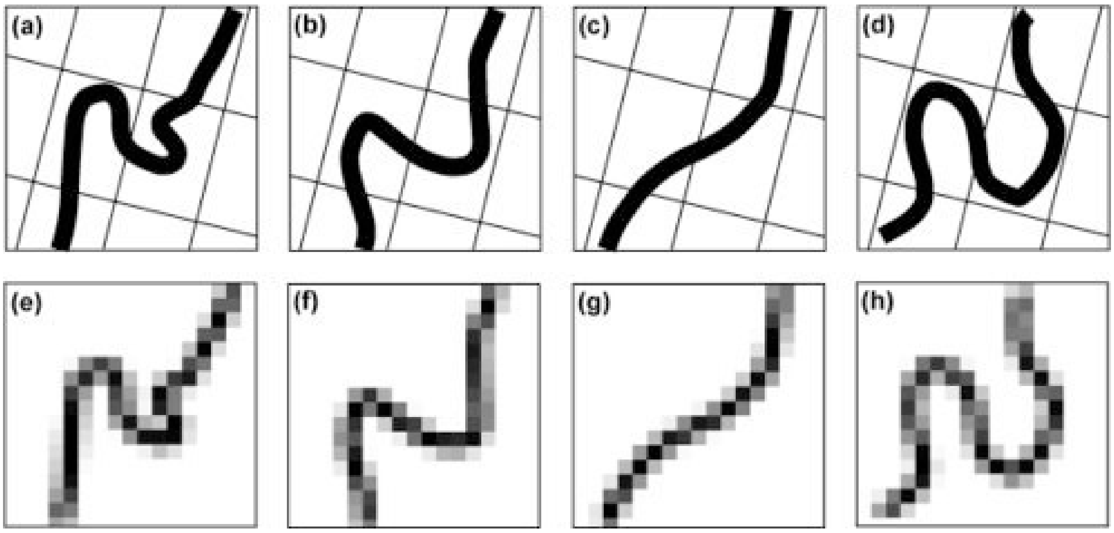

Figure 4: (a-d) Four possible interpretations of a channel morphology based on a coarse 2D seismic grid. Each interpretation is equally valid. (e-h) Schematic illustrations of how each of the interpretations shown in a-d would appear on a timeslice from a laterally continuous, binned 3D seismic volume. This demonstrates that additional information, such as 3D seismic data would be required to distinguish between the possible alternatives (after Thomson and Gaffney 2007).

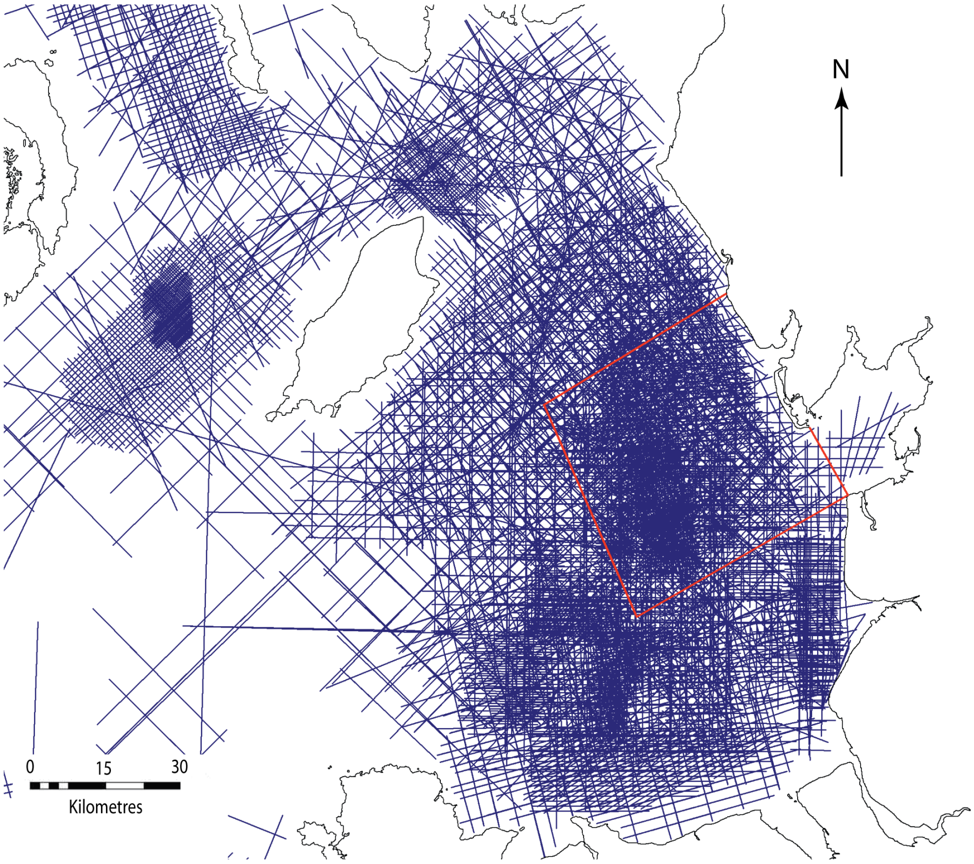

Figure 5: 2D seismic data density for the Irish Sea region (courtesy of BERR/DTi). The pilot project area is outlined here in red.

4.1 Methodological determination

4.1.1 Given the extensive nature of the 2D seismic data (see Figure 5 above) we require an appropriate method of testing and validating 2D data to assess its suitability and also to assist in the generation of an appropriate methodology.

4.1.2 After consideration, the following approach was decided.

1. A standard 3D seismic dataset within the pilot study area would be utilised to identify archaeological features within the study area.
2. A random selection of 2D seismic data over and around this area would be obtained.
3. These 2D datasets would then be investigated to determine if they contained the features identified within the 3D dataset and the intersections recorded.
4. The dataset and features obtained from the 2D datasets would be assessed to determine the possibility of the reconstruction of landscape information from these sources.

4.2 Data holdings accessed by the project

4.2.1 The data required for this project is held in a number of locations and reflects the various requirements for which the data was acquired. For example, high-resolution data of the nearshore zones is held by the UK onshore geophysical data library: even though it is located well within the marine zone. This is due to the data being acquired by the now defunct British Coal Board, and more recently for onshore oil and gas installations and pipelines.

4.2.2 The main datasets used for the project were acquired for the energy industry and reside within three main data libraries. The largest of these is the UK offshore geophysical data library (DTi/BERR) which holds released 2D seismic survey derived from a variety of sources. The UK Onshore Geophysical Data Library (UKOGL) and the British Geological Survey hold smaller quantities of data of various vintage. Other commercial bodies also hold data and information on owners can be obtained online from the UK offshore geophysical library (DTi/BERR). Unfortunately this information is no longer available for direct download.

4.2.3 SeaZone, as commercial wing of UK Hydrographic Office, holds the digital data of the seabed and produces commercial bathymetry products.

4.3 Assessment of density of 2D Datasets available for study

4.3.1 The initial assessment of the availability of 2D datasets was comparatively easy as the three main data repositories provide web portals which allow a visual inspection of the data holdings. These are located at

1. UK DEAL - http://www.ukdeal.co.uk/
2. The UK Onshore Geophysical Data Library (UKOGL) - http://www.ukogl.org.uk/
3. The British Geological Survey - http://www.bgs.ac.uk/

4.3.2 GIS information on available data is provided free of charge from the UKOGL, via their website. The BGS GIS data can also be made available to appropriate projects upon request. GIS data is available from UK DEAL although a registration and subscription fee to the resource is required. It is notable that the UK DEAL information was until very recently available for free public download via their website. This change in access represents a major and new restriction in the availability of data for archaeological use. One issue with this restriction is that selection of data from the UK DEAL dataset for any future project will be significantly hindered by these added costs.

4.3.3 Based upon the previously available free information and the current web resource it was determined that the study area contained a significant coverage of 2D data, a suitable selection of which could be utilised within this study.

4.4 An assessment of the Centrica 3D seismic survey acquired for use within the project

4.4.1 The selected dataset consisted of a single standard 3D seismic survey covering an extensive area of the west of the study area. This was provided by Centrica to the University of Birmingham for research purposes. The survey **MFS3DRE** also known as **"Morecambe and Satellites"** is a 3D seismic reflection survey acquired using standard airgun technology. The resulting digital survey has a bin spacing of 12.5 meters.

4.4.2 The seismic data was made available in digital SEG-Y format and this, with associated survey information, was provided on DVD to VISTA for research purposes. This data may not be generally available for study.

4.4.3 Quality of the data was good and it responsed well to serial timeslicing. The data also proved to be of adequate quality for full processing and archaeological interpretation. Initial results suggest that the main limitation of this dataset for archaeological research resulted from the relatively ephemeral characteristics of the strata of archaeological interest - represented by terrestrial Holocene deposits. Information was confined to a relatively small number of slices, and thus a small vertical resolution. This was, however, an issue of the prevailing geology, rather than a feature of the dataset itself. The archaeological landscape information contained within the data, which was similar to that identified by the North Sea Palaeolandscape Project, was of major value to the assessment presented here.

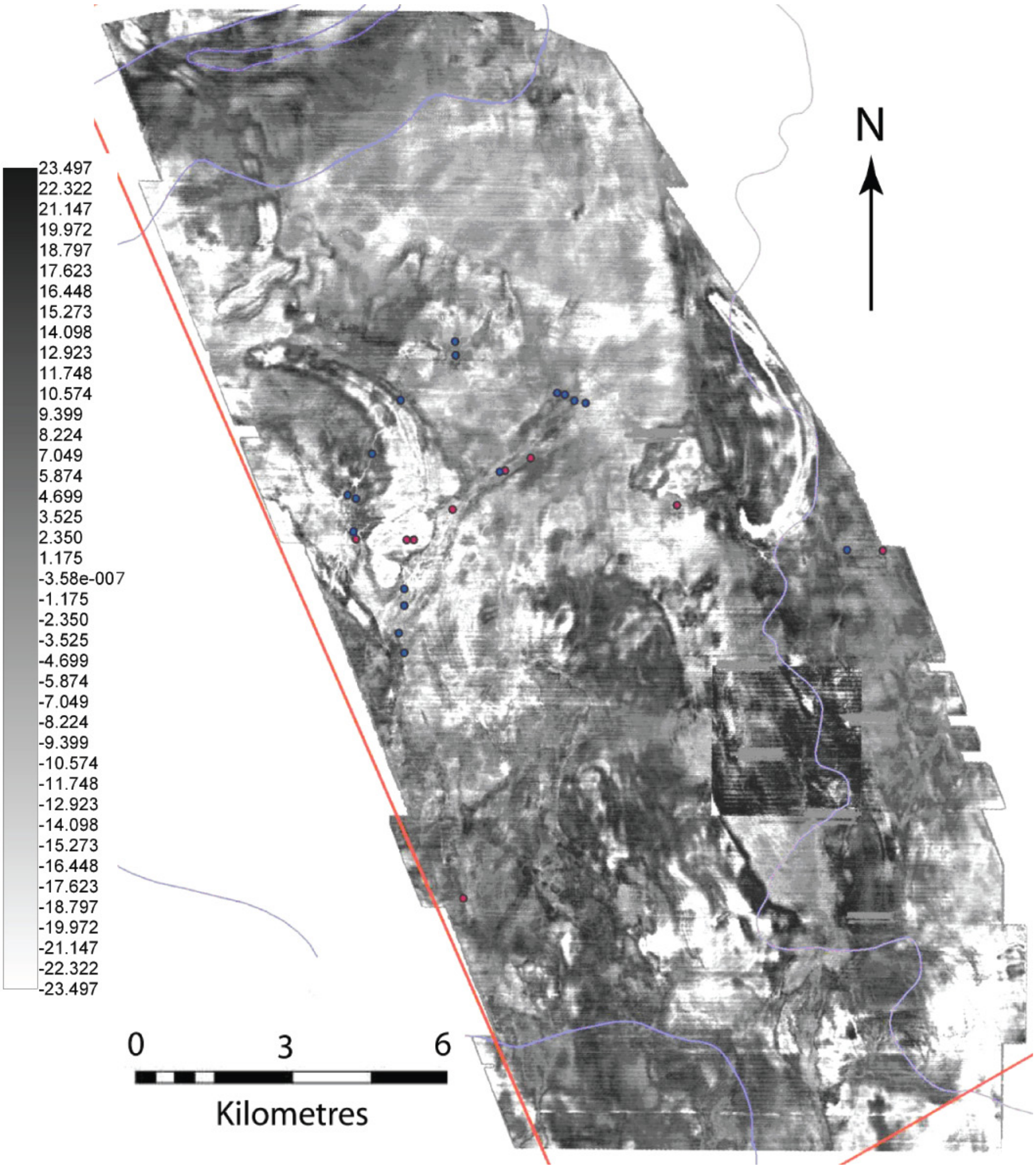

Figure 6: Timeslice Image of the 3D dataset at 0.076s

4.5 An assessment of the BGS 2D geophysical survey data for use within the project

4.5.1 The selected geophysical dataset consisted of 3 shallow seismic surveys comprising a series of lines which covered extensive sections of the study area and which were obtained by the British Geological Survey between 1968 and 1972. For these surveys multiple lines of data were available derived from a combination of common seismic sources (sparker and pinger). The seismic data were made available in the form of scanned paper rolls in TIFF format and the corresponding survey track plots available on DVD. A small fee was charged by the BGS for access and reproduction costs associated with retrieving these images.

4.5.2 Although there was some variability in quality, the selected sparker datasets received from the BGS were adequate for full processing and archaeological interpretation based on the frequency, range and filtering settings during their acquisition. The pinger datasets visualise a very shallow section of the seabed and the indistinct images were less reliable for archaeological interpretation.

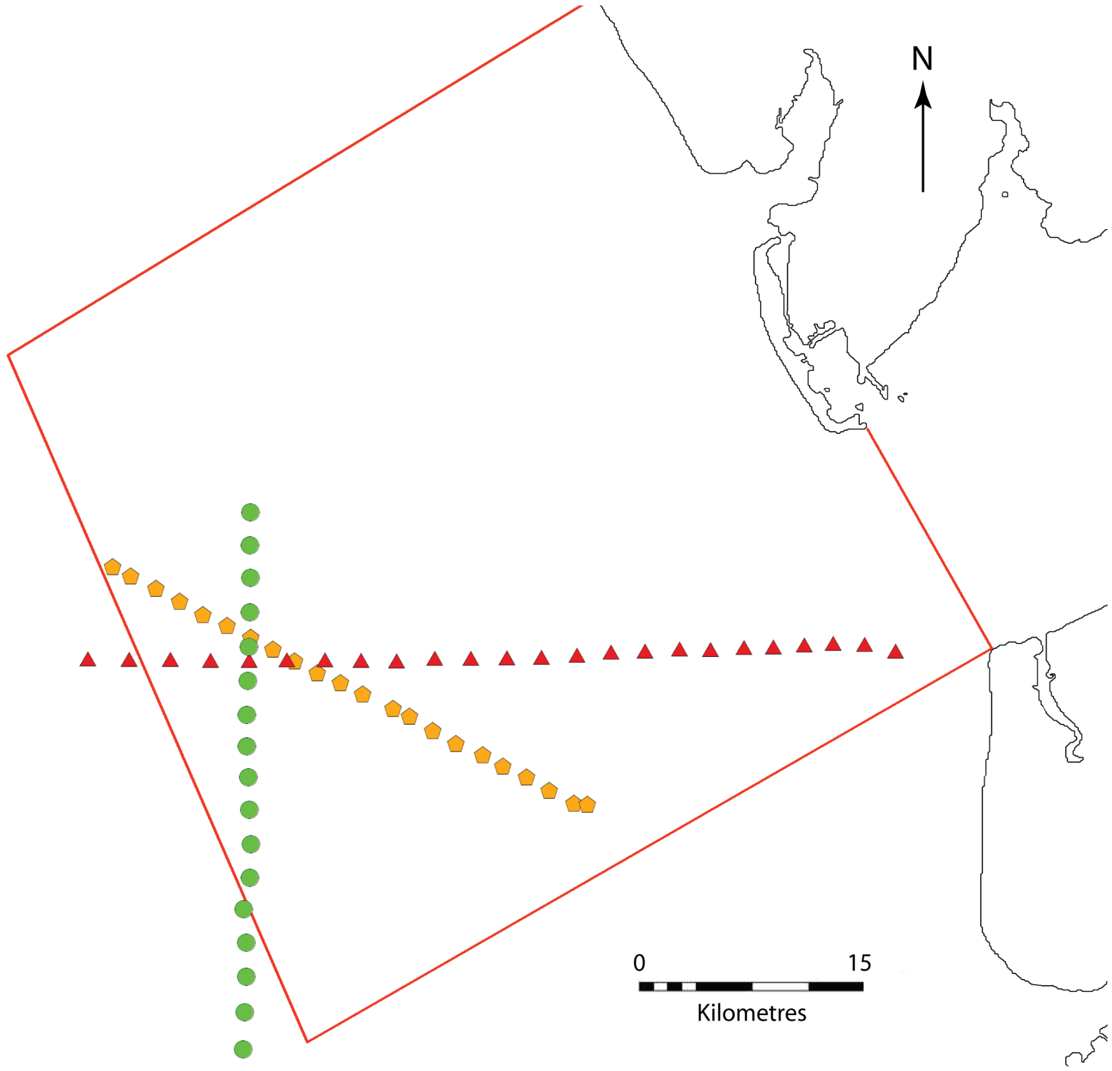

Figure 7: Location tracks of the BGS survey - The 1968 line is orange, 1972 Line 3 is in green and 1972 Line 11 is in red

4.6 *An assessment of the OKOGL 2D data for use within the project*

4.6.1 The selected geophysical dataset consisted of two shallow seismic surveys comprising 11 survey lines which covered the onshore sections of the study area and which were obtained during 1981 and 1987 respectively.

4.6.2 The SW81 survey was undertaken by Prakla Seismos for Shell U.K Ltd. on the 28th of July 1981 and transcribed for the UKOGL on the 12th March 2004 by Veritas data services UK. Ltd. The survey data was acquired utilising a standard airgun as a source and recorded directly to tape as SEG-Y 32bit floating point data.

4.6.3 The U038-87 survey was undertaken by Horizon Ltd. for Ultramar Exploration in 1987. The data underwent further processing at Horizon Exploration Ltd. during August 1987 to January 1988. The survey data acquired in the marine areas of the survey utilised a standard airgun as a source and recorded directly to tape as SEG-B format. The area of survey undertaken within the Bay was acquired utilising an airgun shot with a hydrophone cable laid on the seabed (station interval 25m). A SN348 recording device was utilised to record the data.

4.6.4 Seismic data for both surveys was made available to VISTA in the form of digital stacked and/or migrated seismic data with corresponding survey track plots on DVD. No fee was charged by the UKOGL for access or reproduction costs associated with this research project.

4.6.5 Examination of these datasets suggested that the migrated data possessed better defined reflectors within the top sections of the data than those contained within the purely stacked datasets. This improved definition within the migrated dataset should assist in the reliability of reflector identification.

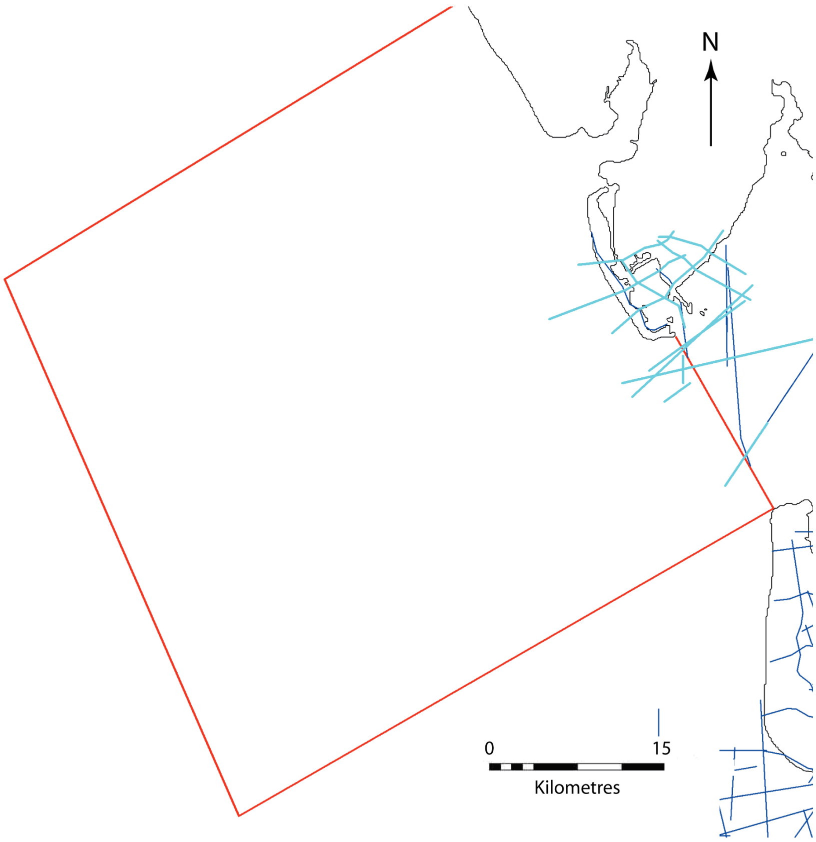

Figure 8: Map of UKOGL 2D seismic lines utilised in this project - selected lines shown here in light blue

4.7 An assessment of the DTi offshore (BERR/Phoenix) 2D Data requested for use within the project

4.7.1 The selected geophysical dataset included series of traditional petroleum industry 2D seismic surveys incorporating a series of intersecting lines coincident with several of the most significant features within the study area. They therefore possessed the greatest potential for validating the proposed methodology. These data were originally obtained by S&A Geophysical Ltd. for Hydrocarbon Resources Ltd. in 1975, and released to the DTi in 1980.

4.7.2 The survey HY752D1002 (CS9 Name) represents a traditional 2D seismic reflection survey. The information available for assessment was based on multiple lines of single hydrophone streamer survey utilising an airgun seismic source.

4.7.3 The original data were obtained from BERR/Phoenix (representing the DTi's data store), which holds a significant number of surveys from this area. The data is stored on the original paper survey rolls, which were subsequently scanned by Phoenix Data Solutions Ltd. for conversion to SEG-Y files. The original paper rolls were scanned and also provided in TIFF format. However data compression techniques used on the images prevented these images from being displayed reliably. This was more likely a software problem than a data format issue, though it should be noted that it is best practice to produce uncompressed TIFF images following the digital archive guidelines recommended by the Archaeological Data Service (http://ads.ahds.ac.uk/project/goodguides/excavation/sect24.html). The corresponding spatial information relating to the survey was also provided on DVD. This data is not freely available for academic or research study. A significant fee had to be paid, and a potentially complex licence agreement agreed to facilitate access to the data. This agreement does not limit the use of the resulting interpretation of the data, which would in this case be used for archaeological purposes. Rather the agreement limits copying and distribution of the original survey data as provided by the agreement. This cost to acquire this data severely limited the number of survey lines requested, and thus the data used represents the maximum that could be afforded by the project. Considerably more data was available for purchase and could have been used to improve the landscape information and results of the pilot, had funds been available. Costs for purchase of data provided by Phoenix are available as Appendix 1.

4.7.4 The data was of variable quality even when the selected lines originated from the same survey. However, the digital nature of the data allowed application of a range of processing techniques to optimise the data output. Unsuitability of the remaining lines resulted from poor response and reflectors in the top sections of the datasets, as well as poor data resolution. The scanning/conversion of the paper records into digital data also potentially introduces an unknown element of error into the process of interpretation.

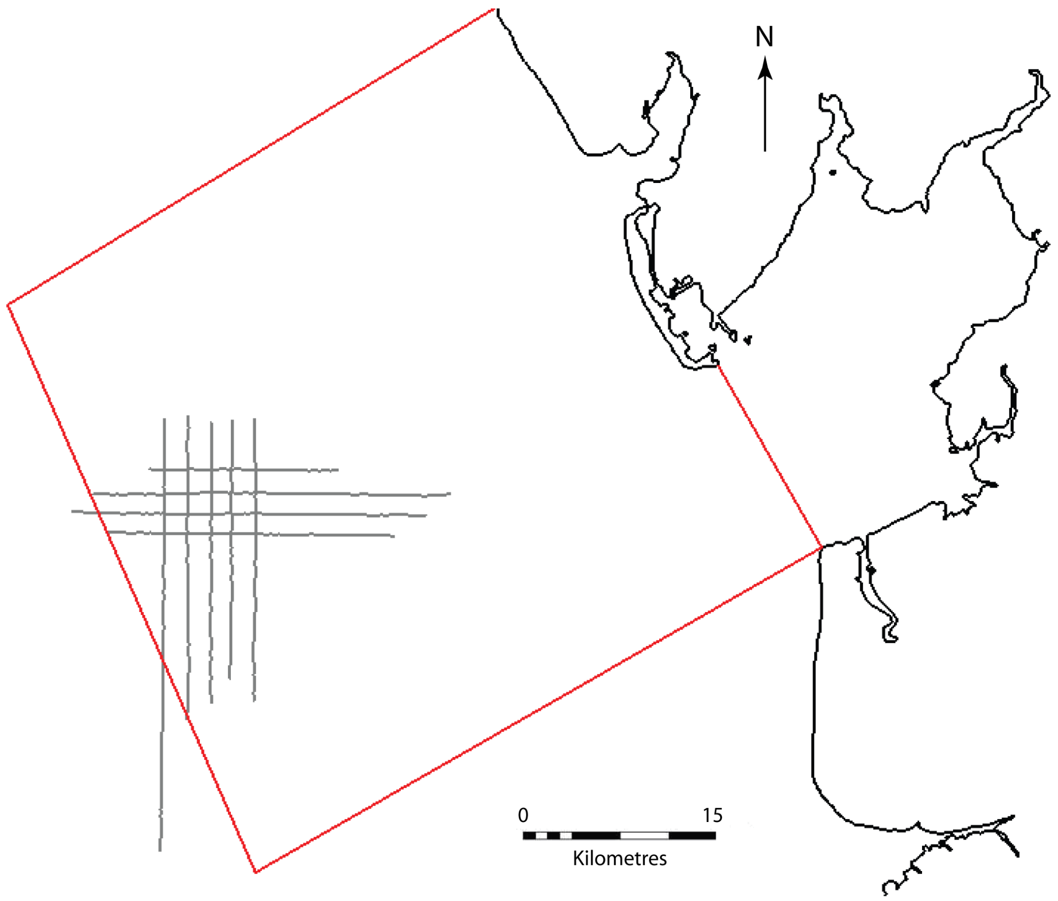

Figure 9: Map of BERR/DTi 2D seismic lines purchased for use in this project - selected lines shown here in grey.

4.8 An assessment of the available SeaZone data for use within the project

4.8.1 A series of SeaZone datasets were selected which represented the range of data products potentially available for analysis within such projects. Digital and gridded bathymetry provided a good image of the current seabed over the entire study area.

4.8.2 The original data were obtained from SeaZone Solutions. The information relating to data was supplied to VISTA on DVD, and provided in a variety of formats. This data is not freely available for academic or research study and a fee, and licence agreement, is required to gain access to the information. For this project, data were provided in ArcGIS shape file format and ESRI compatible grid formats. These were all contained within a pre-generated ArcGIS project which was projected into GCS WGS 1984 co-ordinates.

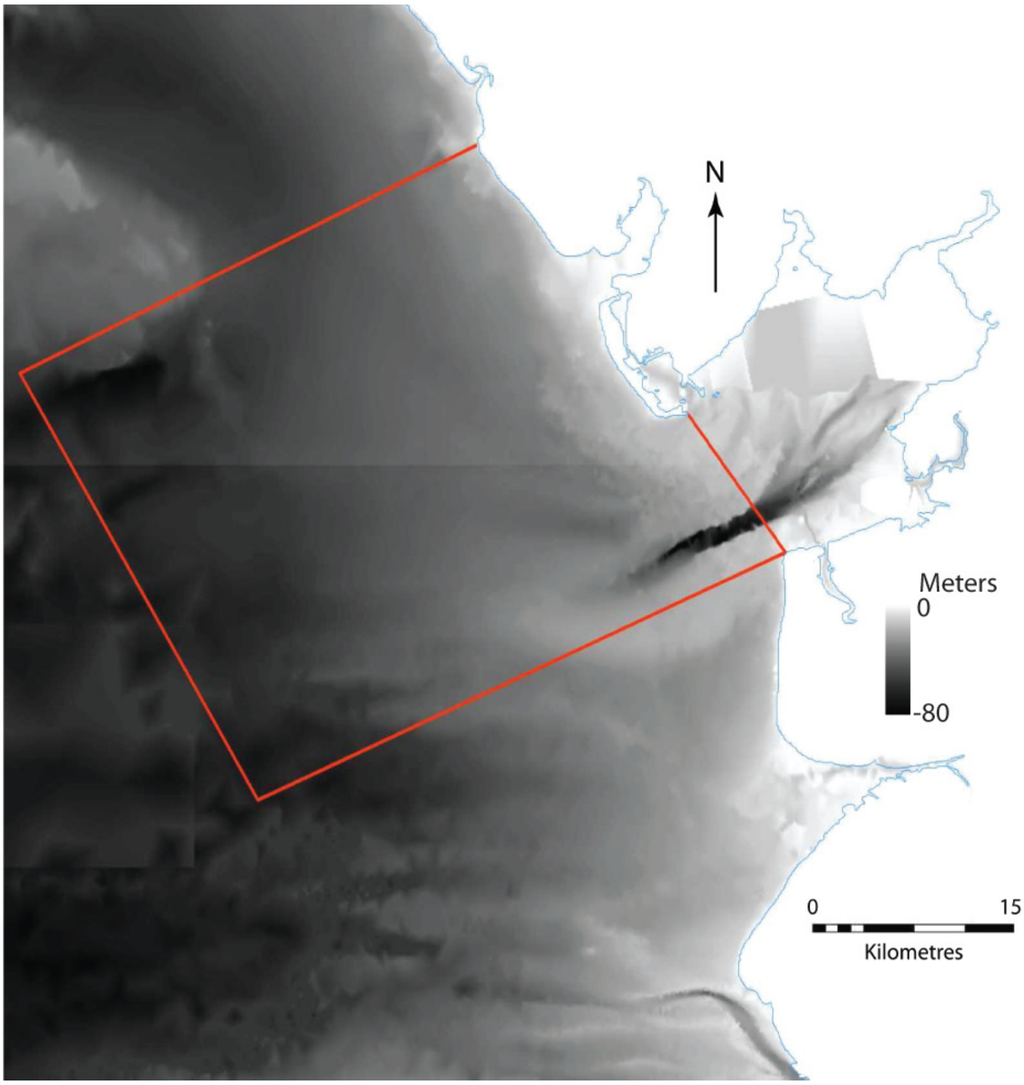

Figure 10: Map of the SeaZone bathymetric purchased for use in this project. Data © British Crown and SeaZone Solutions Limited. All rights reserved. Products Licence No. 042009.001

4.9 Assessment of other information acquired for study

4.9.1 The distribution and depth of Late Pleistocene and Holocene sediments in the UK sector of the Irish Sea Basin have been mapped by the BGS on the basis of seismic-stratigraphic analyses and integrated with lithological and biostratigraphic data from sediments retrieved from shallow boreholes or vibrocores. Unlike the 3D seismic volumes used in the majority of the North Sea Palaeolandscape Project, the seismic data employed in the BGS's seismic-stratigraphic mapping campaign are 2D line profiles totalling a length in excess of 23,000 km. These comprise a combination of low-frequency sparker and air-gun sourced data which achieve local penetration of greater than 800 m. However, resolution decreases with depth, and sedimentary units less than 5m in thickness cannot generally be resolved. Higher frequency sources, such as boomer data, offer significantly improved resolution of shallow seismic reflection events, but often cannot penetrate more than 20m within the Irish Sea. Following established seismic-stratigraphic procedures (Mitchum *et al.* 1977) the 2D seismic data are used to identify a sequence of seismic-stratigraphic units which, individually, are termed as formations separated from their preceding and succeeding units by unconformable surfaces. Each formation is characterised by one or more distinctive seismic facies type, which, in the absence of direct stratigraphic data, are often used to infer the ages of undated seismic units.

4.9.2 Additional information is located within the BGS regional report for the Irish Sea. This is derived from interpretation of scientific seismic lines acquired across the region as well as an extensive seabed sampling program. The mapping contains not only useful information pertaining to the stratigraphy of the region, but also includes mapping of relic bedforms located during survey. Unfortunately, all of the relic bedforms are located outside of the project area and it was not possible to cross calibrate this information with the bathymetric data obtained by the project

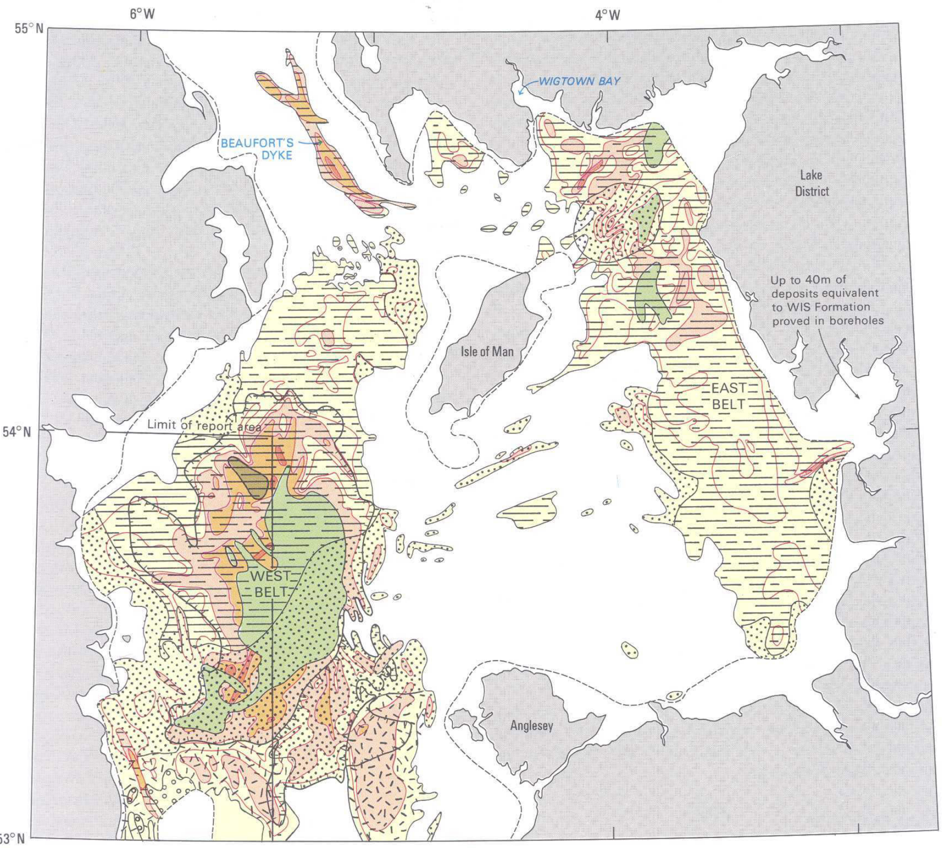

Figure 11: BGS Map of the thickness of the Western Irish Sea Formation (WIS - Upper Pleistocene) from Jackson et al. 1995

5. IMPLEMENTATION AND REFINEMENT OF METHODOLOGY

5.1.1 A variety of methods and datasets were potentially available for use in the project. However, as the choice of methods and hence data types, controls the volume of data used and quality of the results, an optimal approach needed to be developed. A crucial consideration was the need to minimise the time and costs involved in the analysis, whilst at the same time maximising the opportunities to identify correspondences between features observed within the 2D and 3D datasets. Consequently, given the available technologies and the costs involved in acquiring new data, the possibilities of using existing data needed to be evaluated.

5.1 Refinement of the existing 3D Methodology

5.1.2 After initial investigation it was observed that the base 3D data set would be amenable to application of the methodology used within the North Sea Palaeolandscape Project (see Gaffney et al. 2007). The technique of timeslicing is the first step in 3D interpretation of seismic data. This is achieved by dividing the 3D seismic data volume into a series of horizontal slices of equal time. In this project the 3D data volume was sliced into a series of horizons at 0.004 of a second intervals, starting at 0.06 seconds where the first post seabed multiple was imaged, through to 0.15 seconds, where clearly resolvable glacial features appeared. The seabed was poorly resolved in the study area and so, in this region, multiples were used in the timeslicing to gain a full understanding of the features at or near the seabed.

5.1.3 The approach provided clear images of the depositional features, but the thin Holocene cover in this region resulted in limited vertical and hence temporal separation of features (Jackson et al 1995). It was observed from the initial investigation of this dataset, and the BGS report for this region, that the elements of stratigraphy of archaeological interest were considerably thinner than in the North Sea. This was supported by analysis of the slices which suggested a relatively shallow region of interest within the data, thus necessitating a change in end time from 0.25s (NSPP) to 0.15 (WCPP). This means that in the 3D seismic data for the study area the depositional systems tended to be better interpreted in timeslices rather than profiles.

5.1.4 Timeslices can be generated automatically by most seismic interpretation packages, however there is little support for their export into other software. Consequently, other methods must be employed to facilitate this. The export of planar data from a seismic interpretation package is usually facilitated through horizon export. If a perfectly flat horizon is generated within the interpretation package, and associated amplitude data is extracted, it can be utilised as a pseudo timeslice, with identical properties to a timeslice. This pseudo slice information can be exported to an external package in a range of formats suitable for GIS import. Through mathematical manipulation it becomes possible to generate a series of these pseudo slices which can be utilised in a GIS in a similar manner to timeslices within an interpretation package. With the generation of exportable slice information, a suitable output format must be found. After careful consideration, it was considered that output as a simple ASCII text file, in the format X,Y, attribute was the most appropriate given its simplicity, transferability and its non-proprietary format. This ASCII information was then converted to a raster image in ArcGIS and subsequently interpreted.

5.1.5 In order to enhance the features seen in the time slices, several industry standard techniques were employed to improve the visualisation and interpretation. The first of these techniques is opacity rendering (Kidd 1999). This technique converts conventional 3D seismic data into a voxel volume, with each voxel containing the information from the original portion of the 3D seismic volume that it occupies together with an additional (user-defined) variable that controls its opacity. The opacity of individual voxels can therefore be varied as a function of any of their seismic attributes, which thereby allows the user to explore only those voxels that fall within their particular attribute range of interest (usually amplitude). This method therefore permits a clearer solution of the interpretation, and thereby allows a relative dating of the observed structures to be assigned.

5.1.6 Alongside this attempt to improve the definition of the features, a series of standard seismic attributes were also serially timesliced to assist analysis. This attributes included Envelope extraction, Hilbert Transform, Running Sum and Spectral Whitening. Although minor improvements in the definition were realised, no new features were visualised beyond that observed within the standard amplitude datasets.

5.2 Refinement of a methodology for the utilisation of 2D datasets

5.2.1 After detailed examination of the 2D seismic lines it was decided that a combination of standard interpretation procedures coupled with associated GIS recording would be employed during analysis. A workflow for this process is displayed in Figure 12.

5.2.2 Initially the seismic data was examined utilising standard seismic-stratigraphic procedures (Mitchum *et al.* 1977). Digital 2D data, provided as SEG-Y data, was imported directly within SMT Kingdom 8.2 (64bit) seismic analysis software. As the data was provided digitally, it was possible to perform seismic attribute analysis upon these 2D datasets utilising the same suite of attributes as described for the 3D methodology. Generation of this information, however, failed to identify any new features and there was only minor improvement of the identified features. Once completed interpretation of the features was undertaken directly within the seismic analysis software and recorded as a series of culture files. As well as recording the locations of identified features within point files, possible landscape features were also recorded. This information was exported directly into the project GIS for further analysis.

5.2.3 The scanned analogue (paper) data were examined directly within Adobe Photoshop CS3. Again individual incised features as well as possible landscape features were also recorded. As the corresponding survey track log data had been directly added to the GIS it was possible to provide an approximate location for these features and record this information as a point shapefile.

5.2.4 This was achieved through the identification of the nearest fix (or shotpoint) location to the identified feature and then subsequently locating the appropriate record within the GIS. The data within the point file marker table was then populated to provide the necessary supporting data. It is important to note that this method does not provide precise locations for these features as achieved with the other methods. This information was recorded within the shapefile table. Despite this, the error margin likely to be associated with the locations is estimated at +/- 50m, which would permit future investigations to target these areas with relative accuracy.

5.2.5 For both data types the following fields of information were added to the resulting point datasets.

- Reference Number - A unique identifying reference number for the location
- Survey Name - The CS9 Name of the survey in which it is located
- Survey Year - The year in which the survey was recorded (if known)
- Line Name - The survey line name or number in which the location is recorded
- Seismic Source Type - The type of seismic source used to generate the survey, e.g. pinger, airgun, boomer, sparker etc.
- Fix Number - The Fix or Shotpoint number (if known) at which the location is found within the survey
- Feature type - A description of the type of landscape feature the point may represent. e.g. River, Depression, Hill, Wetland, Lake
- Feature Age - The suggested archaeological age of feature
- Data Quality - A direct assessment of the survey data for archaeological purposes with respect to clarity and noise
- Certainty - Clarity and accuracy with which the feature is identified within seismic survey
- Location - A text identifier to indicate the precision of the spatial location. This is given as Precise, Approximate, Imprecise
- Notes - A simple text string provided to allow the recording of any other pertinent observations

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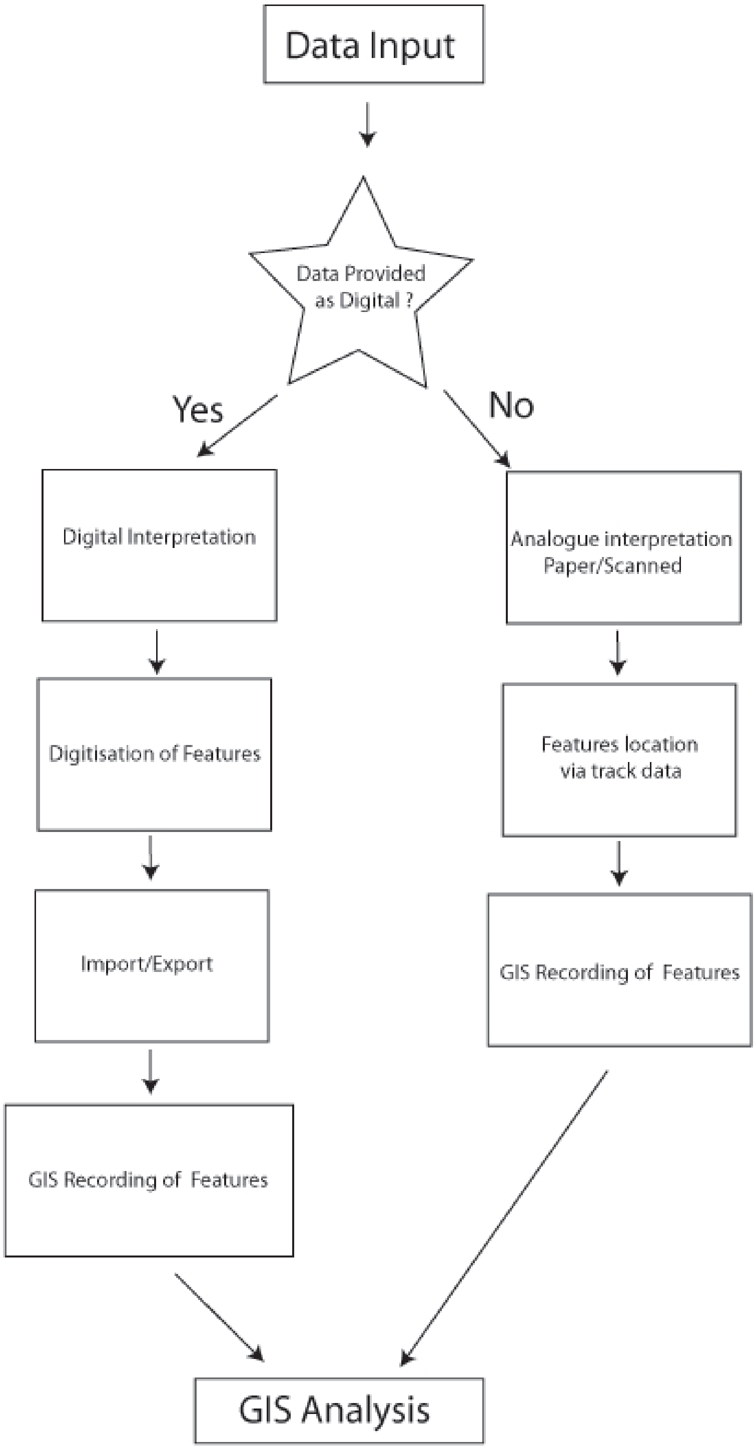

Figure 12: Workflow process for the methodology of identifying and recording of features located within 2D datasets

5.3 Analysis and cross correlation

5.3.1 Once an initial examination of the available 2D datasets had been performed, a detailed examination of the 3D dataset was undertaken to record and analyse all the possible landscape features identified within this data (see Figure 14). This record therefore provided the baseline information against which the results from examination of the 2D dataset were compared.

5.3.2 Digital GIS layers containing the locations of the 2D surveys and associated track log information were imported and overlain on timeslice information obtained from the 3D data. The location of all the intersections between the 2D surveys and the major features observed within the 3D data were then recorded. This provided an "ideal" feature dataset of the maximum number of features that might be recorded within a 2D dataset. This dataset could then be compared directly with the actual 2D features identified within the seismic lines.

5.3.3 This methodology allowed an evaluation of the capacity of the older 2D surveys for the identification and location of features of interest.

5.3.4 A number of the deeper main features were not observed within the BGS dataset. However several large shallow features were within the data. Significantly, several of the target palaeochannels were identified, although those identified within this data were primarily clustered in the deep water sections of the study area. There was no correlation of features observed in the BGS 2D dataset with the bathymetric data.

5.3.5 During the assessment it was demonstrated that the results were not strongly dependant upon the age of the data. Analysis of the earliest survey line available, from 1968, provided some of the best results obtained. Those dating to 1972 contained some noise and discontinuous reflectors. Furthermore, it was observed that the pinger dataset dating from 1968, although characterised by poor penetration, was still able to provide information on a feature of interest (Figure 13 below)

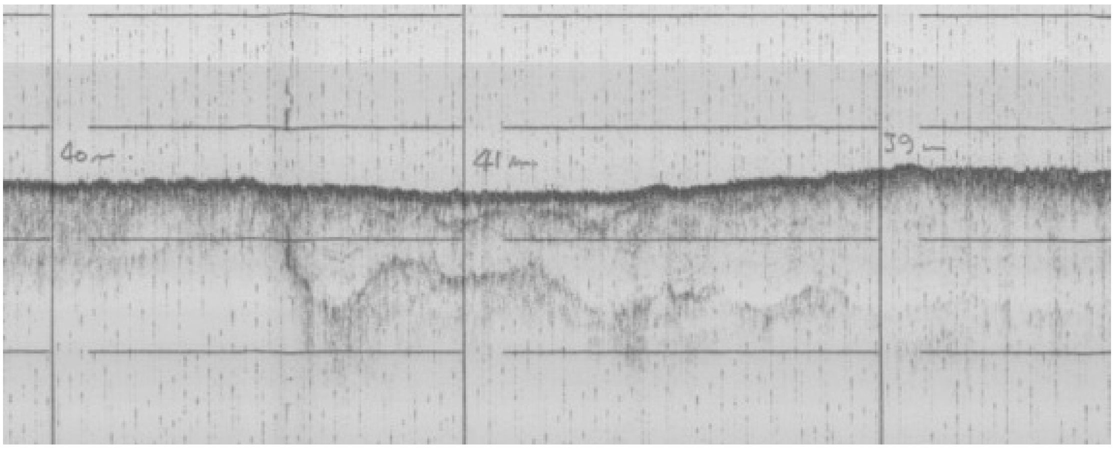

Figure 13: Palaeochannel feature located with the 1968 pinger data

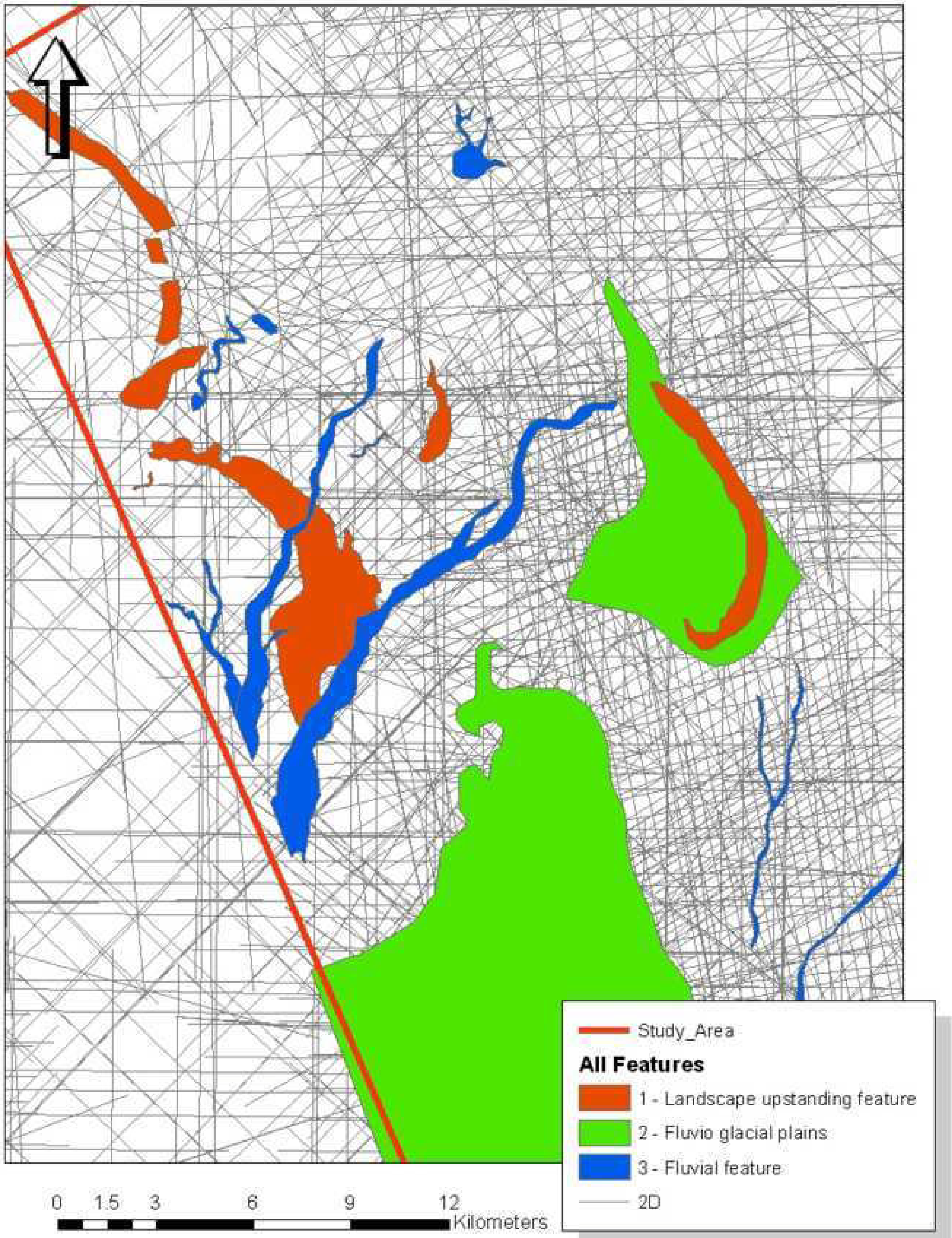

Figure 14: Map of Palaeolandscape features identified within the 3D seismic data
Key: Blue = Probable Holocenefluvial channels and related features: Red = Geological features forming regional highs: Green = Late Upper Palaeolithic fluvioglaical floodplains

5.3.6 The selected lines provided by the UKOGL possessed sufficient detail for the identification of some of the larger palaeogeographic features identified within the 3D data. These were directly correlated with features within the digital bathymetry and BGS reports for the area. These features are only partly infilled, explaining their bathymetric expression.

5.3.7 Additional palaeochannels were observed within the data (see Figure 15). However, noise in key areas prevented optimal feature identification. Generally, palaeochannels seemed to be clustered in the deeper sections of thr survey area. Due to the available data covering only a restricted zone of the shallow water area, and the low line density associated with the area, it was not possible to utilise the data to identify a directional trend in the palaeochannel incision. However these data do indicate that pre-existing shallow water surveys have the potential to recover meaningful information within the marine "white" band. They also vividly highlight the fact that clusters of palaeogeographic features may occur within areas of low data availability. As aggregate extraction rarely takes place within the marine 'white' band, archaeological deposits in these areas are not at risk from such extensive impacts. However, archaeological deposits present in these areas are potentially under threat, of a more limited nature, such as cable laying for windfarms.

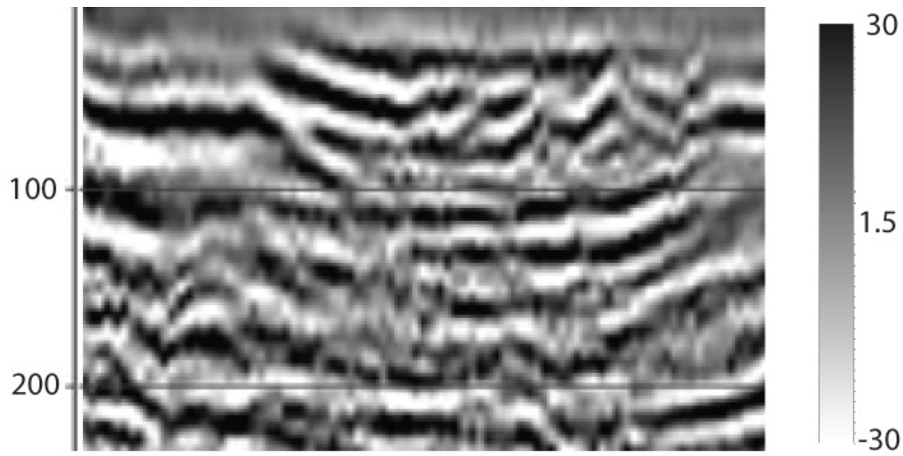

Figure 15: Feature identified within the line UM38-87-12 from the UKOGL
(vertical scale is time in milliseconds)

5.3.8 Examination of the data provided by BERR/DTi suggested that only 6 of the 11 lines were suitable for analysis. The 5 other lines were rejected largely because of noise in the top section and poor resolution of the potential areas of interest. Although this is a very small proportion of the overall dataset, and the unsuitability of any particular line could result from a variety of factors, the 60% usability factor provides invaluable information on the likely utility of such data for future research.

5.3.9 The lines suitable for analysis did, however, provide detail of some of the larger palaeogeographic features that were observed within the 3D seismic data. Unfortunately, noise within the top sections of the data column prevented identification of many of the smaller features.

5.3.10 The position of the fluvial features identified within the DTi datasets were recorded in the seismic interpretation system and cross-referenced to supporting datasets within the GIS. No correspondence was observed with the bathymetric dataset. This suggests that the fluvial features identified within the DTi datasets are currently infilled and do not possess a bathymetric expression.

5.3.11 Examination of the bathymetric data as a standalone suite of information suggested that, over the majority of the study area, features of significance were not directly observable within this dataset. It was only in nearshore locations that a few of the bathymetric deeps possessed a morphology that suggested that they might have relevance to a surviving palaeolandscape. The only major deep recognisable within the dataset, and which may have any palaeogeographic significance, was one associated with Morecambe Bay (Figure 10), and this was confirmed by the UKOGL 2D datasets which cross this area.

5.3.12 Consequently whilst bathymetric data provided excellent coverage across the study area, and acted as a valuable background for the work, it only possesses a minor capacity to identify features of archaeological significance outside the shallow marine zone.

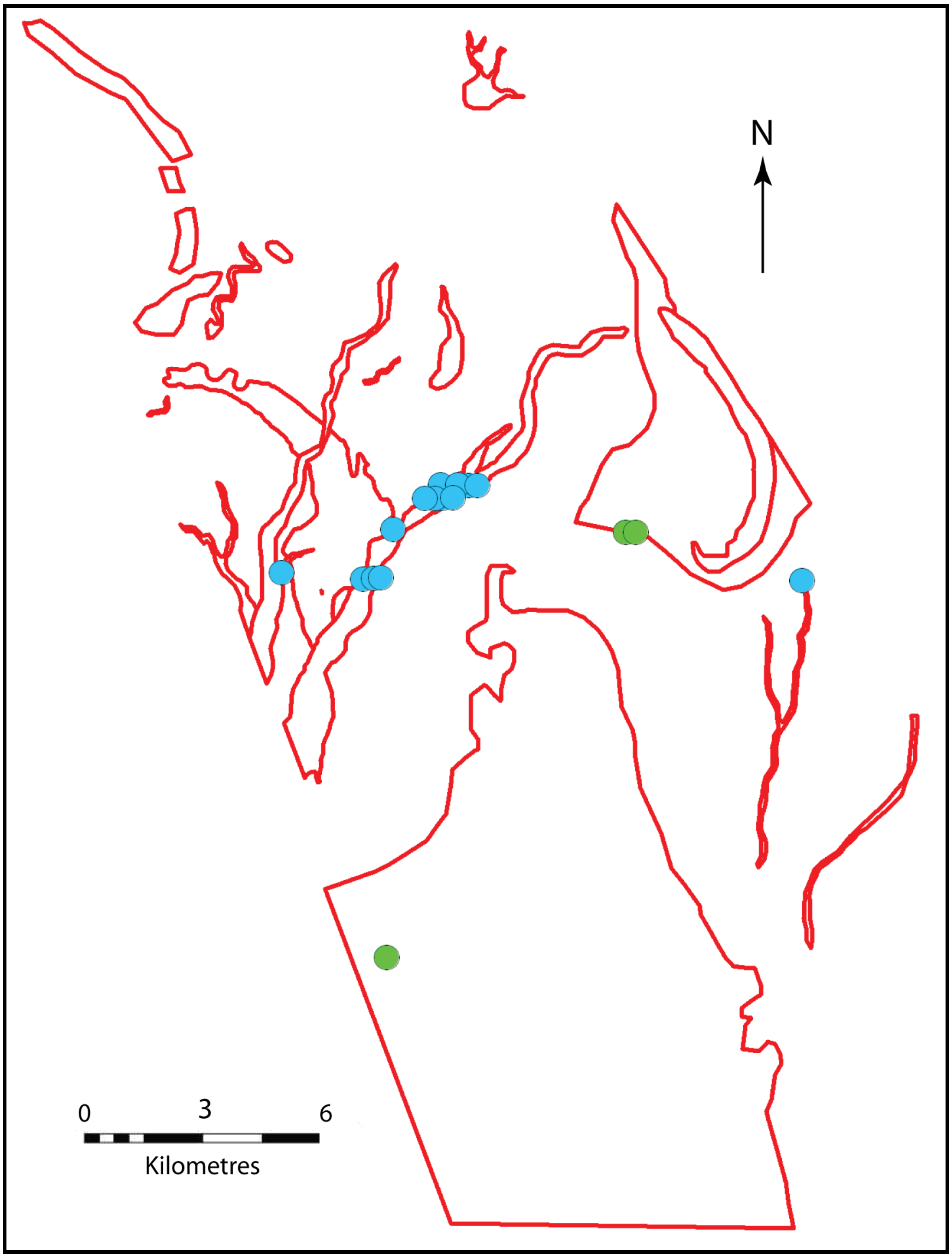

Figure 16: Observed intersections between features observed within the 3D dataset and the 2D seismic datasets. Fluvial features are given in blue. The fluvioglacial plain is shown in green.

5.3.13 Figure 16 provides mapped data on the intersection of features within the 3D and 2D datasets. Several significant points can be drawn from this information. The results were undoubtedly constrained by the availability of data for analysis, and also data quality in some areas. Despite this, it was still possible to identify landscape features within the available dataset. The results suggest that the primary features were identified and, with a degree of caution, it is likely that the overall trend of the main fluvial system in this area could be identified. What is also apparent is that the fluvioglacial plains are less well resolved within the 2D, primarily because of their extensive nature. This may, in part, also be due to the issues of noise and poorer spatial coverage across these areas.

5.4 *Modelling the impact of data availability within the pilot study area*

5.4.1 It should be clear that the primary issue relating to the use of 2D data sets for analysis is probably their availability. Consequently, it seemed reasonable to assess the entire dataset to assess what the impact of varying data availability might be for future projects. To achieve this, an assessment was performed by generating a map of the potential intersections in conjunction with the available 2D line location information for the area.

5.4.2 Initially a point shapefile was generated of all of the 2D lines that intersected the features identified within the 3D seismic data. Points were created along each of the cropped lines at no less than 50m intervals, a resolution comparable to most 3D datasets, and given an attribute relating to the number allocated to the underlying features (Figure 17). The lines were initially cropped so only those that were within the study area were included.

5.4.3 A numeric (double) attribute field – RandomS - was created for these lines, and filled with random values between 0 and 1 generated by the Rnd function in the Calculate Values dialog box in ArcGIS. Sub-samples of 10%, 20% and 50% designed to reflect various data availabilities were then generated by selecting by attribute at RandomS <= 0.1, 0.2, and 0.5 (Figures 18, 19 and 20).

5.4.4 Points at no less than 50m were then generated using the above methodology for each of these sub-samples (Figures 21, 22 and 23) to assess the definition generated by the potential intersections with the features. The definition of the features varied considerably in relation to line sample size. It was determined that at 10%, although features were clearly present, definition of size and alignment was poor. However, definition was considerably improved by a 20% data sample, and proved nearly as good as extensive coverage at 50%.

5.4.5 It should be noted, however, that the study area has a very dense line coverage that is not necessarily representative of the line coverage for the wider area covered by the whole of the 2D line shapefile. In addition, the area within which the features were identified was particularly dense. It can be suggested that the definition of features is therefore related to the relative 2D seismic line density of a particular area.

5.4.6 The line density (determined by [Sum line Length/ area of Study Area] *100) for the entire pilot study area was 0.9%. The density of the sub-samples is presented in the table below.

Sample % of lines within Study Area	Line Density (%)
Whole Area	0.90
Targeted over features	1.23
50%	0.47
20%	0.18
10%	0.09

Table 1: Line density within sample area

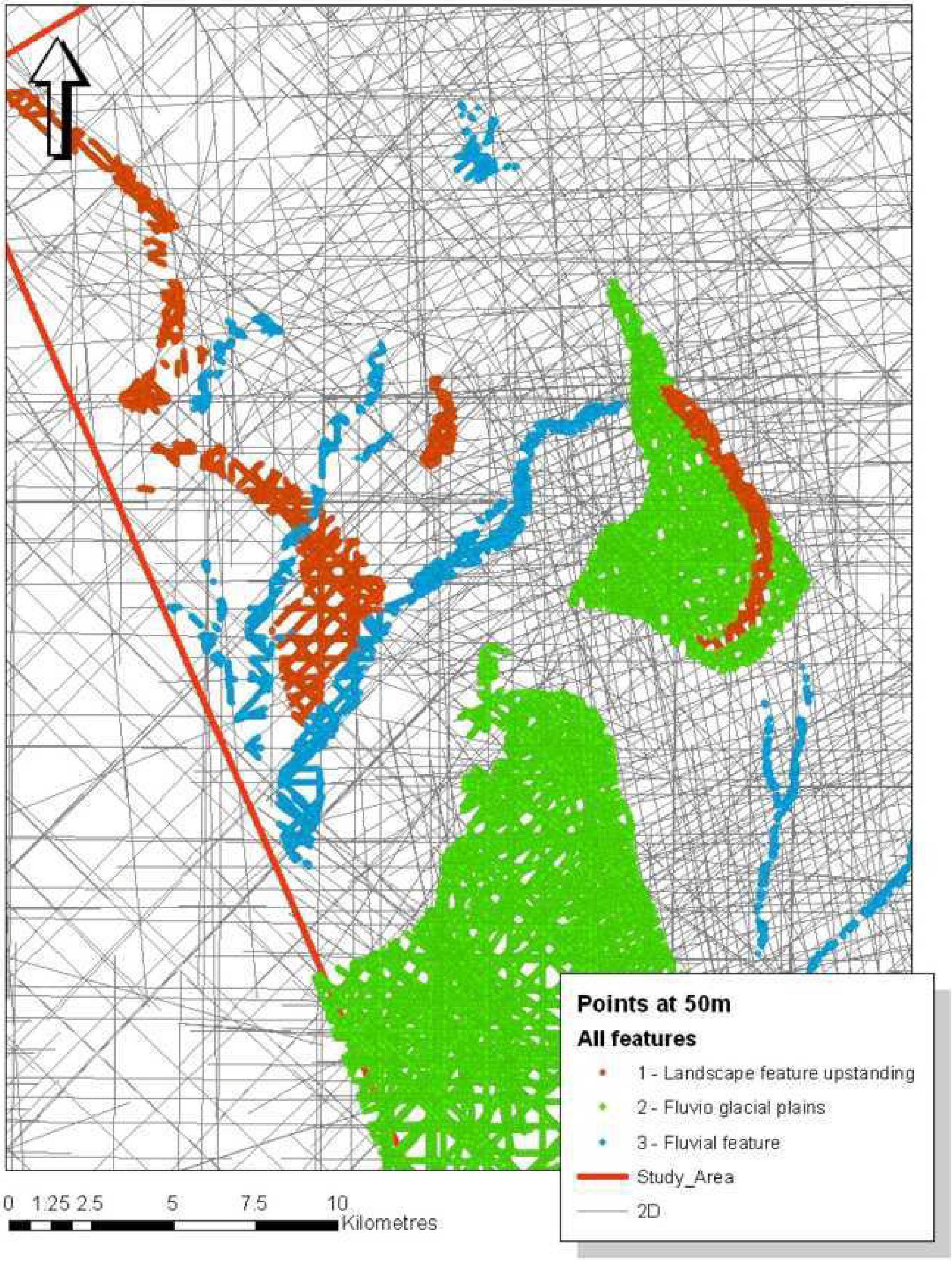

Figure 17: Results of the intersection of all of the 2D lines that intersected the features identified within the 3D seismic data

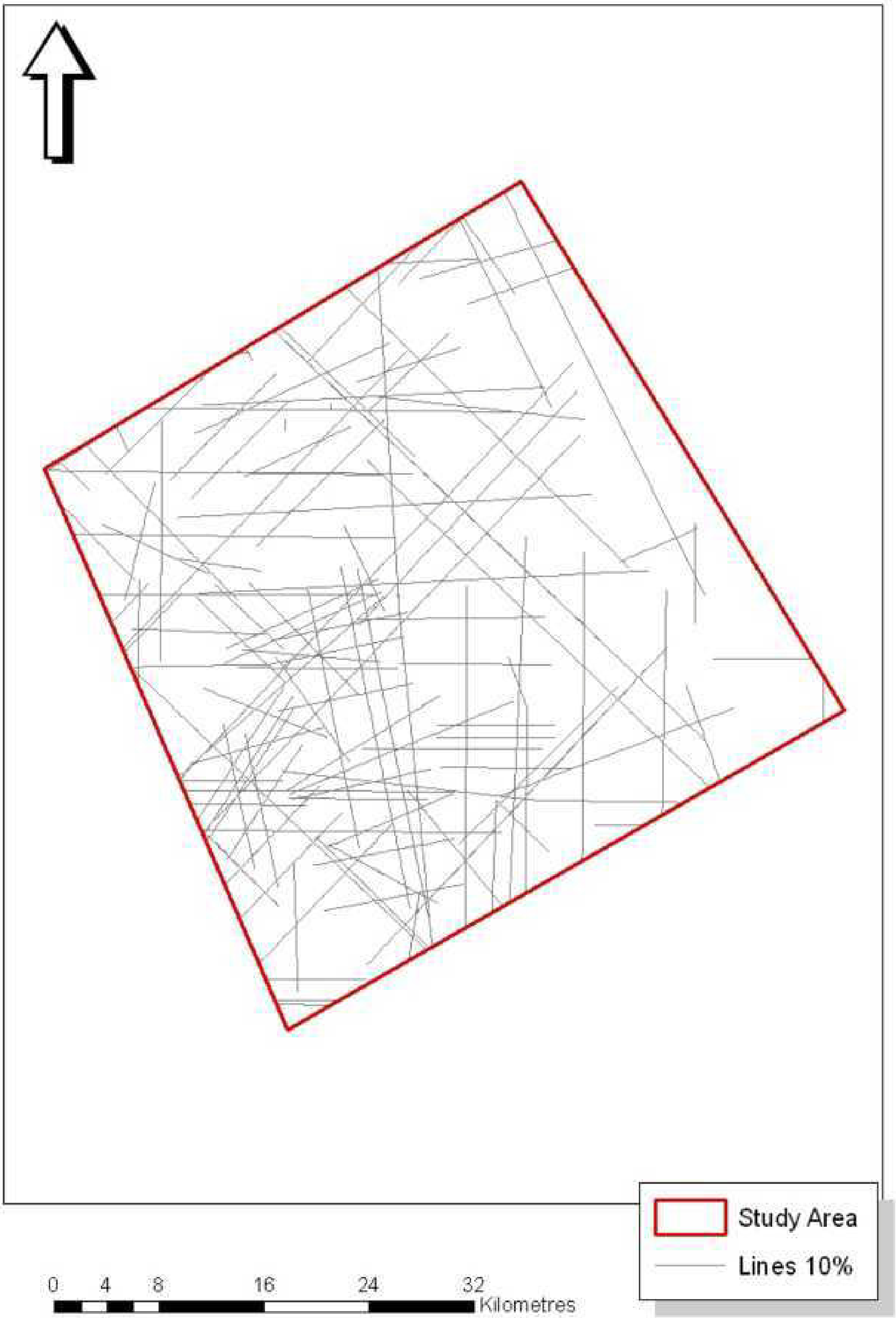

Figure 18: Random sub-samples of 10% of lines

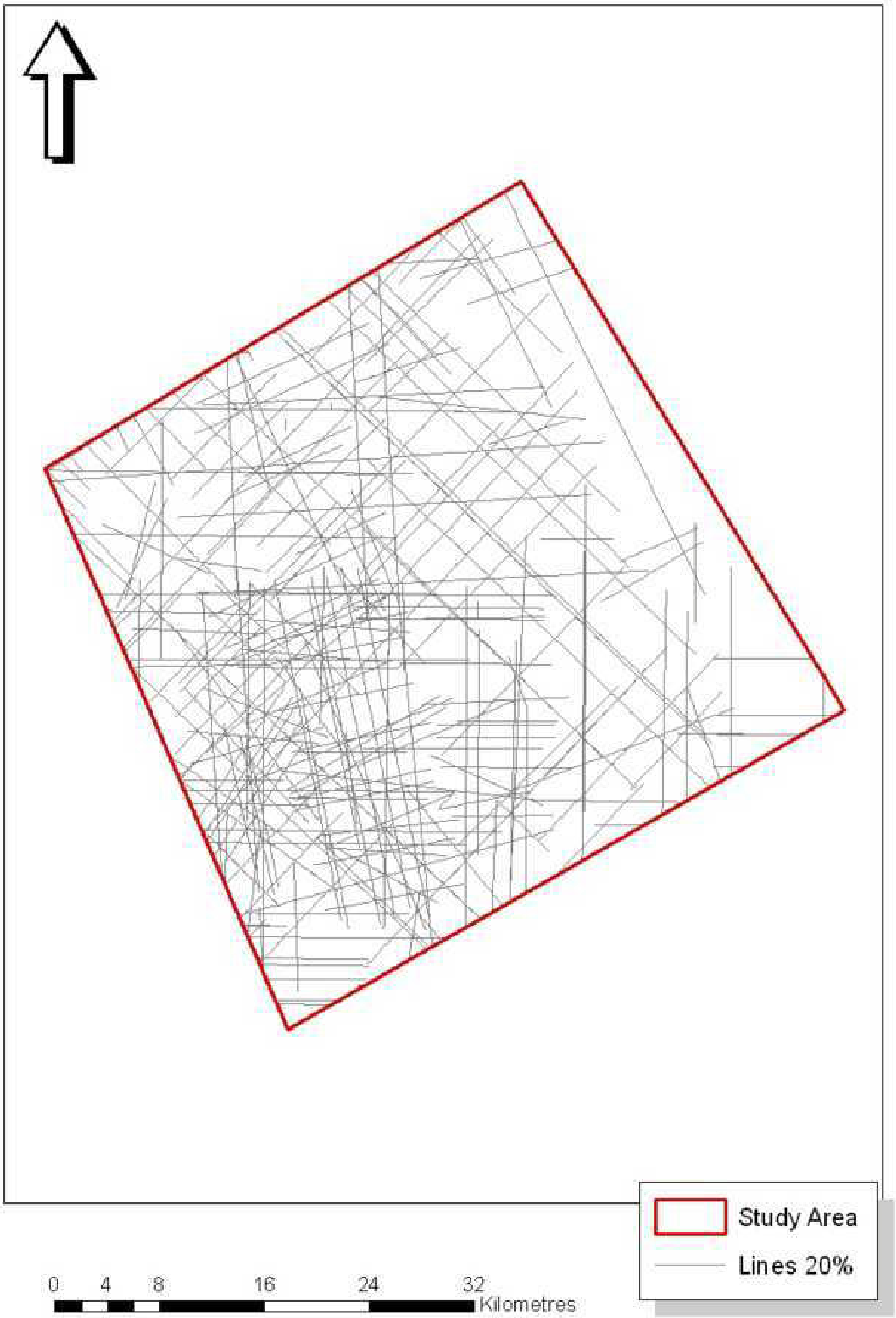

Figure 19: Random sub-samples of 20% of lines

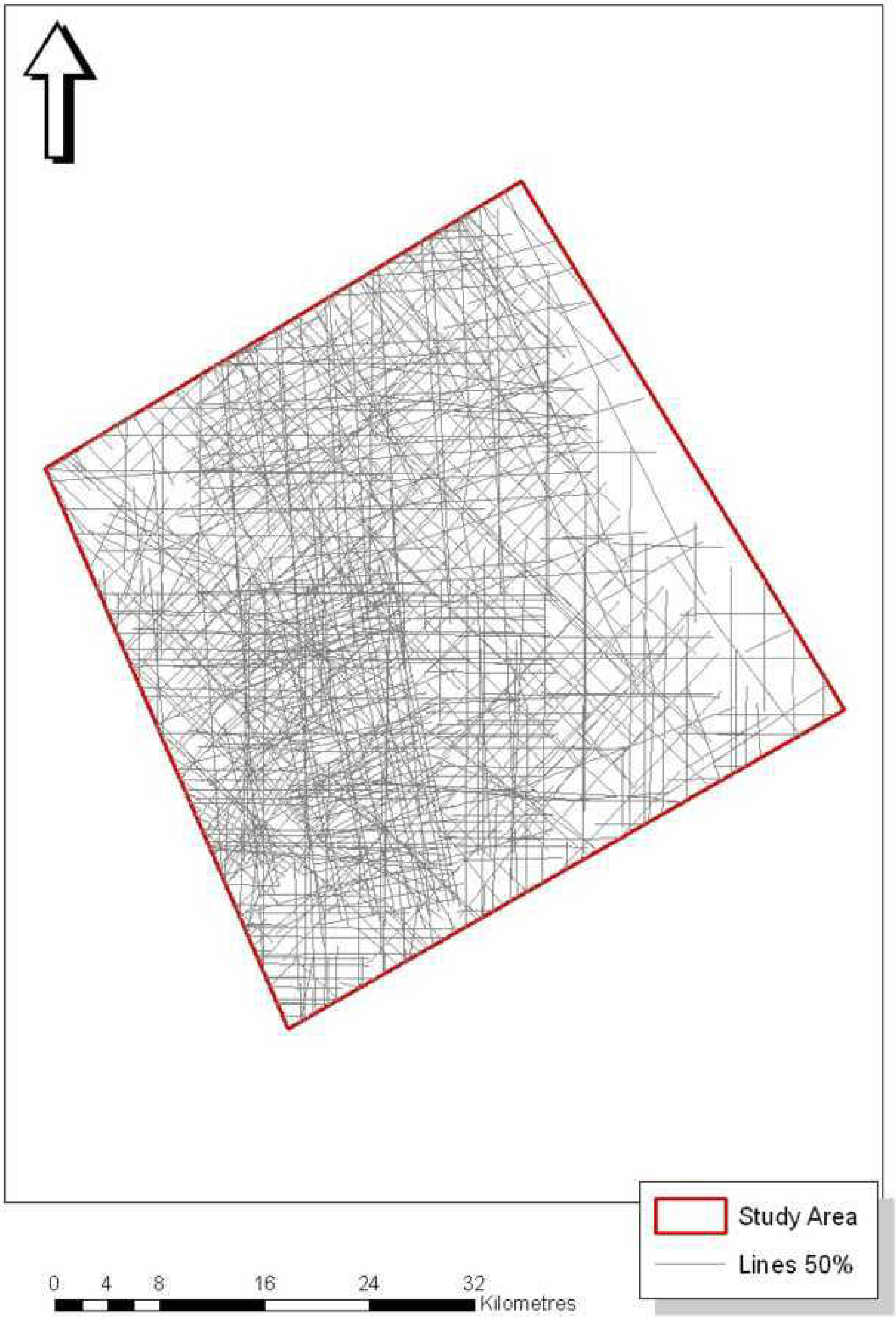

Figure 20: Random sub-samples of 50% of lines

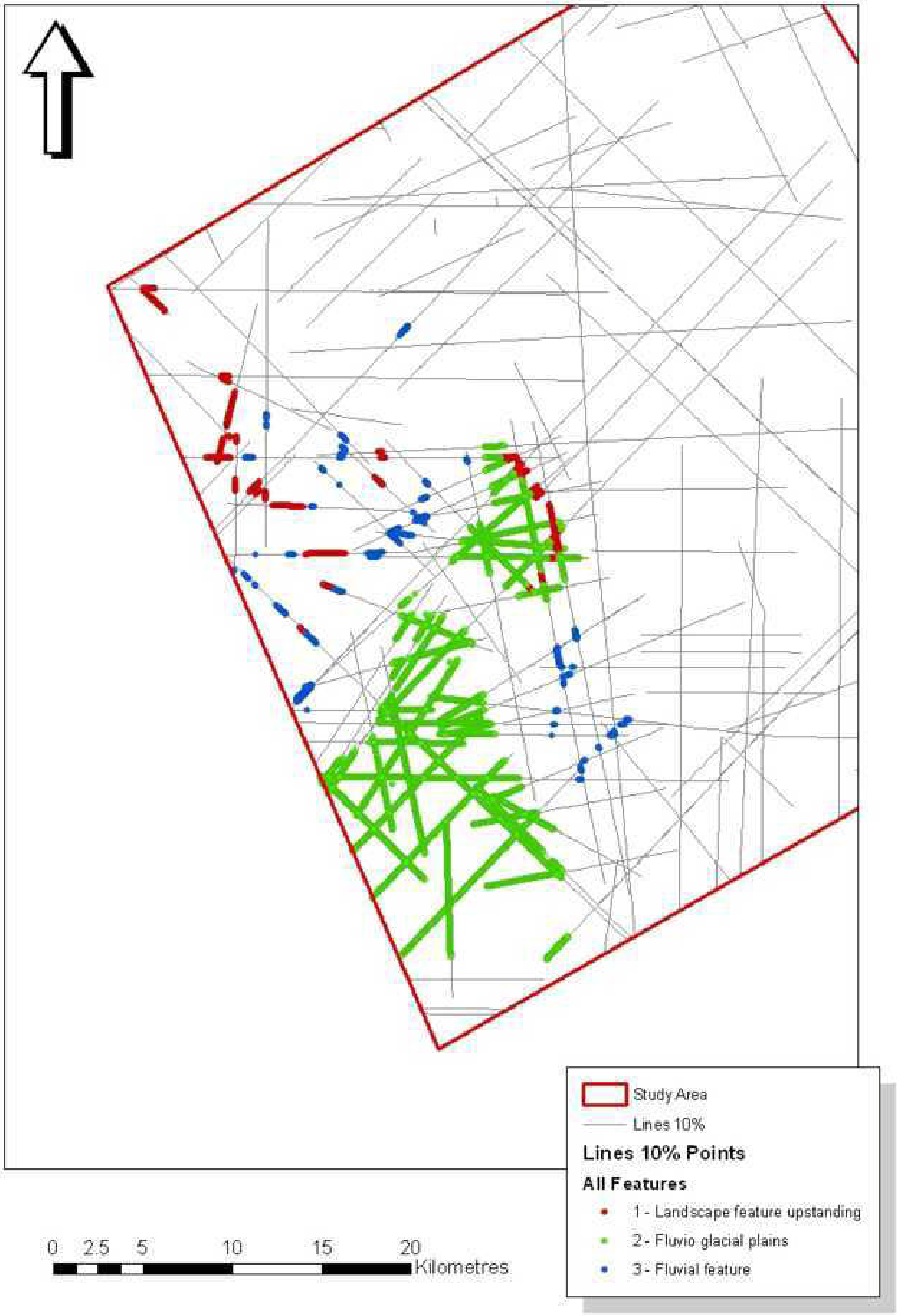

Figure 21: Intersection of features using the sub-samples of 10% of lines

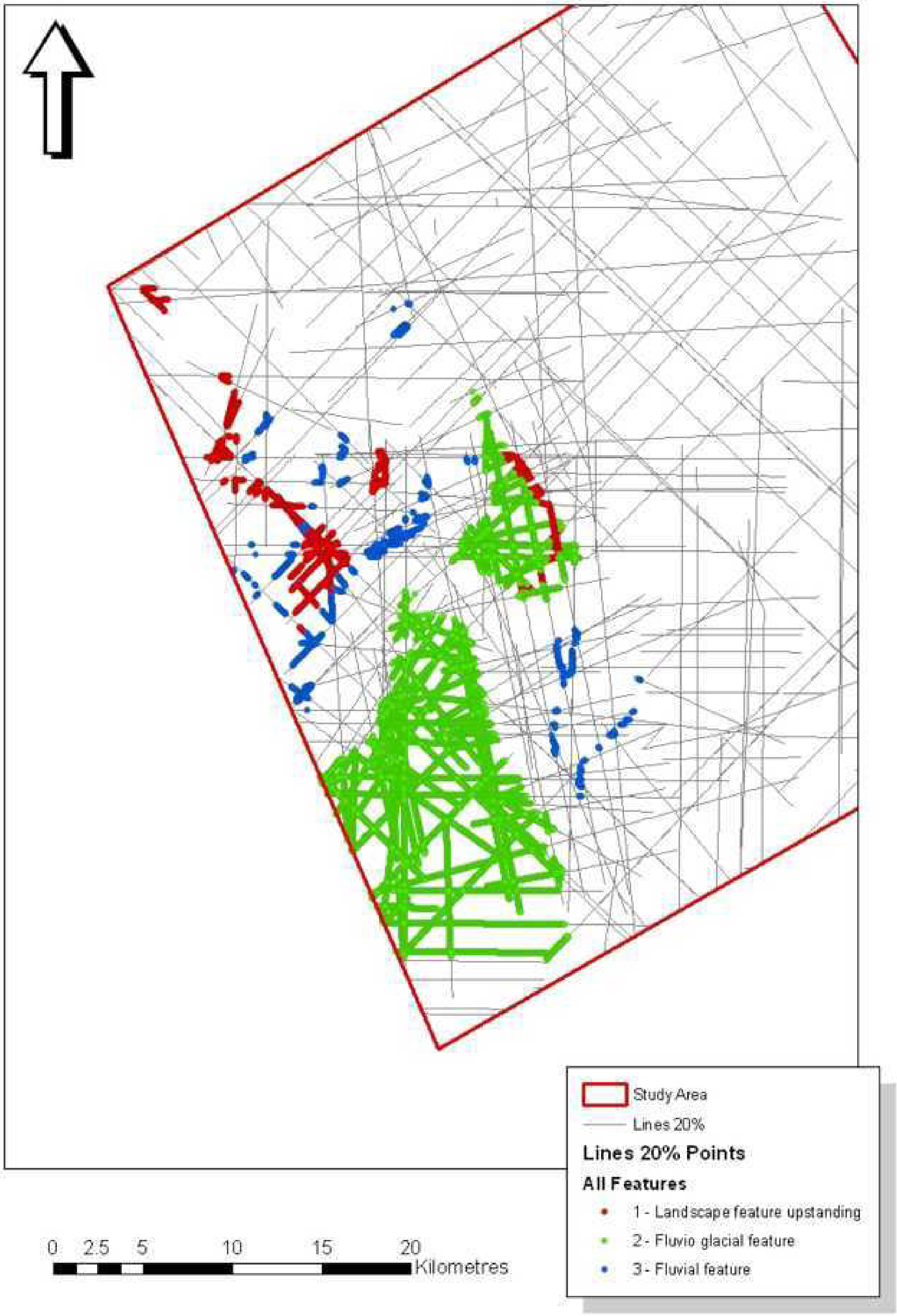

Figure 22: Intersection of features using the sub-samples of 20% of lines

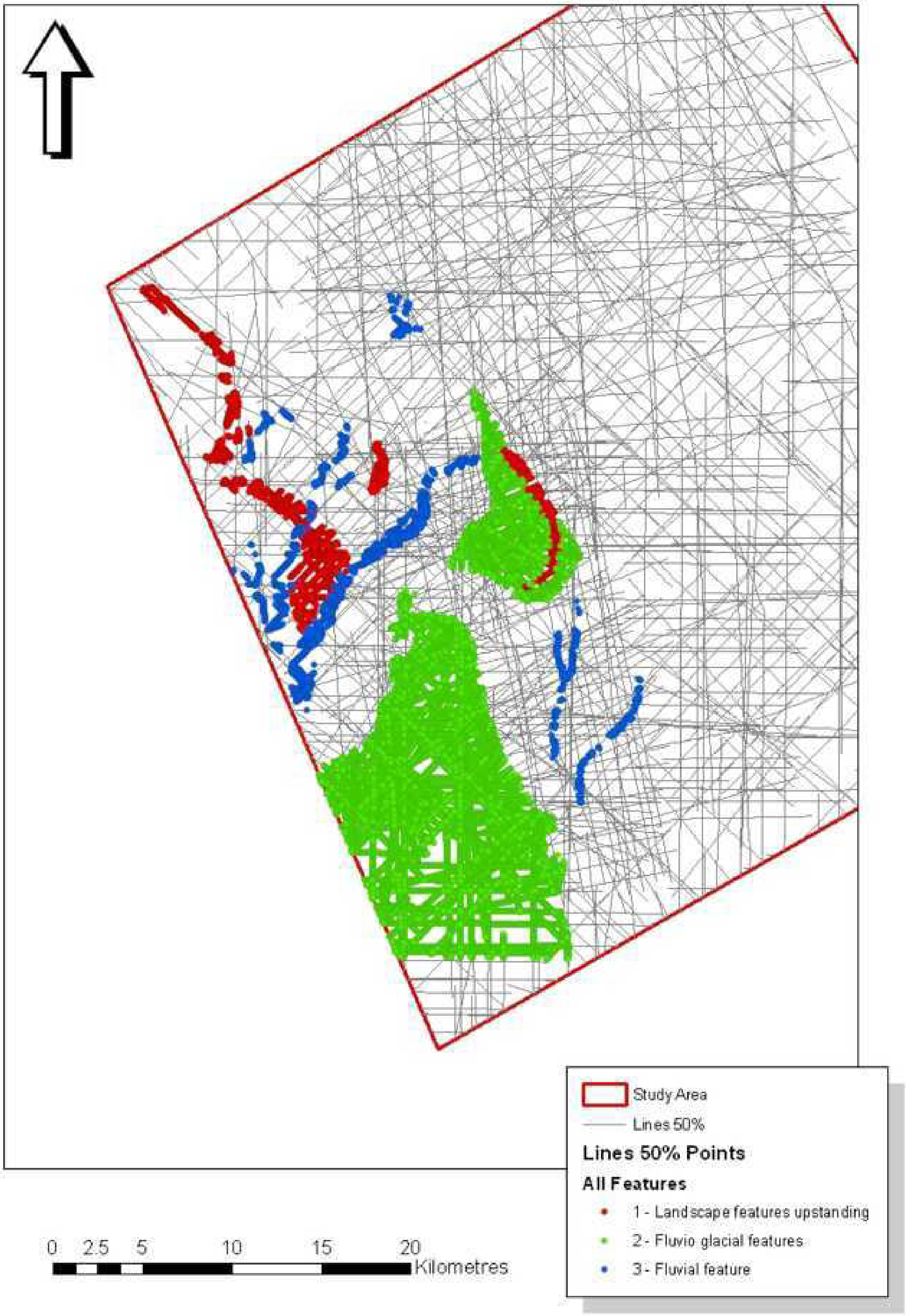

Figure 23: Intersection of features using the sub-samples of 50% of lines

5.5 Modelling the impact of data availability in comparative west coast areas

5.5.1 For comparative purposes, four additional areas were selected for further analysis. Choice of sample areas was based solely on visual identification of concentrations of lines around the western coast (Figure 24). These included:

1 Part of original pilot study srea
2 The Welsh sector of the Irish Sea
3 The Welsh sector - Cardigan Bay
4 The Scottish sector of the Irish Sea
5 The Bristol Channel

5.5.2 The coverage of the lines within these areas ranged from relatively uniform to clustered. A polygon shapefile was created over the known features (Area 1) and then copied to various locations within the overall area covered by the 2D line shapefile. The lines within each of these areas were then exported and placed over the identified features (Figures 25 to 28), and a 50m point shapefile was created for each.

5.5.3 The line density for the additional areas was calculated and is presented in the table below.

Area Number	Line Density (%)
1 (Part of original pilot study area)	1.16
2 (Welsh sector of the Irish Sea)	0.95
3 (Welsh sector - Cardigan Bay)	0.21
4 (Scottish sector of the Irish Sea)	0.23
5 (Bristol Channel)	0.18

Table 2: Additional areas with line density

5.5.4 A grid was then generated over the whole 2D line shapefile in order to map areas where the line density was potentially suitable for sub-sampling and areas where all lines should be included in an analysis.

5.5.5 A total of 748 grid squares each measuring 10km x 10km was created covering the 2D line shapefile (Figure 29). The line density within each grid square was calculated as a percentage (line length to area), and added to the grid square polygon as an attribute (Figure 30). Two further images were created to show the percentage of lines in each grid square needed to be included in any analysis to ensure a maximum line density of 0.5% and 0.2% respectively (Figures 31 and 32).

5.5.6 This suggests that if a research project within these other areas were solely reliant upon 2D data for mapping purposes then, in some circumstances, it might be necessary to acquire all available datasets to achieve a reasonable level of line coverage that would guarantee results comparable to those provided by this pilot project. In such circumstances acquiring supporting data sets would be essential. For example, ALSF funded REC data (held by the BGS) is available in the Bristol Channel. This contains digital 2D seismic profiles that could assist interpretation and line density in this area.

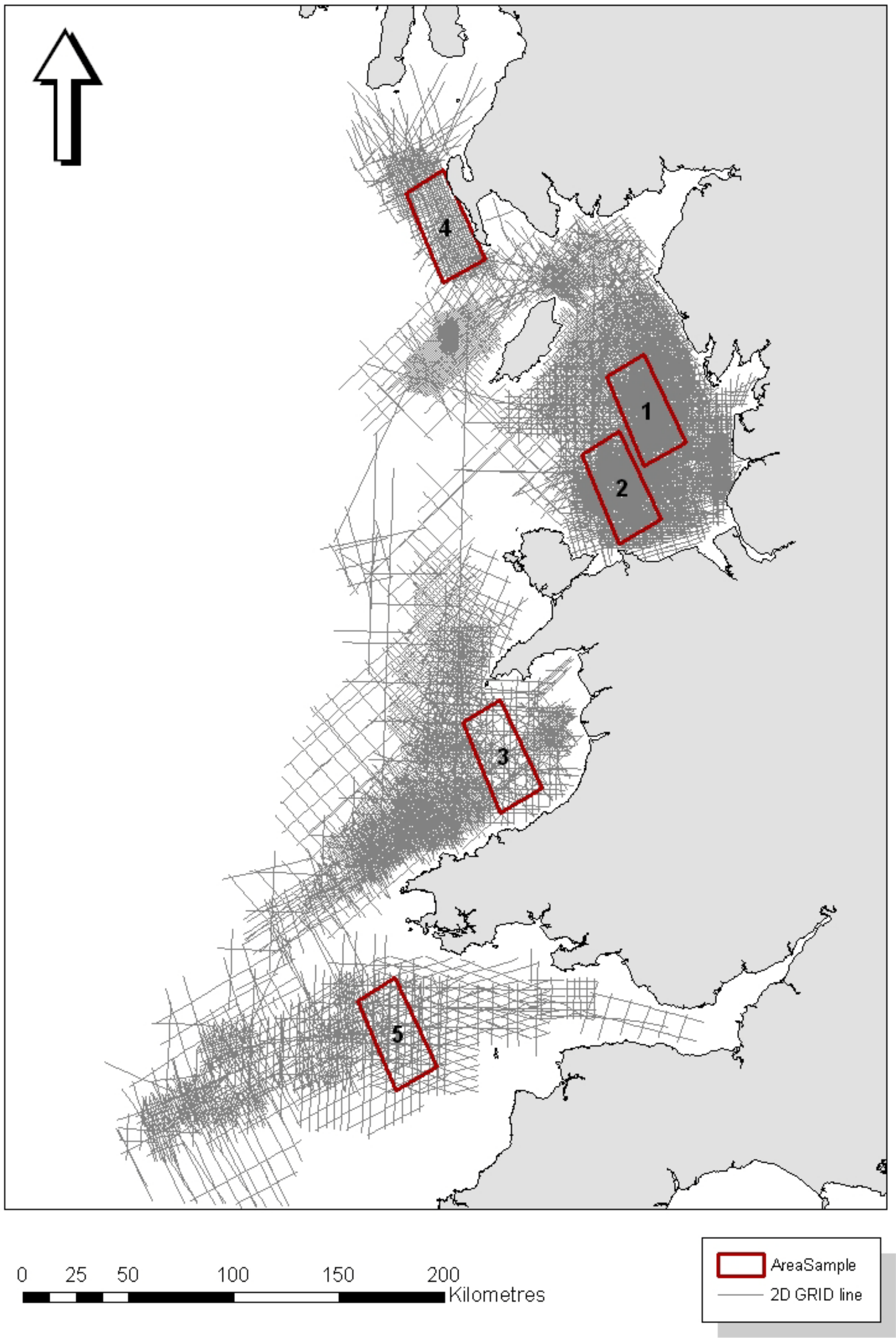

Figure 24: Locations of the selected sample areas of line concentrations around the western coast

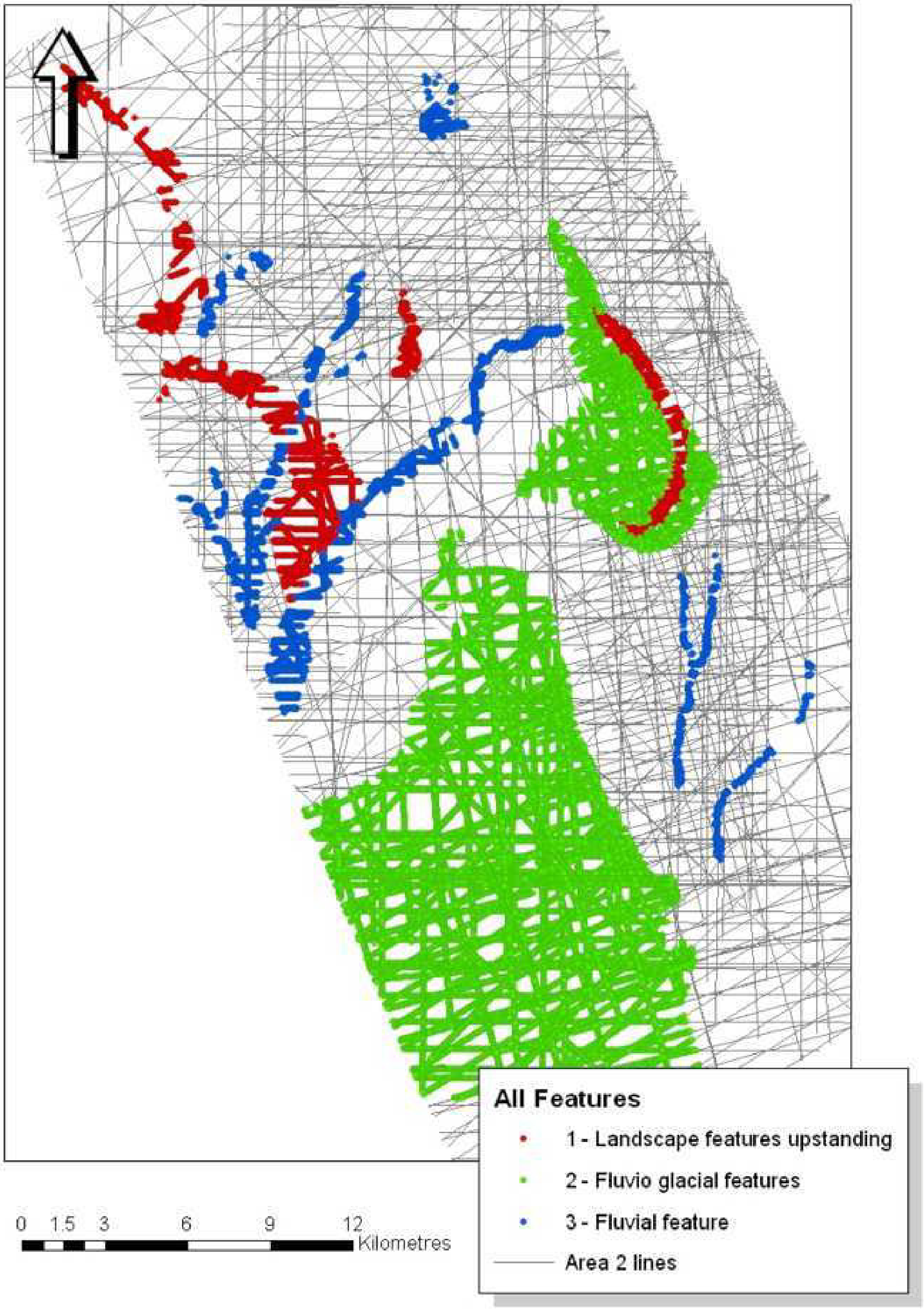

Figure 25: The results of feature location using a line pattern from Area 2. (Utilising a 50m point shapefile)

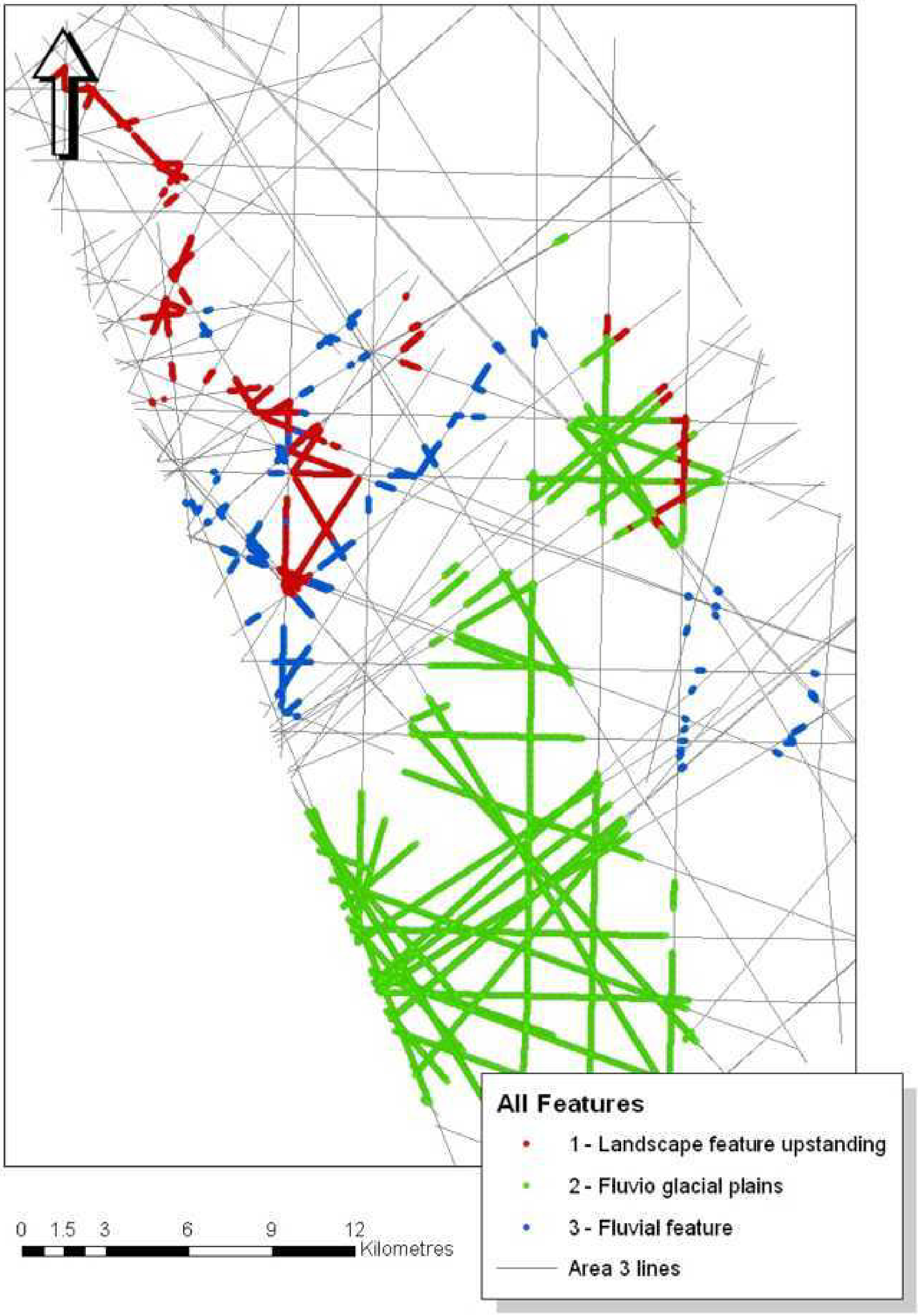

Figure 26: The results of feature location using a line pattern from Area 3. (Utilising a 50m point shapefile)

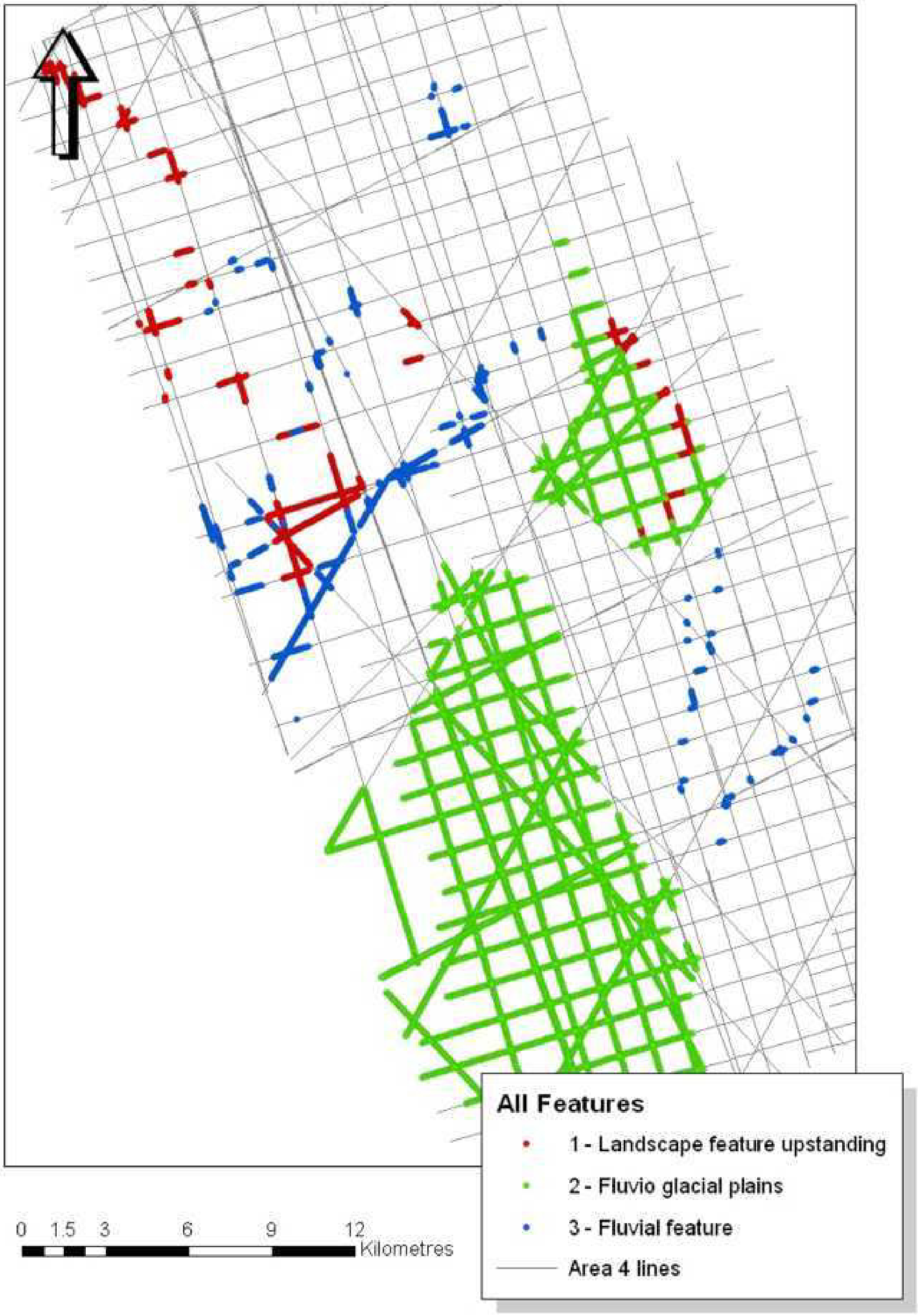

Figure 27: The results of feature location using a line pattern from Area 4. (Utilising a 50m point shapefile)

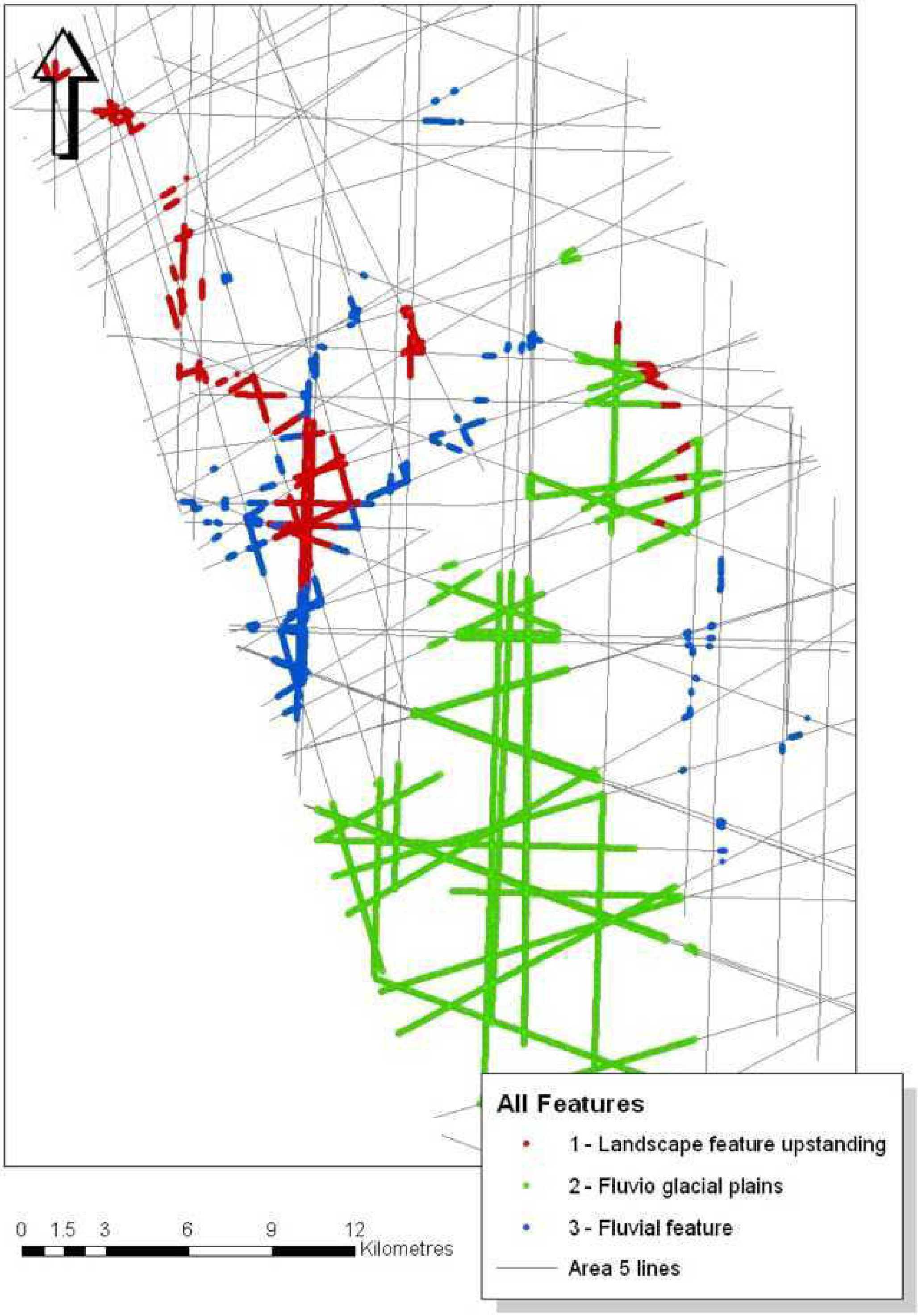

Figure 28: The results of feature location using a line pattern from Area 5. (Utilising a 50m point shapefile)

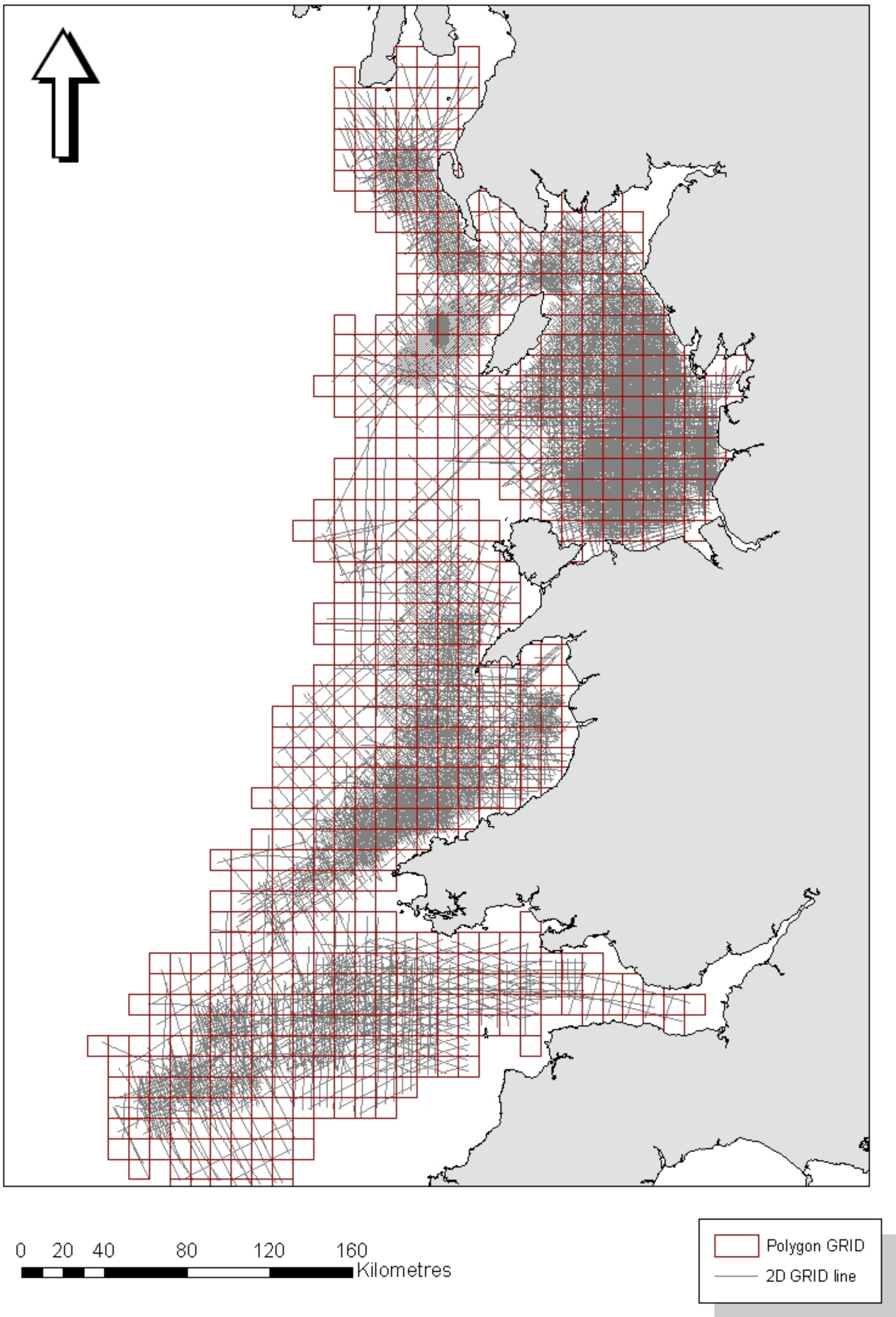

Figure 29: The West Coast as represented by 748 (10km x 10km) grid squares

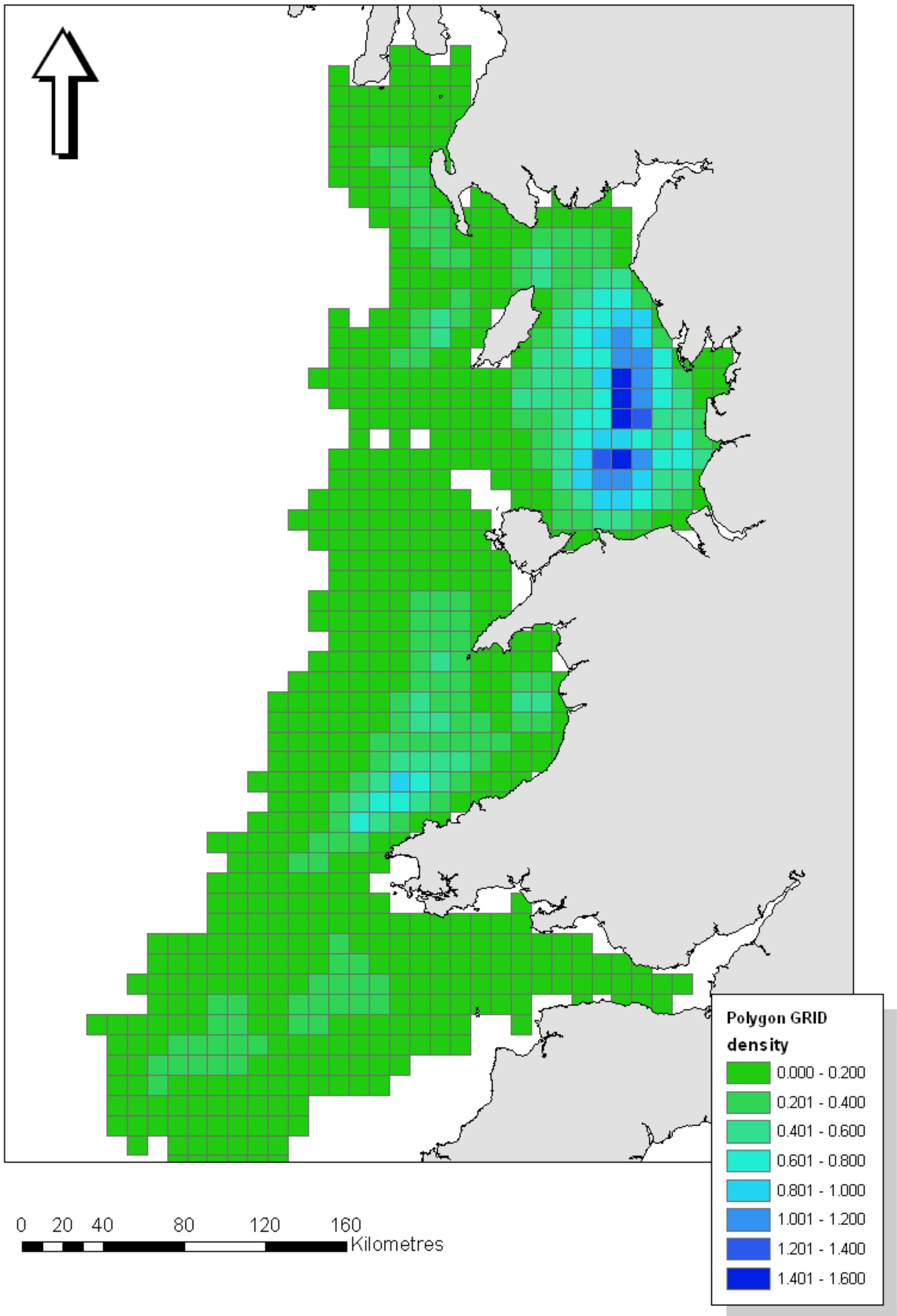

Figure 30: The line density within each grid square (as a percentage)

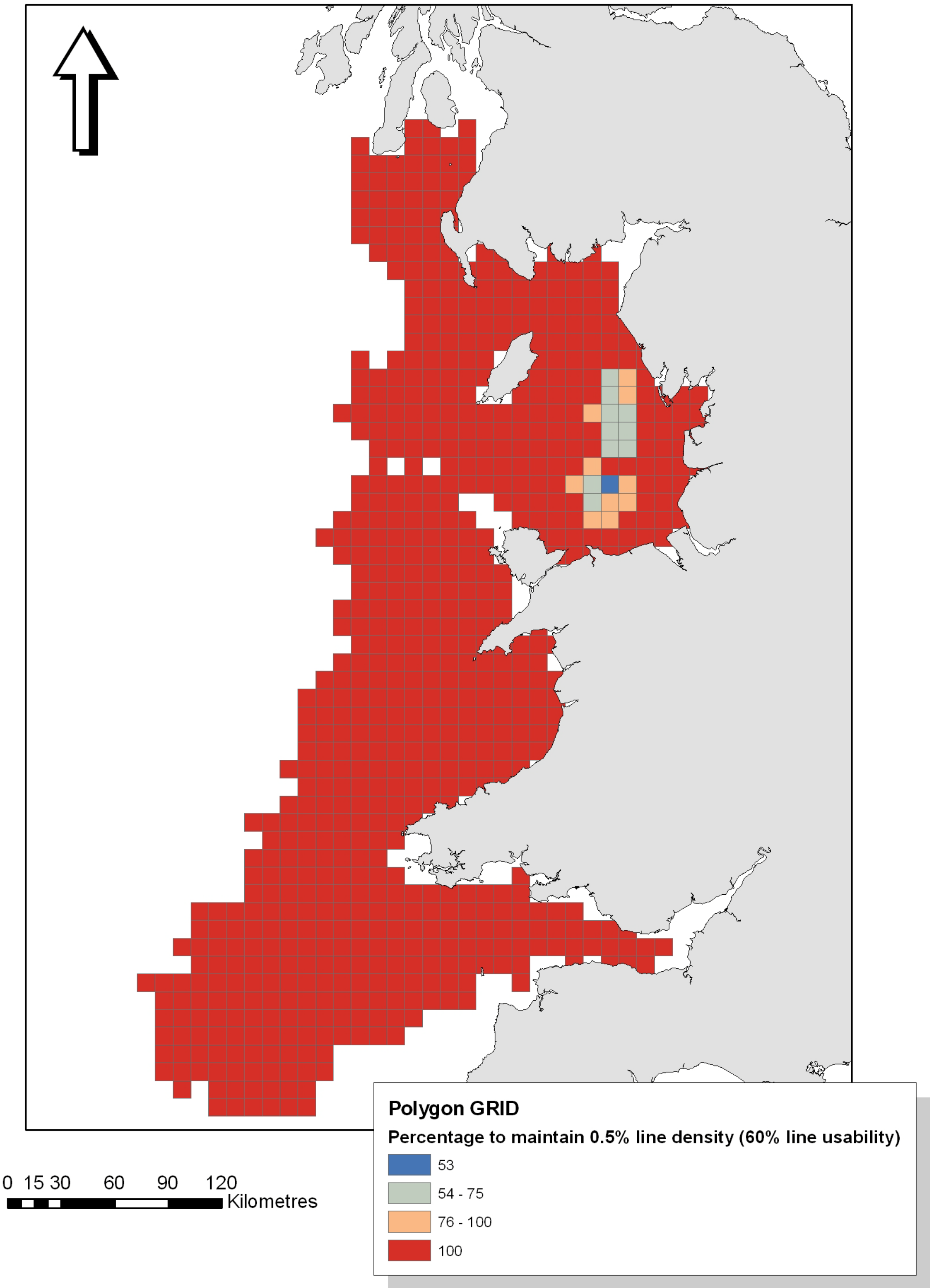

Figure 31: The percentage of lines in each grid square needed to be included in any analysis to ensure a maximum line density of 0.5%, assuming that only 60% of the lines may be useable

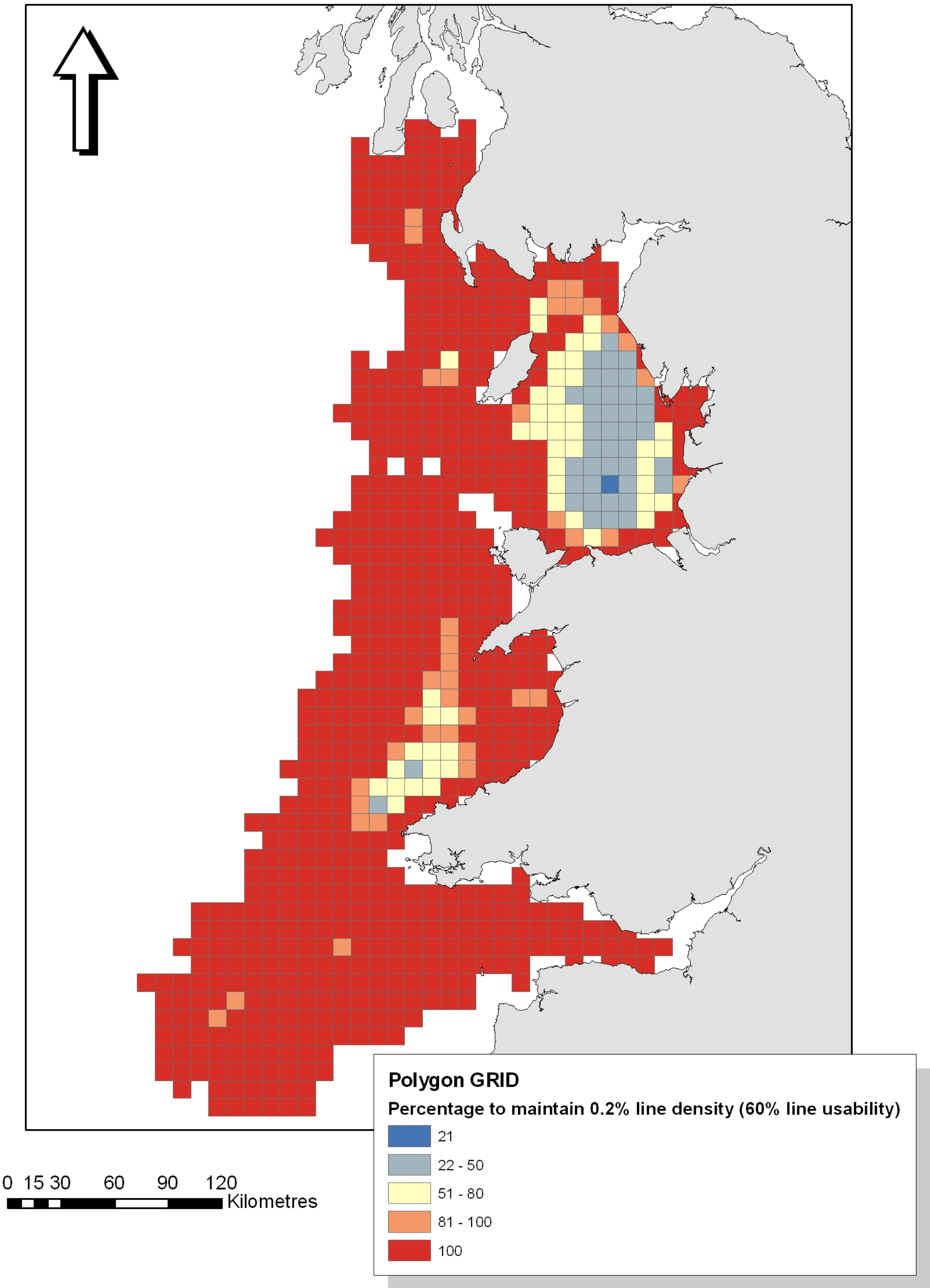

Figure 32: The percentage of lines in each grid square needed to be included in any analysis to ensure a maximum line density of 0.2% assuming that only 60% of the lines may be useable

6. ASSESSMENT OF VIABILITY OF EXTENSIVE RESEARCH PROJECT

6.1 The data provided through this pilot project demonstrates that an extensive project based upon 2D data is indeed possible, although a pragmatic approach may be required in some areas to achieve an appropriate line density if supporting data is not available. However, it is generally true that UK territorial waters may often have been surveyed for a variety of reasons and supporting data is certainly available withinmost of the areas identified for research following this pilot project. It is also important to acknowledge the fact that, for most of the offshore areas of the west coast of England, little or no archaeological baseline data exists with respect to the submerged prehistoric resource. Consequently, any information gleaned by a wider survey would be significant in assisting marine planning and strategy within the region.

6.2 Alongside the critical issue of data availability is the financial consequences of the requirement to purchase large quantities of DTi/BERR stored data. Clearly this will have a major impact upon any larger project and acquisition may well emerge as a major cost. Despite this, the careful selection of data in high line density areas will reduce this impact. Conversely, this means that areas with a low line density will require a greater numbers of lines or access to alternative supporting data sets.

6.3 A minor, but associated project cost, is the requirement to assist the UKOGL with reproduction costs for nearshore data. However, it is important to note that unlike the offshore data store, all data licence and associated costs may be waived.

6.4 It also was apparent from work carried out as part of this project that the available 2D data was of variable quality. However, it may be possible to obtain supplementary datasets to assist in prospection and interpretation. For example, additional 3D datasets are present in the North West of England,

6.5 In conclusion, a wider research project covering other areas of the west coast of England is indeed a viable proposition if expectations are commensurate to the data coverage and appropriate 2D data is made available. If data availability is limited there will be an increased reliance upon supporting data sources, if available. Despite this, in most cases it should still be possible to generate results suitable for planning and management purposes, although available archaeological detail might be reduced.

7. THE LATE PALAEOLITHIC AND MESOLITHIC LANDSCAPE

7.1 Although the resolution of this study is too coarse to identify individual sites or features, it is possible to map landscape features and provide broad topographic information (Gaffney et al 2007, 84). In mapping these landscape features, it is possible to understand the Late Upper Palaeolithic and Early Mesolithic landscape in terms of resources and routes, focal points and barriers, which then aid the identification of areas of high or low archaeological potential. As Mesolithic societies were closely tuned to the economic base, knowledge of this landscape allows us to suggest how the different landscape zones might have been used and where Mesolithic activity took place (ibid.).

7.2 The earliest landscape features identified by this project were the two broad areas of Late Upper Palaeolithic fluvio-glacial plains (Figure 14). These were present beneath palaeo-periglacial outwash and are significant as they were formed by drainage from nearby glaciers, possibly from the Lake District. In human landscape terms, they potentially acted as a barrier to human movement and, as a consequence, suggest a low potential for archaeological remains. However, the identification of a mammoth tusk during monitoring in the Humber region (Wessex Archaeology report to BMAPA 2006) suggests that these areas are not necessarily devoid of archaeological potential.

7.3 The Early Mesolithic was represented within the study area by two large river systems (Figure 33, A), along with several other smaller river systems (Figure 33, B). These have been identified as braided or anastomosed rivers (D or DA classification after Rosgen 1994). These types of rivers provide rich and varied environments with the potential for many different resources including a wide variety of environmental niches and animal and plant resources. As a consequence these represent highly attractive areas for Mesolithic activity.

7.4 Another class of feature identified were several areas of higher ground or upstanding features (Figure 33, C and D). These may well have acted as focal points in the wider landscape or provided opportunities to observe game. These upstanding features are also of importance as they represent areas that would have formed islands during the inundation and possibly the last inhabitable areas within the region. The largest of these upstanding features in particular (Figure 33, D) would have been attractive to past populations due to the proximity of two large river systems, one to the south of the area of higher ground, and one cutting through it (Figure 33, A).

7.5 In addition to the natural resources they may have possessed these river systems form an important component of the wider Mesolithic landscape in terms of movement and communication.

7.6 The identification of these fluvial features is important not only in understanding and mapping the past landscape in terms of past human activity, but also in identifying areas of archaeological potential that may, enhance our knowledge base and understanding of these landscapes and environments further. These river systems have the potential to preserve environmental evidence that supports detailed landscape interpretation as well as proxy traces of human activity.

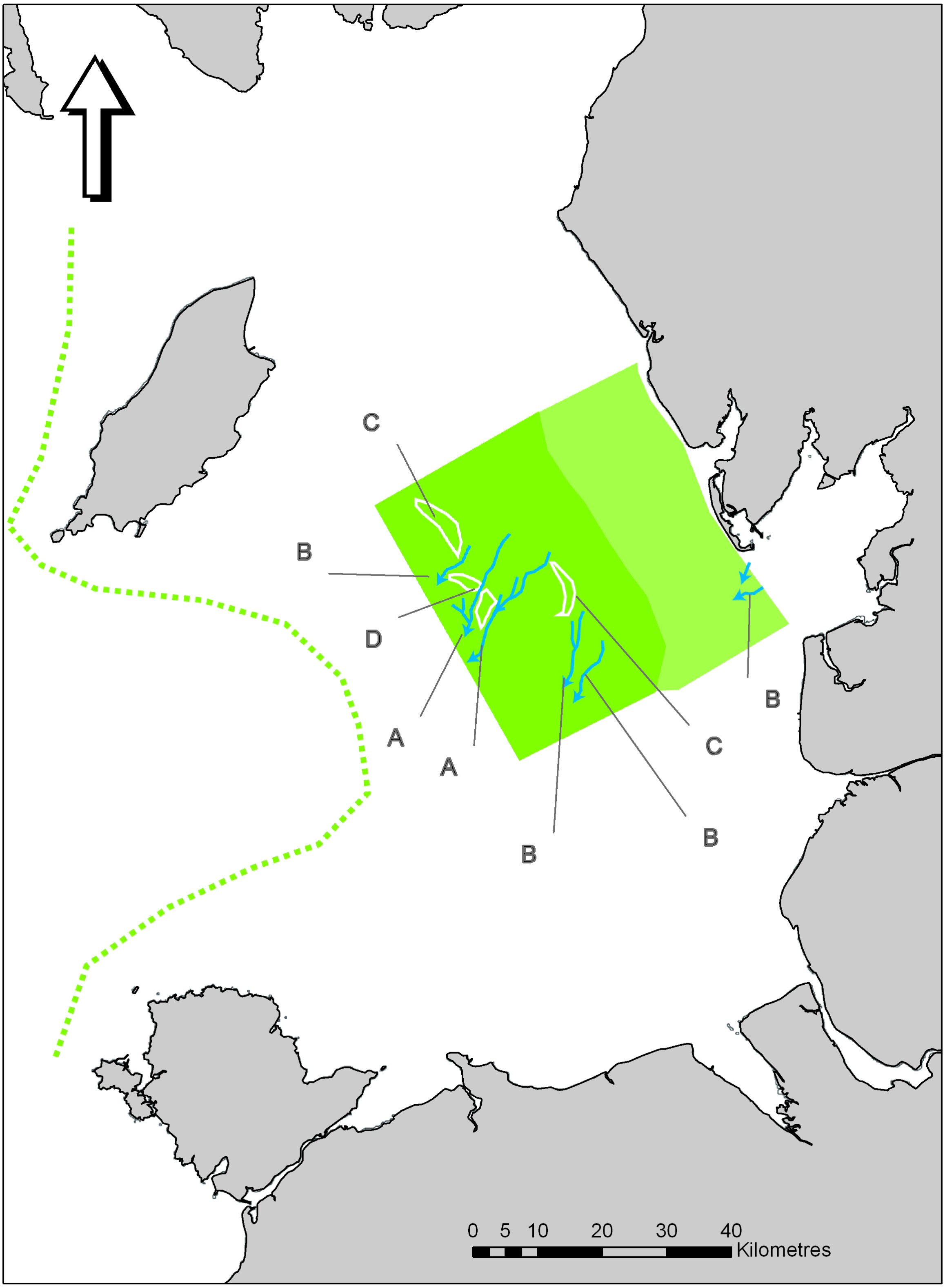

Figure 33: The Early Holocene landscape within the project area. The light green zone reflects nearshore areas which would have represented higher ground, whilst the dark green areas for a lower lying plain.

8. CONCLUSIONS

8.1 This pilot project was carried out to achieve a series of aims. Aim 1 sought *"To develop a methodology for utilising existing 2D and related datasets, where 3D seismic datasets are unavailable".* This pilot project has determined that there exists a considerable archive of 2D data which may be utilised, and that this was amenable to analysis. However, it was also observed that the primary constraint of use of 2D data was ultimately the availability of data for analysis, its spatial coverage and the density of data. Where sufficient 2D data was present, information on landscape features may approach the resolution of that produced by 3D seismic survey. Supporting data, including BGS mapping, was of considerable assistance during the examination of the existing 2D seismic data, and the availability of this and any other relevant data source, including core data, may be required to undertake a larger or comparable project.

8.2 3D seismic data for the study area provided to the project by Centrica Ltd. was utilised to achieve aim 2 *(To refine the existing methodology for 3D datasets)*. It was observed that the 3D seismic data was able to produce pertinent information on the archaeological landscape of the pilot area. The principal contrast with earlier work related to the shallower character of sediments pertaining to the period of interest, the study of which was easily accommodated by the existing methodology.

8.3 Analysis of available data demonstrated that it was possible to identify landscape features that may relate to Late Upper Palaeolithic and Early Mesolithic submerged archaeological landscapes, and support aim 3 *(To use the existing 2D and 3D seismic and related datasets for the investigation of the Late Upper Palaeolithic and Mesolithic Landscape).*Several features of landscape significance were identified and recorded within the pilot study area. For the Late Upper Palaeolithic these were fluvio-glacial plains. The Early Mesolithic was represented by braided river systems.

8.4 Aim 4 sought "To utilise the results of Aims 1 to 3 to assess the viability of an extensive future project". Analysis of the data within the project area and separate sample areas indicated that such a project was possible, but that data acquisition costs and/or data availability might limit outputs and that expectations of such work should be appropriate to the availability of data and supporting resources.

8.5 In conclusion, this project suggests that it is possible to reuse existing 2D datasets to provide information that will assist marine planning in the region and, further heritage protection goals.

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10. APPENDIX 1 - BERR data library price list

DEPARTMENT OF ENERGY & CLIMATE CHANGE

PRICE LIST FOR RELEASED OFFSHORE UK 2-D SEISMIC DATA

(Revised Price List issued February 2008)

2D Seismic Data Compilations -

Seismic data should be ordered via the DEAL web-site www.ukdeal.co.uk
The lines ordered will be compiled by Phoenix and delivered to the customer in the format(s) requested. The customer's right to use the data is restricted and is in the form of a Sub-Licence, a copy of which is available on request.

Sub-Licence Fees and other charges

Basic charge (Sub-Licence Fee) £0.55 per km

This fee includes the provision of scanned images of the selected data

In addition, there is a handling charge per tube of original data of £50.00 per tube (see note below)

Output formats

In addition to the charges outlined above (which include a copy of the scanned images) the customer can also choose additional output options as required.

	£/km
rolled paper print	0.25
SEG-Y file digitised from the film original	3.10

Location data is supplied and charged for according to the time taken to collate the relevant data. Typical charges range from £25.00 to £75.00 depending on the size and complexity of the order.

Minimum order: 50 line km of data. No part-lines may be ordered.

Postage/packing at cost. All prices exclude VAT.

Note: The tube handling charge relates to the way the data are currently archived. The data are stored, by the DTI, in tubes each containing approximately 30 to 40 sections (often this will be one survey). When data are requested the contents of the entire tube are requested, scanned and archived thus preventing unnecessary wear and tear on the originals. In this way staff costs in repeatedly retrieving, selecting and replacing data are also being reduced to a minimum and an electronic version of the DTI seismic archive is being gradually built up. The tube handling charge helps to cover the cost of fulfilling orders for part surveys.

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