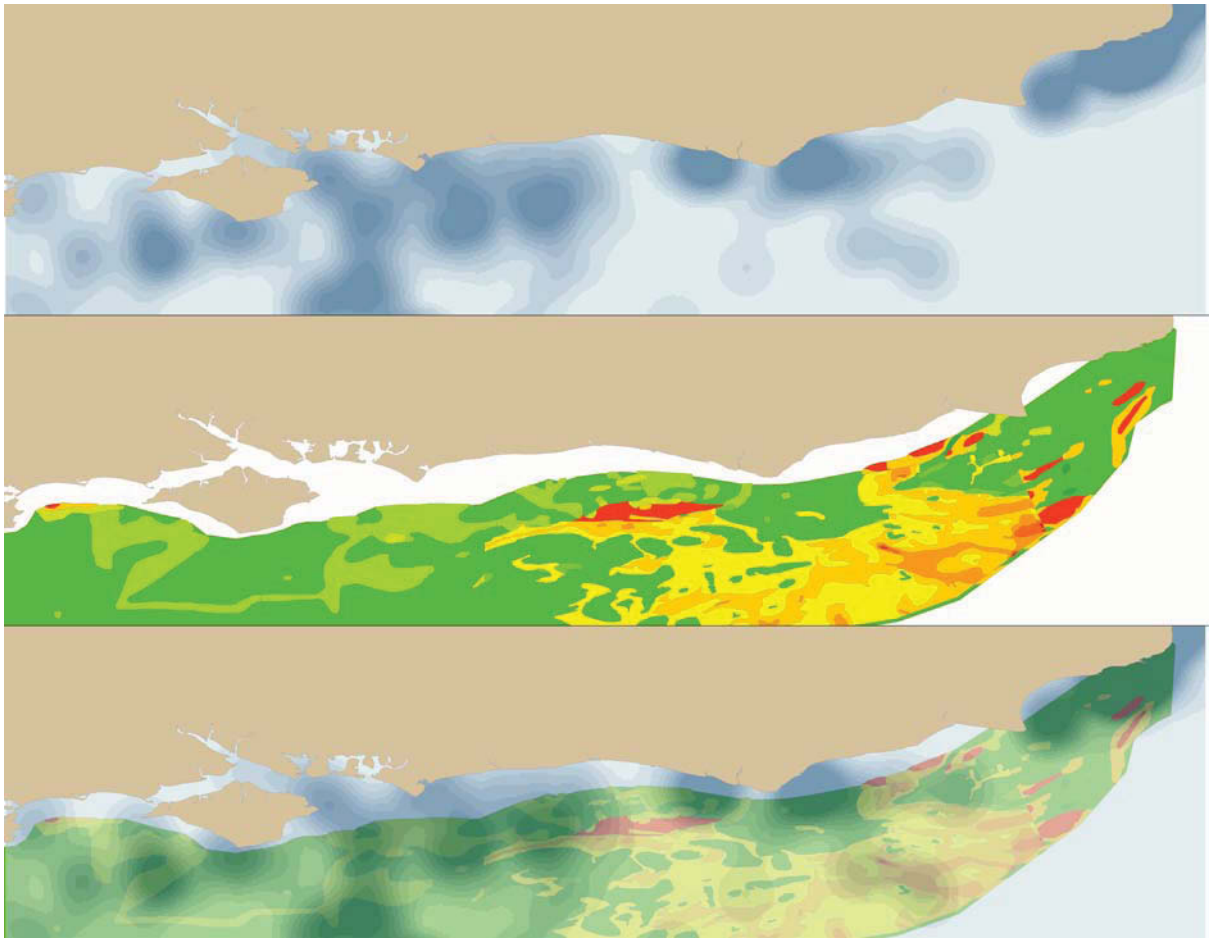
Refining Areas of Maritime Archaeological Potential for Shipwrecks - AMAP 1

PROJECT REPORT 1.1
February 2008



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1 BACKGROUND

1.1. Specification

1.1.1 In May 2007, English Heritage commissioned Bournemouth University to undertake a project entitled *Refining Areas of Maritime Archaeological Potential for Shipwrecks – AMAP1* funded by the Aggregate Levy Sustainability Fund (ALSF). The aim of the project is to undertake quantitative spatial analysis of shipwreck data using GIS to compare typologised wreck scatters to environmental, historical and hydrographic datasets in order to identify biases in the data and refine areas identified as AMAPs during the *Navigational Hazards* project.

1.1.2 The project seeks to advance the aims of the ALSF by improving the interpretation of archaeological potential on the seabed in order to assist industry, regulators and curators in giving guidance on the marine historic environment during marine planning.

1.1.3 Refining the basis for the assessment of archaeological potential on the seabed will improve the regulation of dredging for sand and gravel by enabling a more justified and better informed statement of archaeological potential for impact assessments.

1.1.4 Feedback has been sought from stakeholders throughout the project via steering group meetings and continuing collaboration to ensure that the output of the project meets the needs of the marine industry as a whole. Following discussions with the Crown Estate, BMAPA and English Heritage, it was agreed that the GIS output would provide a "justified characterization" of the marine environment and the potential for shipwrecks to survive in seabed sediments. The aim will be to enable statements on potential to be better justified during archaeological assessments.

1.1.5 The geographical areas chosen as a study area for developing the project methodology included those waters adjacent to the coast of England from the mean low water mark to the median line that demarcates the Eastern English Channel running out from the Wight-Cotentin axis to the entrance to the Dover Straits (Map1).

1.1.6 The deliverables for the AMAP1 project comprise a Geographic Information System (GIS) layer, a report for the Shipwreck Data Review and a written final report to be supplied to the English Heritage (EH) Maritime Team, and to the National Monuments Record (NMR) for integration with the English Heritage archive.

1.1. Background

1.1.1. *Areas of Maritime Archaeological Potential* (AMAP) are areas were it is considered that the navigational (i.e. reefs or sandbanks) or environmental conditions (i.e. tidal races or overfalls) present in the area are likely to have caused shipping loss in the past and where the seabed conditions are such that preservation of archaeological material is thought to be likely.

1.1.2. The *AMAP 1* project proposes to build on the results of the ALSF *Navigational Hazards project*, aiming to produce an interpretative GIS layer for use in marine planning, which uses statistical and spatial analysis of shipwreck data to identify and characterise the relationships between known wrecks and the archaeological and environmental parameters which affect their preservation, in order to assess the potential for archaeological remains of shipwrecks within seabed sediments.

1.1.3. The *Navigational Hazards* project was an ALSF-funded project completed in January 2007 which identified Areas of Maritime Archaeological Potential (AMAPs) through the identification of areas where the potential for ships to be lost due to natural navigational hazards coincides with the potential for archaeological materials to survive, based on percentage content of gravel in seabed sediments.

1.1.4. The project highlighted the need for further variables, such as seabed stability, sediment depth, the nature of localized contemporary maritime activities and their relationship with shipwreck data, which affect the potential for vessels to be lost and to survive on the seabed. The AMAP1 project proposes to enhance the results of the Hazards project by integrating the quantative analysis of additional marine datasets with the current environmental characterization produced for the *Navigational Hazards* project.

1.1.5. The results of the project and GIS output will play a determining role in developing an effective planning tool for assessing the potential for unrecorded shipwreck remains on the seabed, which will prove crucial to developing a firm basis for a national dataset for AMAPs, vital for developing standards for impact assessment and improving heritage management during the marine spatial planning process. The results have suggested that relationships can be characterised between shipwrecks and their environment, demonstrating the value of using wreck data to verify and even further inform environmental characterizations. The project has also demonstrated a great deal of scope for further developing this area of research, by focusing on the following issues:

- enhancement of environmental characterization through collation of further data
- enhancement of wreck data for other sea areas
- testing and enhancement of method over other sea areas
- Integration of temporal aspect of marine environmental characterization to take into account changes in the marine environment

1.1.6. The project has been undertaken by Bournemouth University with the collaboration and expertise of Dr Graeme Earle and Dr Fraser Sturt from Southampton University, and Dr. David Gregory from the National Museum of Denmark. In addition, key collaborative support has been provided by *Seazone Solutions Ltd.* in resolving issues raised during the Shipwreck Data Review and providing advice on the long term methodological approach to restructuring UKHO shipwreck data attribute fields.

1.2. Applications of the project to Marine Planning

1.2.1. The demands of marine spatial planning and localized impact assessments have highlighted the need for a quantative approach to assessing maritime archaeological

potential. Current assessments of archaeological potential for environmental impact assessments (EIA) rely on the qualitative interpretation of known and reported archaeological ship losses. However it is recognized that the recording of shipwreck data is inherently biased by the requirements of hydrographic survey and industrial offshore and coastal development (Merritt, 2007b).

1.2.2. The trends in the presence of shipwrecks on the seabed and their in situ preservation are dependant on a wide range of variables. The nature of the marine environment dictates (1) the level of risk to shipping, (2) the potential for organic and non-organic archaeological materials to survive on the seabed. Records of known shipwrecks, reported losses and marine obstructions currently provide developers, contractors and curators with one of the core datasets on which planning decisions and the assessment of potential impacts of offshore developments are primarily based

1.2.3. The pilot studies undertaken for the development of the *Seacapes Maritime Historical Landscape Characterisations* have made great progress in enhancing the accessibility of historical data for marine and coastal planning, through the characterization of the historical human environment and have tackled the characterization of archaeological potential for sea areas through the interpretation of historical human activities. The results of the *Solent Seascapes* project undertaken by the Hampshire & Wight Trust for Maritime Archaeology, Southampton University and Bournemouth University highlighted the limitations of making qualitative assessments and the need for a methodology for modeling marine environmental data to improve the interpretation of the unquantified archaeological resource (Satchell et Al, 2007).

1.2.4. Besides the records of known and reported shipwrecks, there is currently little basis on which to make an informed interpretation of the potential for archaeological remains to exist on the seabed in advance of geophysical and geotechnical investigations. Time needed to collate the environmental data required to make such interpretations and the expertise required to process and interpret the data restrict the current level to which archaeological potential is being interpreted during preliminary desk-based assessments.

1.2.5. The development of a broad characterization of the environmental variables which affect the potential for archaeological materials to survive and the current trends in known wreck data will provide an accessible tool for archaeologists to better understand the wreck data they have available to them in the context of their surrounding environment, enabling them to better justify the interpretation they make for the potential for further archaeological material to be present.

1.2.6. The output of the AMAP project aims to be used alongside Marine Historical Landscape Characterisations to provide an archaeological context in which to better understand available baseline archaeological data during national, regional and localised archaeological assessments.

1.2.7. The *Marine Aggregate Dredging and the Historic Environment: Guidance Note* (BMAPA and English Heritage 2003) was produced in 2003 through a collaboration between English Heritage and BMAPA to provide stakeholders including developers, regulators, consultants and heritage professionals with a well-defined approach and

clear statement of policy with respect to marine archaeology and marine aggregate. The guidance note states that, "*The non-energy mineral rights to the seabed are vested in the Crown Estate. At present, licenses to carry out aggregate dredging are only granted by the Crown if the application receives consent from the Government through an informal 'Government View' procedure, administered by the Office of the Deputy Prime Minister (ODPM). Since 1989, every new application has had to be accompanied by an Environmental Impact Assessment (EIA)*." The archaeological assessment for EIA equates with the process of 'desk-based assessment' generally applied to development-related archaeology. In the guidance note a desk-based assessment was defined as follows (IFA 1999):

> *"Desk-based assessment is a programme of assessment of the known or potential archaeological resource within a specified area or site on land, inter-tidal zone or underwater. It consists of a collation of existing written, graphic, photographic and electronic information in order to identify the likely character, extent, quality and worth of the known or potential archaeological resource in a local, regional, national or international context as appropriate."*

1.2.8. The AMAP project output is designed to enhance the desk-based assessments of archaeological potential during EIAs as part of the licensing of aggregate extraction areas. The results therefore seek to complement the aggregate industry's current approach to heritage management.

1.2.9. The commissioning of Wessex Archaeology to undertake the *BMAPA Protocol for Reporting Finds of Archaeological Interest* (Wessex Archaeology, 2005) represented the next positive step by the aggregates industry to increase public awareness of the marine historic environment and the role of the marine aggregates industry in its management, by encouraging the recording of finds identified during dredging activities. The results of find reports may in the long-term provide a valuable source of data for testing the AMAP results in future phases of the project.

2. AIMS AND OBJECTIVES

2.1. Project Aim

2.1.1. The aim of the project is to undertake a pilot project to develop a methodology with a view to refining the assessment of Areas of Maritime Archaeological Potential (AMAP) made during the *Navigational Hazards* project. This has been undertaken using quantative spatial analysis of shipwreck data using GIS to compare typologised wreck scatters to environmental, historical and hydrographic datasets in order to further characterize and refine areas identified as AMAPs during the *Navigational Hazards* project. The results have been summized as an environmental characterization of the marine zone using available digital data.

2.1.2. The aim of the method development phase of the AMAP1 project is to develop a GIS which provides a basis for making a more justified interpretation of the potential for unrecorded shipwreck remains within seabed sediments during the marine planning process. The pilot study was undertaken with a view to further test the results by applying the method to other marine areas as part of future AMAP projects.

2.1.3. A Shipwreck data review was undertaken during the initial phase of the project to identify potential constraints to the project methodology created by inconsistencies and constraints in current wreck database structures specifically affecting their application to GIS. The results will be used to inform the broader scale review and enhancement of the AMIE shipwreck database structure to be undertaken for English Heritage in 2008 (*Pers. Comm.* V. Dellino-Musgrave).

2.1.4. The project also aims to produce a methodology which is repeatable to enable it to be easily updated and applied to other assessments of archaeological potential in the future.

2.2. Project Objectives

2.3.1. The main aim of the project has been met by:

(1) Integrating UKHO wreck data and NMR AMIE records of known ship losses to identify and quantify contrasts. Identify matching records, biases in data and make recommendations on updating and refining AMIE records to enhance their application using GIS.
(2) Producing the Shipwreck Data Review Report
(3) Restructure and querying of shipwreck data to identify key trends
(4) Integrating the model for potential for preservation of archaeological materials based on grain size with the results sediment depth analysis and sediment erosion modeling produced by Southampton University – Environmental character
(5) Integrating the assessment of potential for ship losses with an assessment of the significance of shipwreck scatters in the context of data relating to shipwreck biases and nodes of focused maritime activity – Historical Character
(6) Comparing the results in order to identify a refined set of AMAPs along with potential areas for further research
(7) Producing a final project report

2.3. Project Deliverables

2.3.1. The deliverables for the project are as follows:

- Report – Shipwreck Data Review, to be delivered to English Heritage
- Report – Final Report, to be delivered to English Heritage
- Project GIS to be delivered to English Heritage
- Project archive to be delivered to English Heritage
- Project archive to be delivered in digital format to Archaeological Data Services (ADS) for the ALSF *Dissemination on the Web* project

3. METHODOLOGY

3.1. Data Collation

3.1.1. The AMAP project focuses on using available digital data to improve our understanding of archaeological potential.

3.1.2. The project has sought to integrate a combination of shipwreck data, environmental data an historical data as in the development of a methodology for AMAPs:

- Shipwreck Data:
    - UKHO wrecks and obstructions
    - NMR wrecks

- Environmental Data:
    - Bathymetry
    - Seabed sediments
    - Marine Bedrock deposits
    - Borehole data
    - Hydrographic Survey metadata
    - Sediment Transport

- Historical Data:
    - Navigational Hazards
    - Documentary evidence of historical port and harbour activities

3.1.3. The data was collated from a wide range of suppliers, often in different formats, highlighting some of the challenges of collating digital marine data. The data collation process is described below.

3.2. Shipwreck Data

3.2.1. The data for known shipwrecks was requested from the UKHO and NMR during the first phase of the AMAP1 project (Map 2a &2b). The data was reviewed as part of the Shipwreck Data Review and a report was submitted to English Heritage in August 2007 to meet Deliverable 1 of the project.

3.2.2. In order to put the results of the spatial analysis of shipwreck data into context, it was necessary to gain a comprehensive understanding of the constraints of available digital shipwreck data. A review of the data held by the UK Hydrographic Office (UKHO) and the National Monument Record (NMR) was therefore undertaken to identify user constraints in combining the data into a single dataset and querying information. The NMR wreck dataset is held in its Archive Monuments Information England (AMIE) in the form of an Oracle database and a Geographical Information System (GIS) depiction. The results informed both the AMAP1 project and proposed English Heritage project to enhance the AMIE shipwreck database.

3.2.3. Wreck data has been gathered to enable density queries to be run reflecting trends in the state of wrecks on the seabed, the material they are constructed from and the manner in which they were lost. These trends can then be compared with the environmental and historical circumstances which are anticipated to affect the way in which wrecks degrade and are buried.

United Kingdom Hydrographic Office (UKHO) Shipwreck Data

3.2.4. The United Kingdom Hydrographic Office holds a database of shipwrecks, containing accurate co-ordinates for each site, site name and date where known, site description, survey history, information of wreck state and scatter. The data is distributed in digital format through *Seazone Solutions Ltd*.

3.2.5. UKHO shipwreck an obstruction data was ordered from *Seazone Solutions Ltd.* distributors of digital UKHO data. This included the Hydrospatial Wrecks and Obstructions layers and the wrecks and obstructions database upgrade. Both datasets were requested by sending in an ArcGIS shapefile containing a polygon for the project study area, which encompasses all of the Eastern English Channel.

3.2.6. In order to receive the full set of attributes provided by the UKHO, an upgrade database for the wrecks and obstructions data was provided in addition to the Hydrospatial dataset. The wrecks and obstructions upgrade contains a layer identical to the Hydrospatial wrecks layer and a second layer containing the wrecks and obstructions data in the form it was provided in before the Hydrospatial format was created.

3.2.7. The database upgrade is divided between a wrecks layer and a total unrestricted feature layer. The unrestricted data layer is the only dataset delivered which contains the UKHO identifiers (HOID). This was therefore the layer used to join the UKHO and NMR shipwreck records.

3.2.8. The data was delivered as part of a series of the Seazone Hydrospatial dataset. The data is provided in multiple formats to accommodate all leading GIS packages including MapInfo, Cadcorps and ArcGIS. The ArcGIS compatible data was divided into a series of shapefiles accompanied by an .mxd file for ease of use, which enables the data to be immediately viewed.

3.2.9. The data is provided unprojected and referenced to the WGS84 horizontal datum, which is an internationally recognized global reference system for marine data

3.2.10. The conversion table which enables the UKHO and NMR shipwreck data to be joined together was produced by the UKHO and delivered via Seazone Solutions Ltd. In the form of a MS excel spreadsheet. The spreadsheet contains the old identifiers used by the UKHO (field name: HYDROGRAPH) and their equivalent identifiers used in the current system (field name: HOID) although the fields had not been named.

National Monument Record (NMR) Shipwreck Data

3.2.11. NMR records of known ship losses are available either as individual paper records or in a digital format from the National Monument Record office. The NMR was contacted to request all known shipwreck records from the AMIE database in a digital format due to the nature of the project and extent of the study area.

3.2.12. For the purpose of the AMAP1 project the AMIE shipwreck data was delivered as two shapefiles, one for point data and the other for polygons, accompanied by five additional MS Excel spreadsheet containing additional fields. These require varying degrees of processing depending on the fields required for integration within the GIS.

3.2.13. Each of the files delivered is described in the table below:

File Name	Description	Fields
AMAP Refined_AMIEMonumentPoint.shp	Contains mapped records of known shipwreck data	HOB_UID, Name, Description, Mon_precis, Capture_sc, Easting, Northing
AMAP Refined_AMIEMonumentPolygon.shp	Contains mapped records of known shipwreck data	HOB_UID, Name, Description, Mon_precis, Capture_sc, Easting, Northing
AMAP Core Digital Data.xls	Contains the unique identifier (UID), name (where known) and eastings and northings, enabling the core point data to be plotted, along with the text description and location details	UID, NMR number, summary, 100km, Easting, Northing, County, District, Parish, Primary Name
AMAP Phase_Class Data.xls	Contains details of each site's period where known along with feature type classifications.	HOB_UID, Period, Min_date, Max_date, Class scheme, Term
AMAP Condition Status Data.xls	Contains data on the nature of the evidence on which the record is based and whether it lies in the intertidal, marine or terrestrial zone	UID, Condition scheme, Status
AMAP Other Identifier Data.xls	Contains the identifiers for other records of the same site including the old UKHO identifiers	HOB_UID, Identity method, Value
wreck_numbers.xls	Table provided by the UKHO to the NMR. Contains the old and current UKHO identifiers	No field names

Table 1: Description of contents of AMIE records delivered for the AMAP1 project

3.2.14. The GIS data provided contains the core data required to plot each of the features recorded in the database. In order to view information such as the name of the wrecks (where known), the data held within the associated MS Excel files need to be joined to the shapefiles where possible using the unique identifiers for each record. These identifiers are labeled as either HOB_UID or UID.

Shipwreck Data Processing

3.2.15. A review of shipwreck data was undertaken at the start of the project to identify potential constraints to the project methodology created by inconsistencies in current wreck database structures specifically affecting their application to GIS. The results were used to identify possible constraints for the AMAP project resulting from conflicts between the AMIE and UKHO shipwreck database structures, and to inform the broader scale review and enhancement of the AMIE shipwreck database to be undertaken internally by English Heritage in 2008 (*Pers. Comm.* V. Dellino-Musgrave)

3.2.16. The results of the review identified fields within the two databases which contained comparable data (Table 1). These results guided the design of SQL attribute queries for extracting key words reflecting the state of wrecks on the seabed and their manner of loss.

Description	**UKHO Field name**	**NMR field name**
Site Location Datasets	Lat/long co-ordinates	Easting and Northing co-ordinates County Parish Land Use
Wreck Name	SZ Label Name	Name Primary Name
Description of Remains	Wreck Category Contact Description Type of Obstruction General Comments	Summary Description Evidence
Site Status	Status	Area Status
Period	Date_sank	Period Max date Min date Dating method

Table 2: Table showing fields within UKHO and NMR attributes with contain equivalent types of data which contain comparable data

3.2.17. A classification of terms was developed for describing the data extracted from text fields. Data on the cause of loss often described multiple events leading to the loss of the vessel. The manner of loss was therefore described in two new fields, one describing the primary cause of loss (LOSS_TY1) and the other describing secondary activities (LOSS_ACT2) which may affect the presence and state of a wreck on the seabed. New fields were also created to describe wrecks' condition, burial, orientation or scour on the seabed. The classifications used are described in Table 2.

LOSS_TY1	LOSS_ACT2	CONDITION	BURIAL	ORIENTATION	SCOUR
collision	abandonment	intact	exposed	upright	yes
Grounding	capsize	mainly intact	partly buried	inverted	no
explosive charge	drifting	partly broken	partly exposed	on side	
structural failure	salvage	well broken	buried	broken up	
Explosion	capture	debris field			
cargo shift	dispersed				
founder	towing				
fire	refloated				
torpedo					
gunfire					
scuttling					

Table 3: Table showing terms used to guide data extraction from fields within UKHO and NMR attributes for the reclassification of data on the manner of loss and state of wrecks on the seabed

3.2.18. In the broader context of the AMAP1 project, the results of the review highlighted some major constraints within the shipwreck data. The presence of overlapping and potentially conflicting data suggested the need for spatial analysis of wreck data to be undertaken on the two databases separately rather than attempting to summarise the data. However, during the analysis of the data, it was found that as the databases do not both contain the same types of queriable information, queries run on one database could often not be performed on the other.

3.2.19. Queries were therefore run on the largest datasets possible. I some cases information was contained only in one database; for example, the departure and destination data is described in the AMIE database, while information on orientation and burial are held exclusively by the UKHO. In these cases queries were run on the complete dataset for that relevant database. In cases where data was held in both databases, such as information on the manner of loss or condition, queries were run on the joined databases to optimize the number of results.

3.2.20. The contents of attribute fields were reviewed in a sample of wreck records to identify key terms. These terms provided the basis for developing SQL attribute queries to extract the information required for the reclassification of wreck data.

3.2.21. Investigations of the contents of text fields for identifying the manner of loss showed that the order in which key words to be extracted would be difficult to anticipate without extensive checking of the results. Several stages can describe the circumstances leading up to the loss of a vessel. For example, a vessel could be grounded, lost in tow, then salvaged. All of these stages can affect the presence and degradation of the site on the seabed.

3.2.22. The complexity of developing a repeatable process for extracting key terms for the manner of loss of wrecks (Table 3) was felt to be beyond the scope of a pilot project. It is therefore proposed that funding be set aside for future phases of the AMAP1 project to commission *Seazone Solutions Ltd.* to develop a methodology which can be applied to the entire UKHO wreck database. For the purpose of this pilot project,

information on the manner of loss was extracted manually and reclassified to enable vessels lost accidentally to be differentiated from those lost due to military action.

3.3. Environmental Data

Bathymetry & Topography

3.3.1. Marine bathymetric data and coastal elevation data were supplied as part of the Seazone Hydrospatial digital marine dataset. In addition to data provided as depth area polygons and contour polylines, bathymetric data was also provided by *Seazone Solutions Ltd.* in the form of gridded ASCII files.

Superficial Seabed Sediments & Offshore Bedrock Deposits

3.3.2. Seabed sediment data and offshore bedrock deposits were delivered by *Seazone Solutions Ltd.* as part of the Seazone Hydrospatial package. The Natural and Physical feature dataset contains two themes from the British geological Survey (BGS) 1:250 000 scale offshore geological maps including bedrock geology (DigRock250) and sea-bed sediments (DigSBS250).

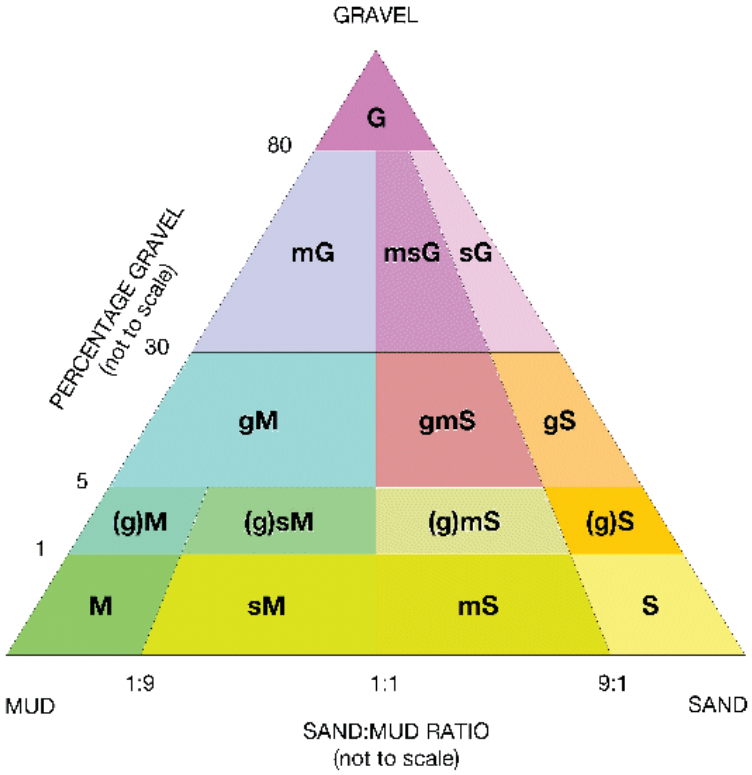
3.3.3. The DigSBS250 map is based on sea-bed grab samples of the top 0.1m, combined with cores and dredge samples as available. A standard Folk triangle classification has been used based on the gravel percentage and the sand to mud ratio (Figure 1).

Borehole Data

3.3.4. The British Geological Survey (BGS) have a national repository for coastal and offshore geological samples including borehole sediment cores and grab sample records. A visit was made to the BGS offices in Keyworth to review and order the sediment data thought to be most relevant to the AMAP project. Vibrocore records were requested in order to collate available records on offshore sediment stratigraphy.

3.3.5. Although a large number of boreholes are held in the BGS archives, access rights have been restricted by the data holder for a high percentage of records. This is generally because the data is considered to be of a commercially sensitive nature. Seventy-two logs were requested from the BGS, fifty-eight of which were taken from the intertidal zone, with only fourteen records available for offshore areas.

3.3.6. The British Ocean Sediment Core Facility (BOSCORF) database based at the National Oceanographic Centre (NOC) was searched using the online search system (http://www.noc.soton.ac.uk/gg/BOSCORF/holdings.html). No records are held for the AMAP1 study area.



M	Mud
sM	Sandy mud
(g)M	Slightly gravelly mud
(g)sM	Slightly gravelly sandy mud
gM	Gravelly mud
S	Sand
mS	Muddy sand
(g)S	Slightly gravelly sand
(g)mS	Slightly gravelly muddy sand
gmS	Gravelly muddy sand
gS	Gravelly sand
G	Gravel
mG	Muddy gravel
msG	Muddy sandy gravel
sG	Sandy gravel

Figure 1: Diagram depicting the R.L. Folk classification (1954) for sediment types used by the BGS

3.3.7. Data was also sought from dredging companies active within the Eastern English Channel. Data was requested for areas classified during the ALSF Navigational Hazards project as having high or very high preservation potential to reduce the sensitivity of the data requested. Little data was however available for this area.

3.3.8. The borehole data received was compiled into a MS Excel spreadsheet listing the depth and character of the sediment type of each stratigraphic layer. The data was then summarized and divided into separate shapefiles by percentage of coarse grain sediment to enable the data to be queried more easily.

3.3.9. All borehole data was delivered to Dr. David Gregory to enable the development of a theoretical reclassification of the preservation character model produced for the Navigational Hazards project. The model was originally based on superficial sediments. The review of the model takes into account sediment stratigraphy by identifying circumstances where changes in sediment type below the seabed surface require a reclassification of the original preservation character.

Seabed Sediment Depth

3.3.10. The need to identify areas where seabed sediments are shallow enough to reduce the potential for archaeological material to be buried was identified during the method development. The data was gathered in order to identify areas where sediment was shallow enough to restrict the potential for archaeological materials to be buried. The collation of accurate and up-to-date sediment depth data however proved difficult.

3.3.11. The intention was to use the stratigraphic information drawn from borehole logs to gain an approximate coverage of sediment depth within the study area. The data collated did not however provide a great enough coverage across the area for any surface modeling to be possible.

3.3.12. The BGS was contacted to investigate the availability of digital maps reflecting the depth of superficial sediment from seabed surface to solid bedrock as suggested on the Offshore & Coastal section of the BGS website (http://www.bgs.ac.uk/britainbeneath/off_thickness.html).

3.3.13. The data provided from the ALSF Eastern English Channel Habit Mapping project contained very accurate data on the depth of sediment for part of the AMAP study area.

3.3.14. The sediment depth map and palae-ochannel map published in the BGS publication "The Geology of the English Channel" (BGS, 1992) were both digitized although the accuracy of the data is known to be only approximate, based on a widely spaced data sampling strategy and the data being published over fifteen years ago.

3.3.15. Digital sediment depth data advertised by the BGS would have been costly to request. The sediment maps sourced from the BGS publication were produced over 15 years ago. Several approaches were therefore trialed to make the most of the data available

and produce a single character map. The depth to bedrock map published by the BGS (BGS1992) was extracted from gridded bathymetry data provided by Seazone Solutions Ltd. The results were compared with the BGS sediment depth map (BGS1992). The comparison showed some correlation between the two datasets although it remained unclear which map was more accurate.

3.3.16. The decision was made to use the published sediment depth map and combine it with higher resolution sediment depth data produced as part of the ALSF Eastern English Channel Habit Mapping project (EECHM), which cover part of the AMAP study area. This provided a character map where the data was as accurate as possible (Map 3).

3.3.17. The BGS have published a map of palaeo-channels (BGS, 1992) which, after being digitized and generalized (Map 4), has been combined with the palaeo-channel mapping undertaken during the Solent Seascapes project by Southampton University. The aim of using palaeochannel maps was to indicate areas where the sediment depth is greater than that reflected in the sediment depth characterization.

Hydrographic Survey Metadata

3.3.18. The aim of collating hydrographic survey metadata was to provide valuable information on the biases in survey coverage and resolution which may have been reflected in the scatter of shipwreck data.

3.3.19. *Seazone Solutions Ltd.* undertook the capture of data from paper survey sheets for the EECHM project and were happy for the BGS to supply the data to Bournemouth University.

3.3.20. In the initial project proposal for the AMAP project it was anticipated that the assessment of known wrecks and obstructions in the context of the types and resolution of hydrographic and geophysical surveys undertaken across different seabed areas, and the regularity within which surveys are repeated, would provide a way of contextualising the biases in the wreck data on which we currently depend for advising strategic assessments for the marine industry.

3.3.21. It was however not possible to get a complete coverage of the chronology and regularity of surveys over different areas. It may be that the collation of survey area data from historical charts may be a more effective way of identifying areas surveyed in greater detail than others. This research would however constitute a project in itself and lies outside of the scope of the AMAP1 project.

3.3.22. The Maritime and Coastguard Agency are responsible for managing the funding of the Civil Hydrography Program (CHP). The surveys undertaken by the MCA have been mapped and made available to the public via GoogleEarth©. The survey areas covered by the UKHO are however not yet available in a mapped format. The coverage of third party surveys alone was too limited to provide useful parallels with wreck data scatters.

Sediment Transport

3.3.23. The integration of results from the the ALSF project "*Development of a Regional Sediment-Erosion Model for submerged Archaeological Sites*" undertaken by Southampton University (Dix et Al., 2007) has enabled the results of the *Navigational Hazards* project to be further refined by meeting the recommendation made by Dr. D Gregory (Merritt et Al., 2007, Appendix 1) to integrate information on sediment transport.

3.3.24. The project aims to "*investigate the application of one of the leading commercial numerical hydrodynamic modeling products, DHI's MIKE 21 software, to the development of regional scale models of seabed sedimentation and erosion and thence to predict the potential impacts on submerged archaeological sites*" (Dix et Al., 2007).

3.3.25. The numerical model produced in the final phase of the project to simulate hydro- and sediment-dynamics in the English Channel at coarse resolution (Dix et Al., 2007) reflecting sediment mobility and direction of sediment (Map 5).

3.3.26. The model has been integrated with shipwreck data and the resulting model from the AMAP1 project to compare results and identify areas with comparative results. The results have encouraged the identification of areas of further research into the modeling of archaeological potential. Dr Fraser Sturt and Dr Graeme Earle provided support in the manipulation of marine datasets and the integration of the sediment-erosion model within the project analysis.

Navigational Hazards Project

3.3.27. The results of the Navigational Hazards project were delivered to English Heritage as an ArcGIS .mxd file and associated geodatabase. The database contains a characterization of areas where a high level of risk to shipping coincides with a high potential for preservation (Map 6b), based on the results of a study in which trends in environmental hazards were characterized from historical sources and summarized in digitized character areas (Map 6a).

3.3.28. The analysis of risk was based on the identification of shallow areas which exhibited trends in environmental navigational hazards, supported by historical evidence of hazards. Bathymetry was reclassified and generalized to reflect the risk of shallow depth areas to shipping. The classification uses a high/medium/low grading. This data layer was integrated into the AMAP characterization in its published form.

3.3.29. The assessment of potential for preservation was based simply on the percentage of gravel contained in different types of marine sediment, which affect the rate at which wrecks are likely to be buried. The percentage of coarse grain sediment in superficial seabed deposits based was generalized from BGS seabed sediments (DigSBS250). The sediment groups based on the Folk Classification (1954) (Fig 1) were reclassified and graded in terms of the potential for archaeological materials to be buried within different sediments. The output of the Navigational Hazards project provided the foundation for the AMAP1 project environmental characterization.

3.3.30. Feedback from stakeholder in the marine industry suggested that the use of a grading system for preservation potential produces a misleading perception of archaeological potential. It was therefore agreed that the preservation potential grading would be replaced by a descriptive character summary of the potential based on the analysis of stratigraphic data and sediment mobility data collated during the AMAP project.

3.3.31. Point data from the Navigational Hazards project showing the locations of dangerous sandbank areas and rock outcrops have been used to improve the level of information on seabed character available for the coastal zone. The data has been used alongside coastal borehole records to gain a better understanding of the environmental character inshore where BGS data is not currently available.

3.4. Historical Data

Historical Port Activities

3.4.1. As suggested during the Navigational Hazards Project, "*the patterns in wreck scatters are also partially dependant on potential for shipping to be traveling within an area of seabed. Although there are inevitably isolated occurrences of vessels making unscheduled stops in ports and harbours due to human error or for emergency purposes, the potential for shipping in an area is primarily dependent on the presence of ports and harbours, the scale of activity and the size of vessels frequenting them*." (Merritt, et al., 2006, Para. 6.8)

3.4.2. Data on the scale and nature of maritime activity in ports and harbours over time was collated from a range of secondary sources by the project Research Assistant in order to identify key nodes of maritime activity. The data was drawn from secondary sources and compiled into a database. The data was then summarized and each port and harbour was graded based on the type and level of activities present for each period.

3.4.3. The structure of the data collated required a on-to-many relationship to be constructed to enable the data to be displayed within the GIS. The port and harbour activity data was therefore added as a database table (.dbf) which could be related to a shapefile displaying the spatial location of each node of maritime activity (Map 7a). The data summarised in the table is contained in Appendix 1.

3.4.4. During the 2002 round of the Aggregate Levy Sustainability Fund a project entitled *England's Shipping* undertaken by Wessex Archaeology (WA) which attempted to use historical sources to map pre-1730 shipping patterns, ship movements, casualties and maritime battles in the past as a way of predicting archaeological potential of the seabed. The database was provided by English Heritage for use on the AMAP1 project. The database GUI was however designed to restrict access to the data in the tables, making the data difficult to view, query and extract. The data held in the England's shipping could be integrated within the AMAP project during future phases if provided in a user-friendly format.

Navigational Hazards project

3.4.5. The non-derived character polygons from the Navigational Hazards project contain extensive information on the nature of risks to navigation (Map 6a). This data has been integrated within the historical AMAP characterization for comparison with data on the manner of loss of vessels.

3.4.6. Point data on historical anchorages and natural hazards such as rocks and banks have also be drawn from the ALSF *Navigational Hazards* project (Map 7b).

Solent and Wight Seascapes - Marine Historical Landscape Characterisation (MHLC)

3.4.7. The pilot studies undertaken for the development of the *Seacapes Maritime Historical Landscape Characterisations* tackled the characterization of archaeological potential for sea areas. The results of the *Solent Seascapes* project undertaken by the Hampshire & Wight Trust for Maritime Archaeology, Southampton University and Bournemouth University highlighted the limitations of making qualitative assessments and the need for a methodology for modeling marine data to improve the interpretation of the unquantified archaeological resource (Satchell et Al, 2007).

3.4.8. The output of the AMAP project aims in part to provide a methodology which can inform the assessment of archaeological potential for coastal and marine areas which are integral to the Seascapes MHLC methodology.

3.4.9. The character polygons produced by Hampshire & Wight Trust, Bournemouth University and Southampton University (Map 8) were integrated within the AMAP1 historical characterization to ensure that the output characterization is interoperable with MHLC within the AMAP1 study area.

4. RESULTS

4.1. Introduction

4.1.1. The analysis of data focuses on identifying and characterizing trends in shipwreck data and their relationships with circumstantial and environmental variables which determine the potential for ships to be lost and the potential for materials to be preserved. The presence and state of wrecks on the seabed are determined by complex web of inter-relating variables (Fig.2). The refinement of AMAPs has been undertaken through the quantative analysis of the available datasets outlined bellow within the project study area in order to identify the relationships between them.

4.1.2. In order to assess the relationships between shipwreck data and the variable affecting their presence and state on the seabed, trends in shipwrecks were first extracted from the attribute fields to produce data layers which could be compared with environmental and historical parameters.

4.1.3. Spatial analysis was used to produce density maps to highlight areas where similar wrecksites were concentrated. These density maps were compared with environmental and historical parameters where relationships were anticipated as suggested in Figure 2.

4.1.4. The re-assessment of the interpretation of preservation potential produced during the *Navigational Hazards* project has been undertaken by Dr David Gregory based on available stratigraphic data. The limited availability of borehole data has led to the production of a theoretical re-categorisation which will be further tested in future phases of the AMAP project. The report produced by Dr Gregory is available in Appendix 2.

4.1.5. The results of wreck queries, data comparisons and the classification of seabed sediments to reflect the potential for shipwrecks to survive have been reported on separately.

4.1.6. The final output of the project comprises a shapefile containing an environmental characterization of the marine zone containing available environmental attributes and summarising trends identified in the shipwreck data. Historical data has been compiled into a separate characterization.

4.1.7. The characterizations were tested to demonstrate the value and effectiveness of the characterizations and to highlight areas of further research and challenges relating to currently available datasets used on the project.

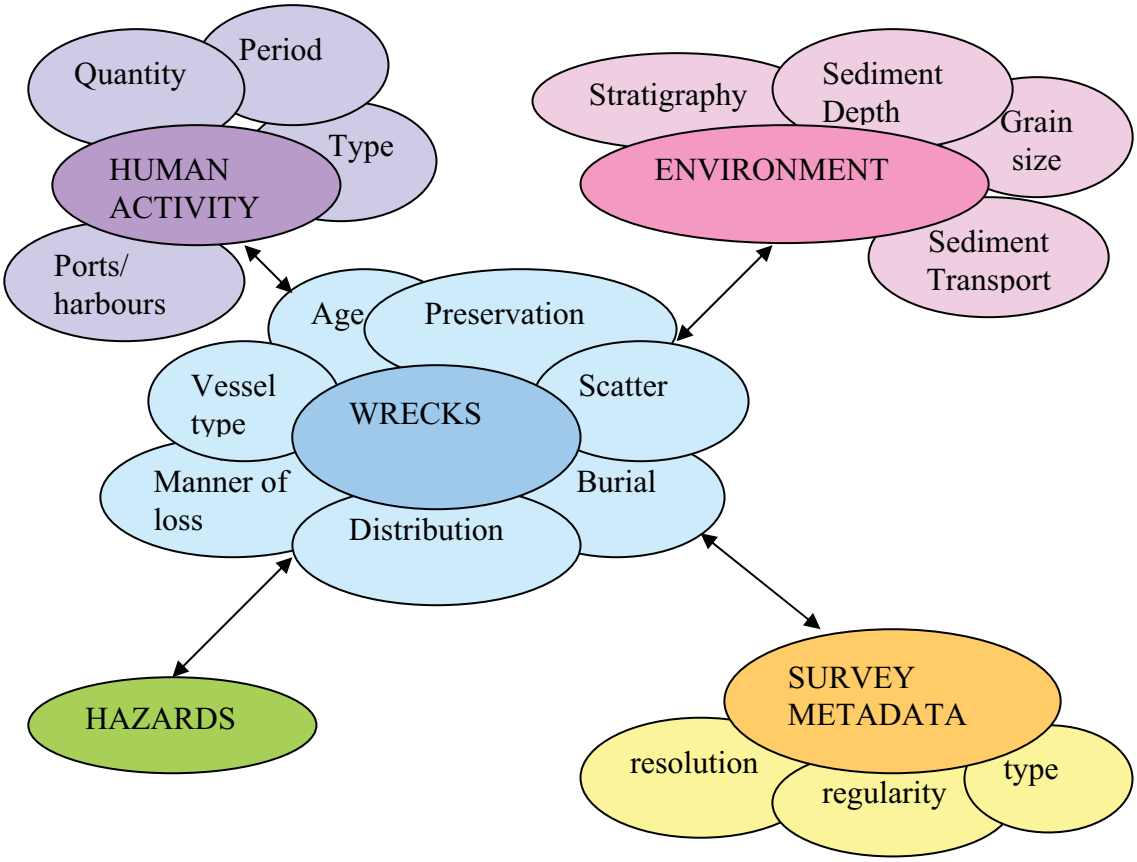


Figure 2: Diagram demonstrating the network of relationships between the available datasets and wreck data which affect the potential for wrecks to exist and survive on the seabed.

4.2. Data Analysis

4.2.1. The analysis of wreck data forms the core of the AMAP1 results, providing a basis for comparing trends in the characteristics of wreck sites with their environmental and historical parameters. The records of wreck data gathered by the UKHO during routine hydrographic surveys provide extensive data on the type, scatter and quantity of material on the seabed. The data gathered by the NMR focuses on collating historical attributes.

4.2.2. The matching records from the UKHO and NMR were identified and integrated during the Shipwreck Data Review. These records contain the greatest range of available information and have therefore provided the basis on which the wreck queries have been run.

4.2.3. Following the integration of NMR and UKHO wreck databases and separation of historical and environmental attributes into separate shapefiles, a series of attribute queries were undertaken to highlight wrecks with similar characteristics. The following groups of wreck were selected out as separate layers using the approach described below:

- iron or steel vessels
- wooden vessels
- vessels recorded as being structurally complete
- vessels recorded as being broken up or dispersed
- wrecks by period
- ships lost through accidental circumstances
- ships lost due to military action
- ships lost due to grounding
- Ships departing from ports and harbours within the study area
- Ships destined for ports and harbours within the study area

4.2.4. As highlighted during the shipwreck data review, the recording of data within attribute fields is often fragmentary. Despite this, the results of the queries suggest that enough data is available from the two databases to reflect some of the key trends relationships between the location and state of wrecks on the seabed and their surrounding environment.

4.2.5. Query results showing dense scatters of wrecks have been mapped as density rasters for comparison with other datasets. Wreck queries where results are dispersed and the investigation of scatter significance have been displayed as points.

4.2.6. The high level of interoperability between variables in shipwreck data and their relationships with their environment was anticipated as illustrated during the development of the project concept. In order to undertake the analysis stage of the project the relationships assumed to exist in Figure 2 were investigated by comparing the coverage of character polygons collated with the density raster maps produced from the shipwreck attribute queries.

Wrecks by Period

4.2.7. The first stage in analyzing wrecks was to assess the trends in period to quantify the anticipated bias towards modern vessels. Dates of loss are recorded in both UKHO and NMR databases although not in compatible formats. The UKHO losses are recorded as full dates (dd/mm/yyyy), although the presence of entries containing question marks (e.g. ??/??/1988) forced the data to be recorded as a text filed rather than a date field or numeric field. This made it difficult to convert to a field containing only the year of loss (yyyy). The NMR date of loss is recorded within two fields, a minimum and maximum date of loss. The maximum date was chosen as the definitive date for comparison with the UKHO.

4.2.8. A new field was created “LOSS_DAT” in which the year of loss was compiled from the two databases. Where the dates in the two databases conflicted, the UKHO date was chosen. Records with conflicting dates can therefore be selected out by querying for records where the “NMR_maxdat” does not equal “LOSS_DAT”. Once the dates had been compiled the following queries were run to quantify the trends in dates of loss:

Period	Query	Total Count	Iron/ steel	Wood	Intact	Scattered	Buried
20th and 21st centuries	"LOSS_DAT" >=1900	1021	245	56	173	158	48
19th century	"LOSS_DAT" <1900 AND "LOSS_DAT" >=1800	65	38	16	15	24	3
18th century or earlier	"LOSS_DAT" <1800 AND "LOSS_DAT" >0	15	0	9	0	11	0

Table 4: Queries run on joined UKHO and NMR databases to reclassify data by period

4.2.9. The query results showed that the vast majority of wrecks were lost during the 20th and 21st century (Table 4; Map 9). Less than 10% of wrecks were dated to the 19th century or earlier. The analysis of scatter for modern wrecks suggested that the majority were recorded as being complete and were constructed either of steel or iron. The pattern of iron and steel wrecks appears to be biased inshore. This is due to a lack of apparent of information on wreck materials in the UKHO contact details (CONTACT_DE) gathered for the majority of wrecks outside of the 12 mile limit.

4.2.10. The vessels lost during the 19th century are surprisingly limited in numbers which could be attributed either to material degradation or more like be due to a contrast in the UKHO's recording strategy between the 20th century and earlier. The UK Hydrographic office has only been responsible for routine hydrographic survey since 1913 (Parham, 2007). Parham states, "*It was not until the coming of steel and iron vessels, whose wrecks formed more permanent navigational hazards, and more regular updating of charts in the late 19th century that wrecks were marked as permanent features. In 1913 the Admiralty (now in the form of the UKHO) took on the formal responsibility of charting known wrecks.*" (para. 3.1.10)

4.2.11. Again a bias is apparent towards iron and steel vessels. The state on the seabed of these wrecks shows a fairly even combination between intact and scattered sites.

4.2.12. As expected, only a very small number of wrecks recorded on the seabed date to the 18th century and earlier. The majority of these vessels are constructed of wood, have been found in shallow waters, and are partly broken up or scattered. No pre-1800 sites have been recorded as buried or partially buried.

State on the Seabed

4.2.13. Wreck queries carried out on the state of wrecks on the seabed focused on separating sites out by their degree of scatter and their degree of burial. For the analysis of the degree of scatter, wrecks recorded as entire were differentiated from those recorded as partially complete or a debris field recorded in the UKHO "contact description". In

addition, the “general condition” field was searched for descriptions referring to scatter.

4.2.14. Wrecks recorded as buried were selected by searching the descriptions of the UKHO “general condition” field to construct attribute queries.

Wreck query	Source	Sample of query
vessels recorded as being structurally intact	UKHO	Unrestricted.SZFEATURE = 'WRECKS' AND Unrestricted.GENERAL_COMMENTS LIKE '%INTACT%' OR Unrestricted.CONTACT_DESCRIPTION LIKE '%INTACT%' OR Unrestricted.DEBRIS_FIELD LIKE '%INTACT%' OR Unrestricted.GENERAL_COMMENTS LIKE '%ONE PIECE%' OR Unrestricted.CONTACT_DESCRIPTION LIKE '%ONE PIECE%' OR Unrestricted.GENERAL_COMMENTS LIKE '%COMPLETE%' OR Unrestricted.GENERAL_COMMENTS LIKE '%IN GOOD STATE%'
vessels recorded as being broken up or dispersed	UKHO	Unrestricted.SZFEATURE = 'WRECKS' AND Unrestricted.GENERAL_COMMENTS LIKE '%DEBRIS%' OR Unrestricted.CONTACT_DESCRIPTION LIKE '%DEBRIS%' OR Unrestricted.DEBRIS_FIELD LIKE '%DEBRIS%' OR Unrestricted.GENERAL_COMMENTS LIKE '%WRECKAGE%' OR Unrestricted.CONTACT_DESCRIPTION LIKE '%WRECKAGE%' OR Unrestricted.GENERAL_COMMENTS LIKE '%VERY BROKEN%' OR Unrestricted.GENERAL_COMMENTS LIKE '%WELL BROKEN%' OR Unrestricted.GENERAL_COMMENTS LIKE '%BROKEN UP%'
Vessels recorded as buried	UKHO	Unrestricted.GENERAL_COMMENTS LIKE '%BURIED%' OR Unrestricted.CONTACT_DESCRIPTION LIKE '%BURIED%' OR Unrestricted.GENERAL_COMMENTS LIKE '%COVERED%' OR Unrestricted.CONTACT_DESCRIPTION LIKE '%COVERED%' OR Unrestricted.GENERAL_COMMENTS LIKE '%SILTED%'

Table 5: Queries run on UKHO text fields to reclassify wrecks by their state on the seabed

4.2.15. Comparison of density maps of vessels recorded as being broken up or scattered with the sediment depth map compiled during the AMAP1 project results showed a strong correlation between broken vessels and areas of seabed where sediment is very shallow with a depth of 1.5m or less (Map 10).

4.2.16. This correlation was to some degree anticipated, on the assumption that wrecks which remain permanently exposed to marine processes on the seabed are likely to eventually degrade. However, the comparison of wrecks recorded as intact with the sediment depth model showed the same correlation with shallow sediments, with an apparent lack of wrecks recorded as intact or scattered within areas of deeper sediment offshore (Map 11).

4.2.17. The UKHO wrecks were symbolized to reflect the methods used to collate wreck data to see whether the bias away from deeper sediment areas offshore reflected a bias in the patterns of wrecks identified during hydrographic survey. The results (Map 12)

show that the majority of UKHO wrecks are either reported and mapped at the time of loss or identified using hydrographic survey techniques using acoustic, magnetic or video sensors. A considerable number of sites are also identified through diver reports. The analysis shows a slightly lower concentration in wrecks across the deeper sediment area off Beachy Head, although there are still some sites identified using acoustic sensors identified in this area. A comparison of the results with survey metadata provided by *Seazone Solutions Ltd.* showed that the area in question has not been surveyed using modern survey methods since the single beam surveys published in 1984 (Map 13). This method of survey and the considerable distance between survey corridors would have restricted the potential for identifying wrecks on the seabed. The number of wrecks recorded during earlier phases of survey however appear to be greater in areas where sediment is below 1.5 m.

4.2.18. The analysis of wrecks recorded as buried or partially buried, again, showed a strong correlation with areas where sediment depth is 1.5m or less (Map14a). Comparison with areas with a high percentage of fine grained sediments characterized during the ALSF Navigational Hazards project showed buried wrecks to be evenly disturbed across areas of coarse and fine grained sediment. Therefore, the presence of some buried sites in areas characterized by a high percentage of gravel suggests that grain size alone does not affect the potential for shipwreck burial.

4.2.19. A comparison of buried wrecks with the residual sediment transport model produced by Southampton University suggests that sites lying in shallow sediment areas characterized by a medium or high level of sediment transport have a potential for burial, in both sandy and gravelly environments (Map 14b). Further development of the sediment model and further testing of the AMAP1 wreck queries in a future phase of the project may provide further insight into these complex relationships.

Wrecks by Materials

4.2.20. The UKHO and NMR shipwreck databases both record information on the material from which vessels are constructed. The attributes in the UKHO dataset contain several text fields which make reference in places to the materials from which vessels are constructed. The records were reviewed to identify these fields and decide on a method for extracting the records. The identification of vessels built of wood, iron, steel and concrete was undertaken by running queries to identify records with fields containing references to these materials. The use of the SQL command LIKE using the percent sign as a wildcard for characters preceding or subsequent to the search string (e.g. "FIELD_NAME" LIKE '%WOOD%') enabled the extraction of all records containing these terms within their fields. Some error is to be anticipated through the use of this method of data extraction. For instance, a steel hulled vessel named “Hazelwood” or a ship carrying a cargo of wooden planks would be selected as part of the results. This approach, though repeatable, does require considerable data checking.

4.2.21. The NMR provided a table of materials associated with wrecksite as a one-to-many relationship. The table was related to both the AMIE point and polygon shapefiles via the HOB_UID identifiers. The results were complied in two newly created fields

"NMR_MAT1" and "NMR_MAT2". Where sites were recorded as having more than one material type, additional materials have been recorded in field "NMR_MAT2".

Wreck query	Field	Source	Sample of query
Iron vessels	"TYPE_OF_OB", "GENERAL_CO", "CIRCUMSTAN" "NMR_MAT1", "NMR_MAT2"	UKHO NMR	"TYPE_OF_OB" LIKE '%IRON%' OR "GENERAL_CO" LIKE '%IRON%' OR "CIRCUMSTAN"LIKE '%IRON%' OR "SURVEYING_" LIKE '%IRON%' OR "DESCRIPTIO" LIKE '%IRON%' OR "DESCRIPTIO" LIKE '%iron%' OR "DESCRIPT_1" LIKE '%IRON%' OR "DESCRIPT_1" LIKE '%iron%' OR "NMR_MAT1" = 'IRON' OR "NMR_MAT1_1" = 'IRON'
Steel vessels	"TYPE_OF_OB", "GENERAL_CO", "CIRCUMSTAN" "NMR_MAT1", "NMR_MAT2"	UKHO NMR	"TYPE_OF_OB" LIKE '%STEEL%' OR "GENERAL_CO" LIKE '%STEEL%' OR "CIRCUMSTAN"LIKE '%STEEL%' OR "SURVEYING_" LIKE '%STEEL%' OR "DESCRIPTIO" LIKE '%STEEL%' OR "DESCRIPTIO" LIKE '%steel%' OR "DESCRIPT_1" LIKE '%STEEL%' OR "DESCRIPT_1" LIKE '%steel%' OR "NMR_MAT1" = 'STEEL' OR "NMR_MAT1_1" = 'STEEL'
Wooden vessels	"TYPE_OF_OB", "GENERAL_CO", "CIRCUMSTAN", "SURVEYING_" "DESCRIPTIO" "DESCRIPT_1" "NMR_MAT1" "NMR_MAT1_1" "NMR_MAT2_1"	UKHO NMR	"TYPE_OF_OB" LIKE '%WOOD%' OR "GENERAL_CO" LIKE '%WOOD%' OR "CIRCUMSTAN"LIKE '%WOOD%' OR "SURVEYING_" LIKE '%WOOD%' OR "DESCRIPTIO" LIKE '%WOOD%' OR "DESCRIPT_1" LIKE '%WOOD%' OR "NMR_MAT1" = 'WOOD' OR "NMR_MAT1_1" = 'WOOD' OR "NMR_MAT2_1" = 'OAK'
Concrete vessels	"TYPE_OF_OB", "GENERAL_CO", "CIRCUMSTAN" "NMR_MAT1", "NMR_MAT2"	UKHO NMR	"TYPE_OF_OB" LIKE '%CONCRETE%' OR "GENERAL_CO" LIKE '%CONCRETE%' OR "CIRCUMSTAN"LIKE '%CONCRETE%' OR "SURVEYING_" LIKE '%CONCRETE%' OR "DESCRIPTIO" LIKE '%CONCRETE%' OR "DESCRIPTIO" LIKE '%concrete%' OR "DESCRIPT_1" LIKE '%CONCRETE%' OR "DESCRIPT_1" LIKE '%concrete%' OR "NMR_MAT1" = 'CONCRETE' OR "NMR_MAT1_1" = 'CONCRETE'

Table 6: Table showing SQL queries applied to extract information on vessel building material types

4.2.22. The AMIE point and polygon shapefiles were both joined to the UKHO wreck layer. Attribute queries were then run to identify records where either UKHO or NMR fields contained references to building materials (Table 6). Only records in the UKHO database and NMR records matched to the UKHO using the old UKHO identifiers were queried as the NMR records with data on materials which were not matched are likely to be duplicate records already held by the UKHO.

4.2.23. The results of the queries were compiled into two newly created fields "MATERIAL" and "MATERIAL2", grouping vessel materials as wood, metal or concrete.

4.2.24. A large number of records did not respond to the extraction of key terms. The type of vessel may be an important source of information for identifying material type in the future. The integration of project results from ALSF Shipwreck Importance project and the input of an archaeologist specializing in ship construction during a future phase of the AMAP project would improve the identification of material type in both the UKHO and NMR databases.

WOODEN VESSELS

4.2.25. The results of records identified as wooden vessels shows a tendency for them to be identified inshore. These results are supported by the suggestion in the final report of the ALSF Shipwreck Importance project (Parham 2007) that, "*In an era of ships built from inherently buoyant material and the nature of warfare encouraging capture rather than destruction of enemy ships losses in deepwater were relatively rare*." (Para. 3.1.17)

4.2.26. There is a strong correlation with AMAPs from the Navigational Hazards project (MAP 15) displaying a medium or high percentage of fine grained sediments such as mud, clay or sand, which suggest an increased potential for wrecks to become buried and thus be preserved (Gregory, 2007). Some sites are also recorded in areas characterized by a high percentage of gravel. This can in most cases be explained by their more recent date of loss, usually after 1980. An increased level of sediment transport in offshore areas may also encourage sediment accretion around these sites.

4.2.27. Comparisons with the sediment transport model shows that wooden sites have also been identified in areas of high energy as well as more stable seabed areas (Map 15).

4.2.28. The concentration of sites inshore may in part be due to a greater potential for sites to be lost and preserved but may also reflect a greater potential for scattered wooden wrecks to be identified inshore. The assessment of the method of identification of wooden wrecks showed that the majority of sites had either been reported at their time of loss or were identified by divers. The popularity of sports diving in the UK has led to the discovery of a considerable number of wreck sites in inshore waters and has no doubt considerably affected the number of wooden wrecks found. Parham (2007) suggests that "*A side effect of amateur diving since the 1950s has been the identification of relatively modern shipwrecks found by other means and the occasional location of older more ephemeral shipwrecks that modern hydrographical surveying techniques cannot find. By and large these are vessels armed with cannon which are easily identified underwater and have been found in the areas of high concentrations of diving, largest around the south and west coasts of the UK*." (para. 3.1.13.)

4.2.29. The analysis showed that a comparatively limited number of wooden sites have been identified through hydrographic survey when compared with iron and steel wrecks (Map 16a).

4.2.30. The results for wooden wrecks were reclassified to show the degree of scatter (Map 16c) which suggested that a high number of wooden wrecks are recorded as broken

up or scattered. Only two wooden wrecks were recorded as buried (Map 16b). An increased potential for wrecks to degrade and scatter on the seabed would make them more prone to burial in dynamic environments, potentially making them more difficult to identify on the seabed. Further testing of the relationships between the state on the seabed of wooden wrecks and their environmental parameters in other marine areas in UK waters may provide further insight into these relationships.

4.2.31. The results of the analysis support the suggestion that "*pre-industrial revolution shipping was highly likely to be lost in relatively shallow waters in unstable environments which would have either broken up relatively quickly or even if this break up did not occur immediately would have occurred well before the development of modern hydrographical surveying techniques, which because of the nature of their use is less likely to be employed in these waters and may not be capable of wreck detection*." (Parham, 2007)

IRON AND STEEL VESSELS

4.2.32. The queries run on the construction of wrecks showed that iron and steel vessels tend to have a fairly even coverage on the seabed with a slight focus in the Solent and in a broad band running along the Eastern English Channel coast. The correlation is less focuses on AMAPs than that seen in the analysis of wooden wrecks, and is strongly biased within the 12 nm limit. Investigation of the attributes of wrecks shows only a small number of records for sites outside of the 12nm limit contain references to the materials from which the wrecks are constructed. This clearly not an accurate representation of the scatter of iron and steel vessels. Again, this hypothesis is supported by the results of the ALSF Shipwreck Importance project (Parham, 2007), stating that, "*The development of iron and later steel ships during the industrial revolution created for the first time ships that, whilst much stronger and less susceptible to damage, lacked inherent buoyancy from the material of which they were built and therefore much more likely to sink once heavily damaged*."(para. 3.1.19). This and the increased potential for vessels to be lost due to collisions, as shown in the analysis of the manner of loss discussed below, and suggests a greater potential for offshore wrecks to be constructed of iron or steel.

4.2.33. The identification of iron and steel constructed vessels could be enhanced through the identification of vessel types known to be assumed to be constructed of iron or steel. This process would however require the input of a specialist in historic ship construction and is outside the remit of this pilot project.

4.2.34. A comparison of the density map of iron and steel vessels with the Navigational Hazard project results showed no recognizable correlation between concentrations in iron vessels and the AMAP Navigational Hazards characterization (Map 17a&b). A lack of bias in the coverage of sites suggests that the existence and survival of iron and steel vessel is not as dependant on environmental parameters as wooden vessels appear to be.

4.2.35. This hypothesis was tested through the investigation of material types recorded in the attributes of AMIE Reported Losses. These records reflect vessels reported as lost for which the wrecksite location is not known. The analysis suggested that, although the database is biased towards reported losses of sites of historical interest, often dating to

the 19th century or earlier, there was a distinct lack of metal ships and a strong bias towards wooden vessels (Map 17c). Although the lack of a known location for these losses, and representation using place names polygons restricts their value as a spatial dataset, the fact that less than ten percent of reported losses are constructed of wood is of great significance.

4.2.36. Analysis showed that for a total of 3669 AMIE polygons only 340 reported losses are recorded as being of metal construction, mostly dating between 1850 and 1950. The vast majority of 2735 records refer to wooden vessels dating primarily to the 18th and 19th centuries. This supports the idea that metal vessels, often of a more recent date, are less likely to decay before they are either reported or recorded through hydrographic survey and an accurate location is plotted (Parham, 2007).

4.2.37. An assessment of the state of iron and steel wrecks on the seabed (Map 18 b&c) suggested a fairly high distribution of intact wrecks as well as scattered wrecks, and that the majority of buried wrecks discussed in paragraph 4.2.17. are constructed of iron or steel.

Manner of Loss

4.2.38. The purpose of identifying a grouping the manner of loss of vessels was to differentiate between vessels lost through accidental circumstances and vessels sunk on purpose such as vessels lost through military action. The distribution of vessels lost through grounding were also identified.

4.2.39. Although there is great scope for a more in depth investigation of the impact of the manner of loss of a vessel on wrecksite formation, the complexity of this task represents a research project in itself and lies outside of the remit of this project. As proposed in paragraph 3.2.22., funding needs to be set aside for a future phase of the AMAP1 project to commission *Seazone Solutions Ltd.* to develop a repeatable methodology which can be applied to the entire UKHO wreck database.

4.2.40. For the AMAP1 pilot project, key terms describing the manner of loss were extracted from text fields and entered into a created field "LOSS_TY". The records were then reclassified as accidental or military using the queries described below (Table 7) and summarized in another new field "LOSS_CAT". The data was divided into two shapefiles reflecting vessels lost due to military action and those due to accidental circumstances. Finally, the key terms were again reclassified by summarizing the loss type in another new field "LOSS_GRP" to enable the data to be displayed by manner of loss (Map 19).

Wreck query	Field	Source	Sample of query
ships lost through accidental circumstances	"LOSS_CAT"	Derived from recategorisation of "LOSS_TY", extracted from UKHO field "CIRCUMSTAN"	"LOSS_TY" = 'wrecked' OR "LOSS_TY" = 'underwater obstruction' OR "LOSS_TY" = 'took on water' OR "LOSS_TY" = 'sunk' OR "LOSS_TY" = 'sunk by drifters' OR "LOSS_TY" = 'struck submerged object' OR "LOSS_TY" = 'struck object' OR "LOSS_TY" = 'stripped, scuttled' OR "LOSS_TY" = 'stranded' OR "LOSS_TY" =

			'storm, towed, sank' OR "LOSS_TY" = 'storm, stranded' OR "LOSS_TY" = 'storm, sank in tow' OR "LOSS_TY" = 'storm, grounded' OR "LOSS_TY" = 'storm, foundered'
ships lost due to military action	"LOSS_CAT"	Derived from recategorisation of "LOSS_TY", extracted from UKHO field "CIRCUMSTAN"	"LOSS_TY" = 'air attack' OR "LOSS_TY" = 'air attack, sank' OR "LOSS_TY" = 'air attack, sunk' OR "LOSS_TY" = 'attacked' OR "LOSS_TY" = 'attacked, sank in tow' OR "LOSS_TY" = 'bombed' OR "LOSS_TY" = 'bombed, abandoned' OR "LOSS_TY" = 'bombed, fire' OR "LOSS_TY" = 'captured, explosives' OR "LOSS_TY" = 'captured, gunfire' OR "LOSS_TY" = 'captured, sunk' OR "LOSS_TY" = 'crashed into sea' OR "LOSS_TY" = 'crashed' OR "LOSS_TY" = 'depth charged' OR "LOSS_TY" = 'explosives' OR "LOSS_TY" = 'gunfire' OR "LOSS_TY" = 'gunfire, abandoned, foundered' OR "LOSS_TY" = 'hull breach, gunfire' OR "LOSS_TY" = 'military fire' OR "LOSS_TY" = 'mined' OR "LOSS_TY" = 'mined, beached' OR "LOSS_TY" = 'mined, broke her back'
ships lost due to grounding	"LOSS_CAT"	Derived from re-categorisation of "LOSS_TY", extracted from UKHO field "CIRCUMSTAN"	"LOSS_TY" = 'damaged, beached' OR "LOSS_TY" = 'fire, grounded' OR "LOSS_TY" = 'grounded' OR "LOSS_TY" = 'grounded, abandoned' OR "LOSS_TY" = 'grounded, broke her back' OR "LOSS_TY" = 'mined, broke her back, beached'

Table 7: Table showing SQL queries applied to extract information on manner of loss following the extraction of key terms

4.2.41. Vessels lost through military action showed that the largest number of vessels lost were due to mines (178/463), with a concentration clearly visible off the south Kent Coast outside Dover. The next highest number of wrecks were due to torpedo attacks (175/463) (Map 19a). The analysis of these sites showed no obvious correlation between manner of loss and their departure or destination. No relationship was either found between the manner of loss and the degree of scatter. Both scattered and intact sites due to military conflict were focused in areas of shallow sediment, in accordance with the results of the analysis of wrecks by their degree of scatter.

4.2.42. Vessels lost through accidental circumstances showed the highest number of wrecks recorded as lost accidentally were due to collisions (202/484) (Map 19b). The next highest result was for ships lost in tow (55/484) and vessels lost through grounding (37/484). Once again, no relationships were apparent between the manner of accidental loss, degree of scatter or their departure and destination points.

4.2.43. The extraction of wrecks lost due to grounding however showed an unsurprising correlation with shallow water depth, and tended to be recorded as scattered (Map 20).

Departures/Destinations

4.2.44. The NMR database contains details of the ports of departure and destinations of vessels where known. These records were queried for vessels lost en route to or from a port or harbour within the project study area.

Wreck query	Source	Sample of query
Ships which departed from port/harbour in AMAP study area	NMR	"NMR_dept" = 'COWES' OR "NMR_dept" = 'DOVER' OR "NMR_dept" = 'ISLE OF WIGHT' OR "NMR_dept" = 'LANGSTONE HARBOUR' OR "NMR_dept" = 'NEWHAVEN' OR "NMR_dept" = 'POOLE' OR "NMR_dept" = 'PORTLAND (DORSET)' OR "NMR_dept" = 'PORTSMOUTH (HAMPSHIRE)' OR "NMR_dept" = 'SHOREHAM BY SEA' OR "NMR_dept" = 'SOLENT' OR "NMR_dept" = 'SOUTHAMPTON' OR "NMR_dept" = 'ST HELENS ROAD'
Ships with destination as port/harbour in AMAP study area	NMR	"NMR_dest" = 'COWES' OR "NMR_dest" = 'DOVER' OR "NMR_dest" = 'ISLE OF WIGHT' OR "NMR_dest" = 'NEWHAVEN' OR "NMR_dest" = 'NEWPORT (ISLE OF WIGHT)' OR "NMR_dest" = 'POOLE' OR "NMR_dest" = 'PORTSMOUTH (HAMPSHIRE)' OR "NMR_dest" = 'SHOREHAM BY SEA' OR "NMR_dest" = 'SOLENT' OR "NMR_dest" = 'SOUTHAMPTON'

Table 8: Table showing SQL queries applied to extract information on wrecks lost within the project area which were either departing from or heading to a local port or harbour

4.2.45. The results showed no immediate patterns, so queries were run on the results to highlight the manner of loss. These showed that the majority of vessels lost offshore traveling to or from a port or harbour within the study area were due to military attack. There were however no clear spatial trends in the scatter of military losses for wrecks lost traveling to or from local ports and harbours.

4.3. Re-classification of Stratigraphy for Characterising Preservation

4.3.1. Following the recommendations of Dr. D. Gregory made during the *Navigational Hazards* project (Merritt et Al., 2007, Appendix 1), BGS borehole data has been collated to identify areas characterised as AMAPs based on grain size where the stratigraphy of sediments underlying the surface sediments mapped by the BGS may affect the original characterization of preservation potential.

4.3.2. Dr David Gregory undertook a refinement of the characterization of preservation potential of the Navigational Hazards model based on sediment grain size and percentage of gravel content drawn from borehole data.

4.3.3. The grading system developed for the Navigational Hazards project is shown in Table 9.

Lithology Description	Folk Classification (Modified)	Gravel (%)	Theoretical Grade of preservation
Mud	M	1	1
Undifferentiated Mud			1
Sandy Mud	sM	1	2
Muddy sand	mS	1	3
Clay and sand			3
Sand	S	1	4
Sand			4
Slightly Gravelly mud	(g)M	5	5
Slightly gravelly sandy mud	(g)sM	5	6
Gravel, sand and silt			6
Slightly gravelly muddy sand	(g)mS	5	7
Slightly gravelly sand	(g)S	5	8
Gravelly mud	gM	5-30	9
Gravelly muddy sand	gmS	5-30	10
Gravelly sand	gS	5-30	11
Gravelly sand			11
Muddy gravel	mG	30-80	12
Muddy sandy gravel	msG	30-80	13
Sandy gravel	sG	30-80	14
Sandy gravel			14
Gravel	G	80	15
Gravel			15
Mussell deposit			16
Diamicton			17
Rock and sediment			18
Rock or Diamicton			19

Table 9:. Grading of sediments in relation to their potential preservation of archaeological materials in the marine environment. 1 being the best and 19 the worst.

4.3.4. The assessment remains theoretical however, due to the limited availability of borehole data discussed in paragraph 3.3.5. The solution may lie in the collation of other sources of stratigraphic information such as sub-bottom profiles in a future phase of the AMAP project. The method as described by Dr Gregory (2008) is outlined bellow. The full report and accompanying appendices are provided in Appendix 2:

- The data files were initally filtered and sorted in Microsoft Excel to obtain the bore hole sample number, position (which was subsequently converted to UTM WGS84 using Grid Inquest software (http://www.qgsl.com/?page=downloads) in order to be able to use the data with existing charts at the National Museum) sediment types and their thicknesses. The sediment types were then classified according to the scheme in Table 9.
- As clay was not present in this initial scheme it was decided to treat clays, or sediment containing clay, as offering a high potential of preservation – ranking them above sands in this instance (1*). This was based on personal experience and discussion with colleagues at the Viking Ship Museum,

Roskilde which has shown that materials found in clay deposits are always in an excellent state of preservation – from an archaeological perspective. One concern was the presence of boulder clays in the sediment types from the study area. Boulder clays are commonly found under water in Denmark, having been deposited during the last Ice Age, and they have a very high bearing capacity (300 to 600 kN/m²) which makes it difficult for materials to "sink" into them and, due to their cohesive nature, they are difficult to transport via water currents .

- There is therefore little chance of these types of sediments encapsulating artefacts – unless of course the area is in a region of high sediment transport where other less cohesive sediments may subsequently be deposited on top of them. Artefacts which have been found in such clays are in an excellent state of preservation but they tend to, in the majority of cases, be pilings or posts which have been physically forced down into the sediment. However, it was assumed that boulder clays would have been limited in the current study area as the extent of the ice front in the last glaciation stopped on a latitude running from the Bristol Channel to East Anglia (Sanderton et al. 1979, p266) and that the clays present were softer clays which would afford more protection to any archaeology deposited on them as they have a lower bearing capacity (75-300 kN/m²) which would enable artefacts to sink into them. This assumption is certainly open to discussion and can be revised when the model is tested.
- Following classification of the bore holes, stacked bar charts were made of the strata within them using Excel in order to help visualisation of the data. A five tiered classification scheme was then prepared. The results are outlined in Appendix 2. The above classification system was designed to take into account both the initial deposition process, i.e. the likelihood of survival depending upon what substrate archaeology was deposited and the chances of survival from post depositional processes, i.e. depending on the grain size it is possible to estimate the physical environmental conditions which have been present when the sediments present in the bore holes were deposited e.g. in increasing order of dynamics clay > mud > sand > gravel.

Level of Potential	**Description of Revised Definition**
Very Poor Preservation Potential	Bore holes containing only rock and / or which were only overlain by a superficial (<1 metre) covering of sediment.
Poor Preservation Potential	Bore holes <2 metres down to bedrock and / or those which predominantly contained gravels.
Good Preservation Potential	Bore holes with overall sediment depths of between 2 and 5 metres where the predominant sediment types were muds, sands and clays.
Very Good Preservation Potential	Bore holes with sediment depths over 5 metres where the predominant sediment types were muds, sands and clays.
Excellent Preservation Potential	Bore holes with sediment depths over 5 metres where the predominant sediment types were clays.

Table 10: Summary of reviewed definitions of levels of potential for preservation of materials in seabed sediments

4.4. Character Polygon output

4.4.1. The development of a planning tool is dependent on the production of character polygons which summarise the relationships identified during the pilot project.

Environmental Characterisation

4.4.1. The environmental characterization has been developed to provide a basis for comparing the parameters which affect the site formation processes of shipwrecks with scatter of shipwrecks with similar environmental characteristics such as the degree of preservation, the burial of sites and the materials they are constructed from.

4.4.2. The environmental characterisation is based on the following datasets:

- Preservation potential
- Water depth
- Sediment depth
- Palaeochannels
- Sediment Transport

4.4.2. Environmental character polygons were produced by generalizing and applying a union between the sub-layers produced for palaeo-channels, sediment depth, grain size and seabed mobility, providing the characterization with the attributes highlighted in yellow. The results of the wreck queries were used to populate fields highlighted in blue.

4.4.3. The output results in a simplified characterization of seabed environmental character, based on the data available at the time of the pilot project. It was however clear from some of the presentations delivered at the ALSF conference 2008, that a great deal of research is being undertaken to enhance seabed mapping for UK waters. The AMAP1 characterization would no doubt benefit from the availability of higher resolution maps for marine sediment transport, seabed morphology and sediment depth when these become available.

4.4.4. The attribute structure behind the environmental character polygons are as follows:

Attribute Label	Description	Example
FID	Unique ID	2154
Shape	Object shape	polygon
SED_DEPTH	Depth of sediment	0-1.5 m
SED_RES	Resolution of sediment depth data	high

SED_SOURCE	Source of sediment depth data	EECHM, 2007
SED_GRP	Sediment depth summary group	0-5 m
GRAIN_SZ	Sediment group classification	High % fine grain sediment
PALAEO_CHN	Areas where palaeochannels have been mapped by the BGS. Differentiates between infilled palaeochannels and unfilled palaeochannels	Infilled palaeochannel
STRAT_CHAR	Based on stratigraphic data currently very limited - REQUIRES FURTHER DATA	Shallow fine grain sediment overlying bedrock
PRES_POT	Based on surface sediment type from Navigational Hazards Project - REMOVED	high
PRES_CHAR	Summary of environmental variables affecting preservation	Shallow, highly mobile sediment
WRK_SCATTER	Based on trends in wreck data, sediment depth and mobility	High/medium/low
WRK_BURIAL	Based on trends in wreck data, sediment depth and mobility	High/medium/low
WRK_EROSION	Based on trends in wreck data, sediment depth and mobility	High/medium/low

Table 11: Attribute filed structure for the output environmental character polygons

Historical Characterisation

4.4.3. The historical characterization was developed to provide a basis for assess the relationships between the historical character of marine areas and shipwreck scatter queries such as their manner of loss, their departure and destination ports and their cargoes. It is based on the following datasets:

- Navigational Hazards navigational risk characterisation
- Solent Seascapes polygons
- Port and harbour activity areas

4.4.4. The attribute fields reflect those recorded for the ALSF Navigational Hazards digitised polygons and refer to the Seascapes areas and nodes of maritime activity in proximity of each area.

Attribute	**Data Type**	**Description**
FID		Auto ID
Shape	OLE Object	Auto object description
OBJECTID	AutoNumber	Auto ID
FID_COAST_CHAR	AutoNumber	Unique auto ID drawn from “feeder” polygons

AREA_NAME	Text	Unique name based on NMR named location names where possible. Otherwise general descriptions of an area was used. Used to join the data in the database to the "feeder" GIS polygons
COAST_CHAR	Text	Describes the character of sea areas, taking into account depth, distribution of prevailing hazards and location with respect to the coastline
HAZ_CHAR	Text	describes the morphology of the seabed areas and trends in hazards natural hazards
ANCHORAGES	Text	Based on a categorisation of *HIGH, MEDIUM, LOW*
COND_CHAR	Text	Refers primarily to trends in sea conditions seastate hazards and exposure of the sea areas to prevailing winds
COND_GRADE		Based on a categorisation of *HIGH, MEDIUM, LOW*
SEABED_CHAR	Text	describes the prevailence of sediment type in each area as this reflects significantly on the potential for preservation of archaeological materials
SEASCAPES_AREA	Text	Refers to the area name for Solent Seascapes character area which the polygon falls within
MARITIME_NODES	Text	Lists ports and harbous within the vicinity of the polygon

Table 12: Attribute filed structure for the output historical character polygons

Data Standards

4.5.1. The resulting GIS products takes into account the following parameters:

1. Data will be supplied in ESRI Shapefile format

2. All non spatial data recorded about any features will be recorded as attributes in line with the recommendations made in English Heritages *Guidelines for English Heritage Project involving GIS* (Froggatt, 2004).

3. All spatial relationships will be topologically clean and correct and will follow the guidelines defined in English Heritages *Guidelines for English Heritage Project involving GIS* (Froggatt, 2004).

4. Data will be supplied to be viewed at 1:50,000 with a Spatial Resolution where possible of 25m.

5. All data will be supplied in metric and in a WGS84 format.

6. The Metadata will be supplied in UKGEMINI format with exploration metadata for each GIS layer. The UK GEMINI Discovery Metadata Standard is a defined element set for describing geo-spatial, discovery level metadata within the United Kingdom. It is derived and therefore compliant with ISO

19115 Geographic Information – Metadata and the UK eGovernment Metadata Standard (eGMS).

4.6. Case-Study

4.6.1. The comparison of wreck data attributes with their environmental and archaeological parameters has highlighted the complexity of their relationships. Further testing of these apparent relationships across other UK marine zones will be crucial to assessing their validity across different types of marine environment. This extension of the project research area should be conducted before extensive testing of the method is undertaken through the application of in-depth case studies.

4.6.2. For the purpose of this pilot project, it was agreed that method as it stands would be looked at in the context of a case-study to demonstrate how the system is anticipated to be applied.

4.6.3. This has been done by looking at the data available within and surrounding the aggregate license areas to the east of the Isle of Wight (License areas 351, 340, 451,122/3 and 407) (Map 21a). A case-study area has been created to reflect the area of investigation.

4.6.4. The first step was to look at the wrecks within the study area. This shows a predominance of metal wrecks, with an even distribution between intact and scattered sites across the area.

4.6.5. Four wooden wrecks are also recorded surrounding area 122/3. These include:

- ESTRELITA, a fishing vessel lost in 1975, recorded as an entire wreck, though no information is provided on scatter (HO_ID 19032). A second location is given for ESTRELITA (POSS), (HO_ID 19044)
- Unknown wreck, recorded as a wooden steam ship, partial wreck detected in 1969 (HO_ID 20052, HOB_UID 767337)
- Unknown wreck recorded as a possible wooden yacht, notable debris detected in 1968 (HO_ID 19066, HOB_UID 767335)

4.6.6. Looking at the sediment transport model (Map 21b), the areas 351, 340, 451 and 122/3 all lie within a transitional area where the level of sediment transport is changing from high to low, potentially leading to an increased level of sediment accretion. The directionality of sediment transport model indicates a vortex of sediment movement over these areas which may also suggest localized accretion of gravel. In the context of shipwreck potential, this suggests that the potential for buried sites to exist is greater due to the complex and dynamic movement of sediment. There are no buried wrecks recorded within the license areas, although three partly buried sites are recorded to the south and east of area 451. These sites include the following:

- GERARDA, lost in 1882 following a collision, reported as very broken up and well buried (HO_ID 19891, HOB_UID 767292).

- Unknown wreck, reported as area of scattered debris or small wreck (HO_ID 63369).

- HMS PRINCE LEOPOLD, British landing craft, torpedoed in 1944 by U621. She is constructed of steel and recorded as intact and partially buried (HO_ID19937, HOB_UID 911734).

4.6.7. Area 407 lies further to the south in an area of high sediment transport, where the directionality of sediment transport runs from west to east. The wrecks identified within the surrounding area include the FALLODON (HO_ID 18948, HOB_UID 895329), an unknown wreck (HO_ID 19869, HOB_UID 767280) and UB81 (HO_ID 19882, HOB_UID 804831). All three sites are constructed of steel and recorded as intact. Both known sites were recorded as lost in 1917 through military action. There are no records of buried wrecks in the vicinity of this area.

4.6.8. The characterization of sediment depth (Map 21c) shows all license areas encompass seabed areas characterized by a high percentage of coarse grained sediment with a depth to bedrock of under 5 m. The high or medium levels of sediment transport across the areas, as discussed above, may contribute to a periodic and localized increase in sediment depth. In addition to this, all areas lie predominantly within areas of infilled palaeo-channels, suggesting that sediment depth is considerably greater than suggested from the sediment depth map. This may also have a considerable impact on the assessment of potential for prehistoric land surfaces although this lies outside of the remit of the AMAP1 project.

4.6.9. The characterization of AMAPs developed during the ALSF Navigational Hazards project (Map 21d) shows that all areas apart from area 122/3 lie in areas where water depth is over 20m. The distribution of wooden wrecks analysed during the AMAP1 project suggest a lower potential for wooden wrecks to be found in deeper water. The low percentage of fine grain sediment may also reduce the potential for wooden sites to be preserved in these areas. Area 122/3 is classified as having a higher percentage of fine grained sediments within the gravel mix. The complex dynamic sediment transport character, coinciding with shallower seabed areas in the north western part of the area and the presence of sandy seabed areas in the vicinity of the license area may suggest a greater potential for finding scattered wooden wrecks in area 122/3. The presence of three wooden vessels surrounding the area may support this hypothesis.

4.6.10. The analysis of this case-study area is based on the results of the pilot study. The testing of relationships in other areas around the UK, and further development of the interpretation of the sediment transport model during the MACHU project may provide further insight into the significance of wreck distributions in a future phase of the AMAP1 project.

5. CONCLUSIONS

5.1. The aim of the AMAP project is to characterize the relationships between shipwrecks and the archaeological and environmental variables which affect their presence and state on the seabed in order to produce a GIS product, based on the data collated, which encourages a more justified interpretation of the potential for wrecks to exist and survive on the seabed.

5.2. The analysis of shipwrecks during the AMAP1 project has determined the information contained in wreck data which may provide further insight into trends in preservation, through their comparison with environmental parameters. The key trends identified through the comparison of wreck data are summarized as follows:

- Wrecks queried by period show a strong bias towards 20-21st century, and a very low number of known sites from the 19th century or earlier. The majority of sites were modern and constructed of iron or steel, many of which were recorded as structurally complete. The small number of sites dating to 1800 or earlier were, tend to be constructed of wood.

- Intact and scattered vessels tend to correlate with shallow seabed sediments and medium/high sediment transport. This may be explained partly through the more limited potential for wrecks to be buried, but is in this case also reflected through biases in survey metadata

- Buried wrecks tend to correlate with seabed areas of shallow fine grained sediment with a high or medium level of sediment transport. The majority of buried and partially buried wrecks are constructed of iron or steel

- Wooden wrecks tend to be concentrated inshore, a likely to break up at a faster rate than iron or steel wrecks, survive better in fine grained sediments where they have a greater potential for burial. The increased potential for fragmentation and eventual burial may explain why far fewer wooden wrecks are identified through hydrographic survey

- Iron/steel wrecks are more at risk from sinking when damaged and as a result apprear to be evenly spread across the seabed. They tend to be better documented as they tend to be more recent in date and are less prone to degradation before identification on the seabed. As a result, few iron and steel wrecks have been recorded as unidentified reported losses in the NMR database.

5.3. The comparison of trends in wreck sites with their environmental parameters suggested correlations between the datasets despite the variability in data quality. The relationships identified currently apply specifically to the study area for the AMAP1 project, and can not be applied to other marine zones without further testing.

5.4. The testing of these relationships in other areas of seabed around the UK may provide further insight into the nature of these trends and provide a greater understanding of potential. The testing of these trends through a second phase of the AMAP project is key to developing a more confident assessment of the relationships between wrecks and their environment in order to development of a repeatable method. The availability of environmental data within other marine zones will also affect the development of a characterization.

5.5. It is therefore proposed that the second phase of the AMAP project focus on testing the method in UK waters off the Eastern English Coast, running from the eastern limit of the current AMAP1 study area, incorporating the Thames Estuary and running north to the Mouth of the River Humber.

5.6. The project methodology has led to the development of two characterizations, one reflecting available data on the environmental parameters affecting the preservation of wrecks, the other reflecting historical variables such as the location of ports and harbours, and the navigational hazards existing on their approaches. The secondary output of the project is the restructured wreck datasets produced by combining matching records from the UKHO and NMR databases which contain the greatest level of information on the circumstances of loss of vessels, their structural characteristics and their state on the seabed. This data will however remain under the copyright from the Seazone Solutions license as the UKHO data provides the basis for joined data to be represented.

5.7. The collation of environmental variables has highlighted the need for key datasets to be made more accessible for research purposes. The development of accurate mapping of offshore sediment stratigraphy, including sediment depth, through sediment modelling, and increased availability of boreholes and sub bottom profiles would enable a greater understanding of the potential for materials to be buried preserved. The model for preservation potential developed for the AMAP1 project remains theoretical due to the difficulties in gathering accurate data during the brief timescale of the pilot project.

5.8. A distinct lack of environmental data was noted along the intertidal and inshore areas, with key datasets such as BGS sediment data avoiding these changeable areas. Further research into coastal morphology may improve our understanding of the nature of wrecks and their environments in these key areas.

5.9. The output of the AMAP project meets the original research objectives by producing a refined interpretation of AMAPs within a regional study area, by developing the basis for a method for producing more justified characterizations of the nature of unrecorded shipwrecks which may exist in seabed sediments. The long term aim is to use the recognized effects of environment on known wrecks as a basis for justify the likely nature of unrecorded wrecks in different types of marine environment.

5.10. In addition the project has highlighted the need for further regional and national datasets to be developed and made available to the research community, in order to pave the way to the development of a methodology for the production of a national AMAP spatial dataset, which aims to provide coastal and offshore planners with a

scientifically founded tool for justifying the assessment of archaeological potential during strategic and development-led assessments of the historic environment in the marine zone.

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APPENDIX 1: NODES OF MARITIME ACTIVITY

UID1	PORT NAME	PERIOD	ACTIVITY GRADE	SHIPBUILDING	COASTAL TRADE	INT TRADE	LEISURE	NAVAL PORT	NAVAL DEPOT	DEFENSE	FISHING	WHALING	MARI-CULTURE	PACKET SHIPPING	MILITARY TRANSP	CIVIL TRANSP	SMUGGLING	COMMENT
1	Southampton	Prehistoric	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	Southampton	Roman	High	0	1	1	0	0	1	1	0	0	0	0	0	0	0	Import/Export, Sea defences and army supply
3	Southampton	Saxon	High	0	1	1	0	0	0	0	0	0	0	0	0	0	0	Import/Export
4	Southampton	Medieval	Very high	0	1	1	0	0	0	0	0	0	0	0	0	0	0	Import/Export
5	Southampton	Post-Medieval	Very high	1	1	1	0	0	0	0	0	1	0	0	0	0	0	Import/Export, warships, fishing
6	Southampton	Modern	Very high	1	1	1	1	0	0	0	0	0	0	0	0	0	0	Import/Export, warships, fishing on a larger scale than before
7	Shoreham	Roman	Medium	0	1	0	0	0	0	0	0	0	0	0	0	1	0	Carried Transport across the end of the Adur Tidal Estuary
8	Shoreham	Saxon	Medium	0	1	0	0	0	0	0	0	0	0	0	0	0	0	Probable location of a Anglo-Saxon port (St Cuthman's Port) at Steyning, probable wharf site identified
9	Shoreham	Medieval	High	1	1	1	0	0	1	0	0	0	0	0	0	0	0	
10	Shoreham	Post-Medieval	Medium	1	1	1	0	0	0	0	0	0	0	1	0	0	0	
11	Shoreham	Modern	Low	0	0	0	1	0	0	0	1	0	0	0	0	0	0	
12	Pagham	Saxon	Very low	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Pagham Harbour was probably used as a landing place by the Saxons, who called it Uedringmutha
13	Pagham	Medieval	Very low	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

UID1	PORT NAME	PERIOD	ACTIVITY GRADE	SHIPBUILDING	COASTAL TRADE	INT TRADE	LEISURE	NAVAL PORT	NAVAL DEPOT	DEFENSE	FISHING	WHALING	MARI-CULTURE	PACKET SHIPPING	MILITARY TRANSP	CIVIL TRANSP	SMUGGLING	COMMENT
14	Pagham	Post-Medieval	Low	0	1	0	0	0	0	0	0	0	0	0	0	0	0	After the Middle Ages Pagham was restricted to small coastal shipping due to the small size and shallow nature of the harbour, and after the construction of a tidal mill and quay at Sidlesham most vessels landed there.
15	Pagham	Modern	nil	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
16	Rye	Roman	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
17	Rye	Saxon	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
18	Rye	Medieval	High	1	0	0	0	0	0	0	0	0	0	0	0	0	0	Cinque Port
19	Rye	Post-Medieval	Medium	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
20	Rye	Modern	Very low	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
21	Newhaven	Roman	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
22	Newhaven	Saxon	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
23	Newhaven	Medieval	Very low	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
24	Newhaven	Post-Medieval	Medium	0	1	0	0	0	0	0	0	0	0	1	0	0	0	
25	Newhaven	Modern	High	0	0	0	1	0	1	0	0	0	0	0	0	1	0	
26	Littlehampton	Roman	Low	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Fishing took place from the mouth of the river Arun in the Romano-British era.
27	Littlehampton	Saxon	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
28	Littlehampton	Medieval	Medium	0	1	0	0	0	0	0	1	0	0	0	0	0	0	
29	Littlehampton	Post-Medieval	Medium	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
30	Littlehampton	Modern	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
31	Chichester	Prehistoric	Demonstrated	0	0	0	0	0	0	0	1	0	0	0	0	0	0	Neolithic worked flint suggests fishing activity maNeolithic worked flint suggests fishing activity may have been present on Chichester Harbour

UID1	PORT NAME	PERIOD	ACTIVITY GRADE	SHIPBUILDING	COASTAL TRADE	INT TRADE	LEISURE	NAVAL PORT	NAVAL DEPOT	DEFENSE	FISHING	WHALING	MARI-CULTURE	PACKET SHIPPING	MILITARY TRANSP	CIVIL TRANSP	SMUGGLING	COMMENT
32	Chichester	Roman	Medium	0	1	0	0	0	0	0	0	0	0	0	0	0	0	trade suggested from construction of harbour wall
33	Chichester	Saxon	Medium	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
34	Chichester	Medieval	Medium	0	1	1	0	0	0	0	0	0	0	0	0	0	0	
35	Chichester	Post-Medieval	Medium	1	1	1	0	0	0	0	0	0	0	0	0	0	0	
36	Chichester	Modern	Low	0	0	0	1	0	0	0	0	0	1	0	0	0	0	
37	Emsworth	Medieval	Low	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
38	Emsworth	Post-Medieval	Medium	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
39	Emsworth	Modern	Low	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
40	Poole	Prehistoric	Demonstrated and assumed	0	1	0	0	0	0	0	0	0	0	0	0	0	0	Demonstrated by the log boat find, and assumed with the import and export from the various production sites found within the area
41	Poole	Roman	High	0	1	0	0	0	0	0	0	0	0	0	0	0	0	Large scale fishing and poole was the main supply base along the south coast for the roman occupation. Varying levels of import/export also
42	Poole	Saxon	Low	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
43	Poole	Medieval	Medium	0	1	1	0	0	0	0	0	0	0	0	1	0	0	
44	Poole	Post-Medieval	Medium	0	1	1	0	0	0	0	0	0	0	0	0	0	0	
45	Poole	Modern	High	1	0	0	1	0	0	1	1	0	0	0	1	1	0	
46	Hengisbury	Prehistoric	Demonstrated	0	1	0	0	0	0	1	0	0	0	0	0	0	0	In Bronze Age the building of large earthworks which cut off the head was undertaken, it cut off the head to the main land creating a defended port. Varying levels of import/export as well

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47	Hengisbury	Roman	Low	0	1	0	0	0	0	0	0	0	0	0	0	0	0	This is the only salt production export that carried on in to the Roman period, and shows that the head declined and ceased to be a port during the Roman occupation of Britain
48	Hengisbury	Saxon	Low	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
49	Hengisbury	Medieval	Low	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
50	Hengisbury	Post-Medieval	Low	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
51	Hengisbury	Modern	Low/nil ?	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
52	Bournemouth	Medieval	Low	0	1	0	0	0	0	0	1	0	0	0	0	0	0	
53	Bournemouth	Post-Medieval	Low	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
54	Bournemouth	Modern	Low	0	0	0	1	0	0	0	0	0	0	0	0	1	0	
55	Christchurch	Prehistoric	Assumed	0	1	0	0	0	0	0	0	0	0	0	0	0	0	Small amount of trade in Pre-historic and Roman periods, probably due to Christchurch Harbour infrastructure only being built and used as a harbour in the Saxon period.
56	Christchurch	Roman	Low	0	1	0	0	0	0	0	0	0	0	0	0	0	0	
57	Christchurch	Saxon	L/M	0	1	0	0	0	0	1	1	0	0	0	0	0	0	
58	Christchurch	Medieval	Medium	0	1	1	0	0	0	0	1	0	0	0	0	0	0	
59	Christchurch	Post-Medieval	Medium	0	1	1	0	0	0	0	1	0	0	0	0	0	1	
60	Christchurch	Modern	Medium	0	0	0	1	0	0	1	0	0	0	0	0	0	0	
61	Lymington	Prehistoric	Assumed	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
62	Lymington	Roman	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
63	Lymington	Saxon	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
64	Lymington	Medieval	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
65	Lymington	Post-Medieval	Medium	1	0	0	0	0	0	0	0	0	0	0	0	0	0	
66	Lymington	Modern	Medium	0	0	0	1	0	0	0	1	0	0	0	0	1	0	

UID1	PORT NAME	PERIOD	ACTIVITY GRADE	SHIPBUILDING	COASTAL TRADE	INT TRADE	LEISURE	NAVAL PORT	NAVAL DEPOT	DEFENSE	FISHING	WHALING	MARI-CULTURE	PACKET SHIPPING	MILITARY TRANSP	CIVIL TRANSP	SMUGGLING	COMMENT
67	Brighton	Prehistoric	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
68	Brighton	Roman	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
69	Brighton	Saxon	Very Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
70	Brighton	Medieval	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
71	Brighton	Post-Medieval	Medium	0	0	0	0	0	0	0	1	0	0	0	0	1	0	
72	Brighton	Modern	Low	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
73	Eastbourne	Prehistoric	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
74	Eastbourne	Roman	Medium	0	1	0	0	0	0	1	1	0	0	0	1	0	0	
75	Eastbourne	Saxon	Medium	0	1	0	0	0	0	1	1	0	0	0	0	1	0	
76	Eastbourne	Medieval	Medium	0	0	0	0	0	1	1	1	0	0	0	1	1	0	
77	Eastbourne	Post-Medieval	Medium	0	0	0	0	0	1	1	1	0	0	0	1	1	0	
78	Eastbourne	Modern	Low	0	0	0	1	0	0	0	1	0	0	0	0	0	0	
79	Bulverhythe	Prehistoric	Demonstrated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Stone Anchor found
80	Bulverhythe	Roman	Medium	0	1	0	0	0	0	0	0	0	0	0	0	0	0	Salt Marshes mentioned
81	Bulverhythe	Saxon	Medium	0	1	0	0	0	0	0	0	0	0	0	0	0	0	Salt Marshes mentioned in many chronicles
82	Bulverhythe	Medieval	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
83	Bulverhythe	Post-Medieval	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
84	Bulverhythe	Modern	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
85	Hastings	Prehistoric	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
86	Hastings	Roman	Medium	0	1	1	0	0	0	0	0	0	0	0	0	0	0	Town formation around route of trade goods from their production locations to the new deepwater port
87	Hastings	Saxon	L/M	0	1	1	0	0	0	0	0	0	0	0	0	0	0	Same trade routes and traditions as those started by the romans
88	Winchelsea	Prehistoric	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
89	Wichelsea	Roman	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
90	Winchelsea	Saxon	Very Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	

UID1	PORT NAME	PERIOD	ACTIVITY GRADE	SHIPBUILDING	COASTAL TRADE	INT TRADE	LEISURE	NAVAL PORT	NAVAL DEPOT	DEFENSE	FISHING	WHALING	MARI-CULTURE	PACKET SHIPPING	MILITARY TRANSP	CIVIL TRANSP	SMUGGLING	COMMENT
91	Winchelsea	Medieval	Medium	0	1	0	0	0	1	1	1	0	0	0	0	0	0	Recorded as second only to London and Southampton in the Pipe Roll, however town is lost in the Great storm of 13th C
92	Winchelsea	Post-Medieval	Low	0	0	0	0	0	0	1	1	0	0	0	0	0	0	Defended only some of the time
93	Winchelsea	Modern	Low	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
94	Rye	Prehistoric	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
95	Rye	Roman	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
96	Rye	Saxon	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	This is the period in which the town is founded
97	Rye	Medieval	Medium	0	1	0	0	0	0	1	1	0	0	0	0	0	0	Designated as a cinque port during this time
98	Rye	Post-Medieval	Low	0	1	0	0	0	0	1	1	0	0	0	0	0	0	Same as before but on a lower scale due to the silting up of the harbour mouth
99	Rye	Modern	Low	0	0	0	1	0	0	0	0	0	0	0	0	0	0	
100	New Romney	Prehistoric	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
101	New Romney	Roman	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
102	New Romney	Saxon	Medium	0	1	1	0	0	0	0	1	1	0	0	0	0	0	it was a flourishing port in all aspects
103	New Romney	Medieval	Low	0	1	1	0	0	0	0	1	0	0	0	0	0	0	the harbour started to silt up and therefore activity declined
104	New Romney	Post-Medieval	Very Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	Town suffered a huge decline in maritime activity
105	New Romney	Modern	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Town is a mile away from the sea now
106	Hythe	Prehistoric	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
107	Hythe	Roman	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
108	Hythe	Saxon	Very Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	very small fishing settlement

UID1	PORT NAME	PERIOD	ACTIVITY GRADE	SHIPBUILDING	COASTAL TRADE	INT TRADE	LEISURE	NAVAL PORT	NAVAL DEPOT	DEFENSE	FISHING	WHALING	MARI-CULTURE	PACKET SHIPPING	MILITARY TRANSP	CIVIL TRANSP	SMUGGLING	COMMENT
109	Hythe	Medieval	Medium	0	0	0	0	0	0	1	1	0	0	0	0	0	0	one of the original 5 cinque ports
110	Hythe	Post-Medieval	Medium	0	1	0	0	0	0	1	1	0	0	0	0	0	0	still a cinque port but was also fortified during this period
111	Hythe	Modern	Low	0	0	0	1	0	0	0	1	0	0	0	0	0	0	
112	Hastings	Medieval	Medium	0	1	0	0	0	0	1	1	0	0	0	0	0	0	town flourishes post Norman invasion
113	Hastings	Pots-Medieval	Medium	0	1	1	0	0	0	0	1	0	0	0	0	0	0	several sea battles in the area
114	Hastings	Modern	Low	0	0	0	1	0	0	0	1	0	0	0	0	0	0	
115	Folkestone	Prehistoric	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
116	Folkestone	Roman	Very Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
117	Folkestone	Saxon	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	Lots of Vikings raids so some form of idependant activity as well
118	Folkestone	Medieval	Low	0	0	0	0	0	0	0	1	0	0	0	0	0	0	was an arm of Dover's cinque port classification
119	Folkestone	Post-Medieval	High	0	1	1	0	0	0	1	1	0	0	0	0	0	0	Harbour built, then railway causing rapid increase in trade
120	Folkestone	Modern	Very High	0	0	1	1	0	0	1	1	0	0	0	0	1	0	
121	Dover	Prehistoric	Demonstrated	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Dover boat and Langdon Bay, found possible evidence for international trade, definate coastal trade
122	Dover	Roman	High	0	1	1	0	0	0	0	1	0	0	0	0	0	0	building of harbour and lighthouses suggests large scale activity
123	Dover	Saxon	High	1	1	1	0	0	0	0	1	0	0	0	0	0	0	Still high activity despite old Roman harbour beginning to silt up
124	Dover	Medieval	High	0	0	0	0	0	0	1	0	0	0	0	0	0	0	

UID1	PORT NAME	PERIOD	ACTIVITY GRADE	SHIPBUILDING	COASTAL TRADE	INT TRADE	LEISURE	NAVAL PORT	NAVAL DEPOT	DEFENSE	FISHING	WHALING	MARI-CULTURE	PACKET SHIPPING	MILITARY TRANSP	CIVIL TRANSP	SMUGGLING	COMMENT
125	Dover	Post-Medieval	High	1	1	1	0	0	0	1	0	0	0	0	0	0	0	new harbours built to facilitate bigger ships and to address the silting up of the old one
126	Dover	Modern	Very High	0	1	1	1	0	0	0	1	0	0	0	0	1	0	
127	Deal	Prehistoric	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	settlements in the area but none found close to the shoreline
128	Deal	Roman	Low	0	1	0	0	0	0	0	1	0	0	0	0	0	0	
129	Deal	Medieval	Medium	0	1	1	0	0	0	1	1	0	0	0	0	0	0	Increase in activity due to the prosperous period, and Various viking raids
130	Deal	Post-Medieval	medium	0	1	0	0	0	0	1	1	0	0	0	0	0	0	King Henry VIII built 3 castles in the area to defend the anchorages, so increased military activity as well
131	Deal	Modern	Low	0	0	0	1	0	0	0	0	0	0	0	0	1	0	Decline in maritime activity, as it moved to bigger ports nearby
132	Portsmouth	Prehistoric	Assumed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
133	Portsmouth	Saxon	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
134	Portsmouth	Medieval	High	1	1	1	0	1	0	1	1	0	0	0	1	0	0	
135	Portsmouth	Post-Medieval	Very High	1	1	1	0	1	1	1	1	0	0	1	1	1	0	
136	Portsmouth	Modern	Very High	1	1	1	1	1	1	1	1	0	0	1	1	1	0	
137	Langstone	Prehistoric	None	0	0	0	0	0	0	0	0	0	0	0	0	0	0	no sea water until 700BC
138	Langstone	Roman	?	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
139	Langstone	Saxon	Low	0	0	0	0	0	0	0	1	0	0	0	0	1	0	HWTMA found a saxon boat
140	Langstone	Medieval		0	0	0	0	0	0	0	0	0	0	0	0	0	0	

APPENDIX 2: REFINING THE ASSESSMENT OF PRESERVATION POTENTIAL WITHIN MARINE SEABED SEDIMENTS

By Dr. D. Gregory (2008)

AMAP 1 – Refining the Assessment of Preservation Potential within Marine Seabed Sediments

Introduction

The current project aimed to build upon the results of the *Mapping Navigational Hazards as Areas of Maritime Archaeological Potential Project*, completed in January 2007 (Merritt, 2007), by integrating the quantitative analysis of additional marine data sets (see Merritt; 2007,3.1.1) with the environmental characterisations produced for the Navigational Hazards project. To this end, the National Museum of Denmark's role was to assess British Geological Survey (BGS) borehole data from the study area and to identify areas characterised as AMAPs based on the characterisation scheme proposed in the Navigational Hazards project (Gregory, 2006).

The grading system developed for the *Navigational Hazards* project is shown in Table 1 and the reader is referred to Gregory (2007) for the rationale behind its development.

Lithology Description	Folk Classification (Modified)	Gravel (%)	Theoretical Grade of preservation
Mud	M	1	1
Undifferentiated Mud			1
Sandy Mud	sM	1	2
Muddy sand	mS	1	3
Clay and sand			3
Sand	S	1	4
Sand			4
Slightly Gravelly mud	(g)M	5	5
Slightly gravelly sandy mud	(g)sM	5	6
Gravel, sand and silt			6
Slightly gravelly muddy sand	(g)mS	5	7
Slightly gravelly sand	(g)S	5	8
Gravelly mud	gM	5-30	9
Gravelly muddy sand	gmS	5-30	10
Gravelly sand	gS	5-30	11
Gravelly sand			11
Muddy gravel	mG	30-80	12
Muddy sandy gravel	msG	30-80	13
Sandy gravel	sG	30-80	14
Sandy gravel			14
Gravel	G	80	15
Gravel			15
Mussell deposit			16
Diamicton			17
Rock and sediment			18
Rock or Diamicton			19

Table 1. Grading of sediments in relation to their potential preservatrion of archaeological materials in the marine environment. 1 being the best and 19 the worst.

The aim of the current project was to apply this grading system to sediment data from bore holes collected by the British Geological Service (BGS).

BGS Bore Hole data

Data from 76 bores holes were provided for analysis: 60 onshore and 16 offshore

Initially, it had been envisioned that with sufficient data it would be possible to interpolate the various strata between the bore holes and create sub surface maps of the geology in the area. However, as Figure 1 shows, there was insufficient data to reliably achieve this.

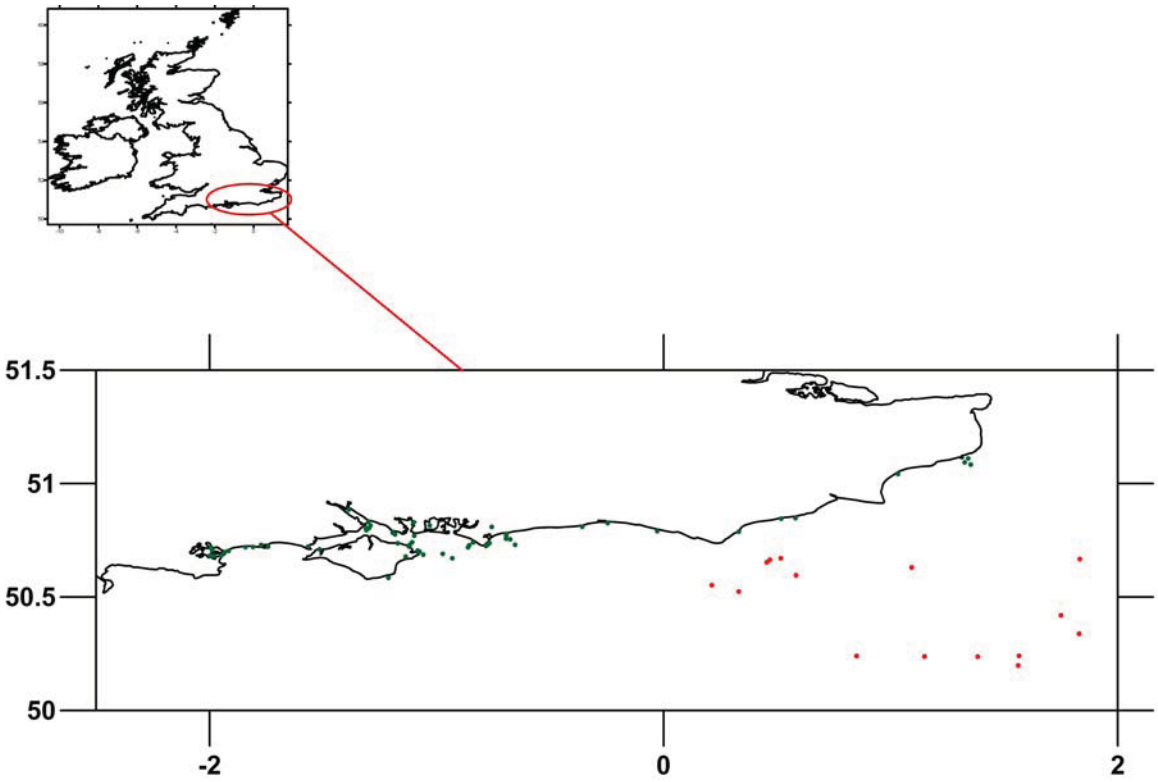


Figure1. Spatial distribution of the bore hole data sets. Green dots are the onshore data and red the offshore.

Further limitations of the data were:

- Water depths at which the bore holes were taken was not available so it was not possible to relate them in three dimensions. As the majority of bore hole data were very close in shore it may be the dynamics of the environemnt ie wave action and wave induced currents which play a greater role in the preservation of archaeology.
- It was uncertain whether the cores were taken down to natural bedrock or not. However, it has been assumed that they have been taken to bedrock.
- The system used to record the various sediment types in the bore holes was not in harmony with that used for the Navigational Hazards project. Many of the strata in the bore holes were described as clay; a sediment type not used in the Navigational

projects and thus a new rationale for preservation had to be developed incorporating this sediment type.

Assessment of the Bore Hole Data

The data files were initally filtered and sorted in Microsoft Excel to obtain the bore hole sample number, position (which was subsequently converted to UTM WGS84 using Grid Inquest software (http://www.qgsl.com/?page=downloads) in order to be able to use the data with existing charts at the National Museum) sediment types and their thicknesses. The sediment types were then classified according to the scheme in Table 1. As clay was not present in this initial scheme it was decided to treat clays, or sediment containing clay, as offering a high potential of preservation – ranking them above sands in this instance (1*). This was based on personal experience and discussion with colleagues at the Viking Ship Museum, Roskilde which has shown that materials found in clay deposits are always in an excellent state of preservation – from an archaeological perspective. One concern was the prescence of boulder clays in the sediment types from the study area. Boulder clays are commonly found under water in Denmark, having been deposited during the last Ice Age, and they have a very high bearing capacity (300 to 600 kN/m²) which makes it difficult for materials to "sink" into them and, due to their cohsive nature, they are difficult to transport via water currents. There is therefore litle chance of these types of sediments encapsulating artefacts – unless of course the area is in a region of high sediment transport where other less cohesive sediments may subsequently be deposited on top of them. Artefacts which have been found in such clays are in an excellent state of preservation but they tend to, in the majority of cases, be pilings or posts which have been physically forced down into the sediment. However, it was assumed that boulder clays would have been limited in the current study area as the extent of the ice front in the last glaciation stopped on a latitude running from the Bristol Channel to East Anglia (Sanderton et al. 1979, p266) and that the clays present were softer clays which would afford more protection to any archaeology deposited on them as they have a lower bearing capacity (75-300 kN/m²) which would enable artefacts to sink into them. This assumption is certainly open to dicussion and can be revised when the model is tested.

Following classification of the bore holes, stacked bar charts were made of the strata within them using Excel in order to help visualisation of the data. A five tiered classification scheme was then prepared.

Classification scheme for potential preservation

The processed data for the onshore and offshore cores are given in Appendix 1

Very Poor Preservation Potential

Bore holes containing only rock and / or which were only overlain by a superficial (<1 metre) covering of sediment. Bar charts of the all bore holes are given in Appendix 2.

Poor Preservation Potential

Bore holes <2 metre down to bedrock and / or those which predominantly contained gravels. Bar charts of the all bore holes are given in Appendix 3.

Good Preservation Potential

Bore holes with overall sediment depths of between 2 and 5 mtres where the predominat sediment types were muds, sands and clays. Bar charts of the all bore holes are given in Appendix 4.

Very Good Preservation Potential

Bore holes with sediment depths over 5 mtres where the predominant sediment types were muds, sands and clays. The raw data and corresponding bar charts are given in Bar charts of the all bore holes are given in Appendix 5..

Excellent Preservation Potential

Bore holes with sediment depths over 5 metres where the predominat sediment types were clays. Bar charts of the all bore holes are given in Appendix 6.

The above classification system was designed to take into account both the initial deposition process, i.e. the likelihood of survival depending upon what substrate archaeology was deposited and the chances of survivial from post depositional processes, i.e. depending on the grain size it is possible to estimate the physical environemntal conditions which have been present when the sediments present in the bore holes were deposited e.g. in increasing order of dynamics clay > mud > sand > gravel.

Results

Using the above rationale the bore holes were classified as follows:

Onshore

Bore Hole	Latitude	Longitude
Very Poor		
50/00/476	50.670995	-0.931340
50/00/460	50.719326	-0.862172
50/00/486	50.730164	-0.654509
50/01/863	50.699991	-1.075841
50/01/864	50.723055	-1.121954
50/01/865	50.741942	-1.108065
50/01/878	50.736940	-1.171124
50/01/879	50.783888	-1.193615
50/01/873	50.829443	-1.102224
SZ08NE6	50.702938	-1.916534
TR33NW4	51.111161	1.341011
TR33NW2	51.093545	1.324742
TQ30SE15	50.790274	-0.028572
TR33NW3	51.084043	1.351909
Poor		
SZ68NW4	50.704945	-1.083702
SZ39SW44	50.709968	-1.515433
SZ19SE102	50.729908	-1.773526
50/00/462	50.728326	-0.856513
50/00/485	50.754496	-0.676169
50/00/484	50.809662	-0.757346
SZ39SW25	50.723022	-1.564599
TQ60SW63	50.788231	0.330875
TQ10SE102	50.809778	-0.359047
TQ20SW110	50.825771	-0.246596
Good Preservation		
SZ08NW6	50.697554	-1.933817
SZ99NW36	50.757259	-0.693926
SU50SW2	50.815116	-1.291491
TQ80NW13	50.847732	0.580615
50/00/477	50.690497	-0.973002
50/01/876	50.686944	-1.059180
TR13SW29	51.042147	1.031701
SZ69NW74	50.770533	-1.099012
SZ08NW7	50.682814	-1.948418
50/01/877	50.678330	-1.136122
SU40SE279	50.804002	-1.297619
TQ70NE106	50.845335	0.517407
SZ49NE2	50.794362	-1.309682
Very Good Preservation		
SZ19SE65	50.721931	-1.742823
SZ19SW169	50.720619	-1.809126
SZ89SE17	50.738184	-0.767443
SZ57NE140	50.584157	-1.212413
SZ08NW30	50.706926	-1.989036
SZ08NW78	50.682107	-1.998766
SZ08NW87	50.681161	-1.980522
Excellent Preservation		
SZ89SE5	50.724950	-0.783233
SU40NW33	50.885441	-1.387236
SU40SE246	50.832256	-1.300320
SZ89SE11	50.731063	-0.774431
SZ89SW10	50.740749	-0.839515
SU60SE9	50.815307	-1.030440
SZ99NW39	50.770116	-0.693710
SZ09SW188	50.720596	-1.994275
SU40SE281	50.804990	-1.312505
SZ99NW46	50.778211	-0.693768
SZ19SW54	50.719498	-1.841569
SZ59NE17	50.776550	-1.183430
SZ08NW9	50.691351	-1.937366
SZ69SW23	50.729319	-1.119074
SU60SE9	50.815307	-1.030440

Offshore

Bore hole	Latitude	Longitude
50/00/523	50.664	0.468
50/00/522	50.653	0.454
50/02/232	50.241	1.565
50/02/230	50.419	1.750
50/02/240	50.237	1.383
50/01/105	50.240	0.850
50/02/241	50.667	1.833
50/00/533	50.552	0.212
50/02/229	50.238	1.148
50/00/520	50.596	0.583
50/02/231	50.338	1.830
50/02/242	50.630	1.092
50/02/223	50.199	1.561
50/01/106	50.524	0.331

The resulting classifications were plotted onto a map of the area as shown in Figure 2

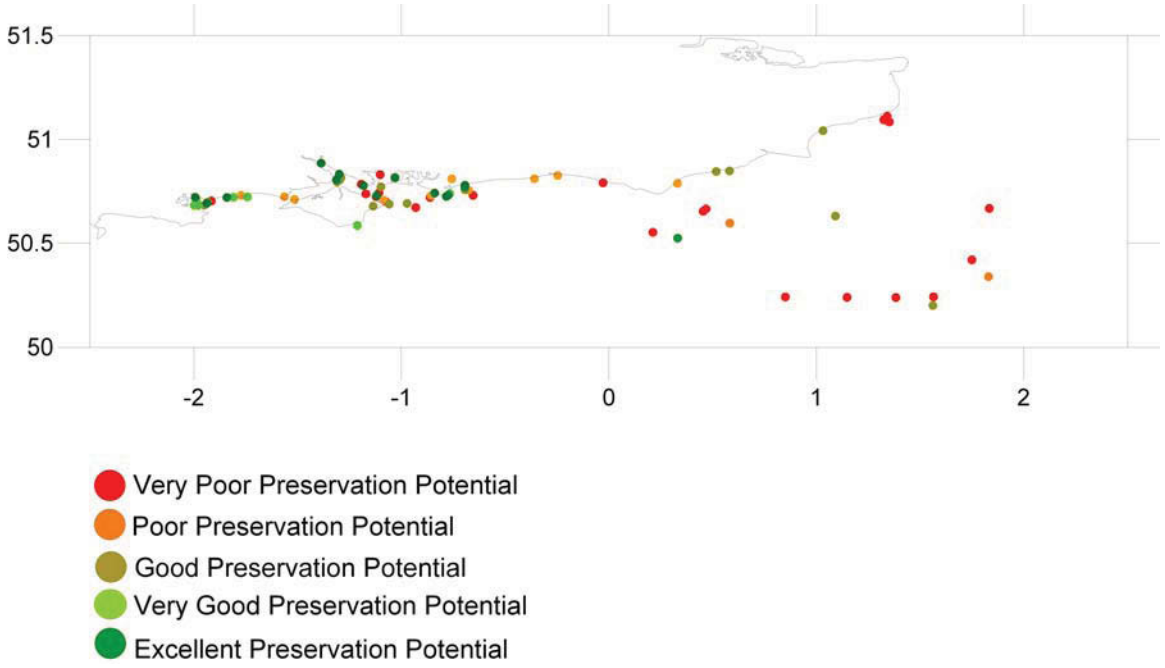


Figure 2. Distribution map of the preservation potential of the sediments in the bore hole data.

Appendix 1: Processed data for Onshore and offshore bore hole data

Onshore Data

Sample	Latitude	Longitude	Layer Thickness (metres)	Sediment Type	Grading
SZ08NW87	50.6811607	-1.980521626	-1.80	Mud	1.00
	50.6811607	-1.980521626	-0.20	Gravel	15.00
	50.6811607	-1.980521626	-1.50	Gravelly Sand	11.00
SZ08NW78	50.6821066	-1.998765971	-0.50	Sandy Gravel	14.00
	50.6821066	-1.998765971	-1.50	Clay and Sand	3.00
	50.6821066	-1.998765971	-6.10	Gravelly Sand	11.00
	50.6821066	-1.998765971	-0.35	Clay	1*
	50.6821066	-1.998765971	-10.76	Sand	4.00
SZ08NW30	50.70692641	-1.989036497	-10.00	Gravelly Sand	11.00
	50.70692641	-1.989036497	-10.00	Sand	4.00
	50.70692641	-1.989036497	-5.70	Gravelly Sand	11.00
SZ09SW188	50.72059582	-1.994274944	-1.80	Sandy Mud	2.00
	50.72059582	-1.994274944	-2.90	Clay	1*
	50.72059582	-1.994274944	-0.50	Sand	4.00
	50.72059582	-1.994274944	-1.10	Clay	1*
	50.72059582	-1.994274944	-0.30	Gravelly Sand	11.00
	50.72059582	-1.994274944	-1.20	Gravelly Clay	1*
	50.72059582	-1.994274944	-18.40	Clay	1*
SZ08NW6	50.6975542	-1.933817341	-0.90	Sand	4.00
	50.6975542	-1.933817341	-0.32	Peat	1*
	50.6975542	-1.933817341	-1.83	Sandy Gravel	14.00
	50.6975542	-1.933817341	-0.61	Sand	4.00
	50.6975542	-1.933817341	-0.61	Sandy Gravel	14.00
SZ08NW9	50.69135126	-1.937365553	-0.60	Muddy Sand	3.00
	50.69135126	-1.937365553	-0.90	Sand	4.00
	50.69135126	-1.937365553	-3.10	Clay	1*
	50.69135126	-1.937365553	-1.05	Sandy Clay	1*
	50.69135126	-1.937365553	-2.05	Sand	4.00
SZ08NW7	50.68281386	-1.948417917	-0.45	Mud	1.00
	50.68281386	-1.948417917	-1.07	Sand	4.00
	50.68281386	-1.948417917	-4.60	Gravelly Sand	11.00
	50.68281386	-1.948417917	-3.05	Sand	4.00
SZ19SW54	50.7194981	-1.841569371	-1.20	Sand	4.00
	50.7194981	-1.841569371	-0.90	Gravelly Sand	11.00
	50.7194981	-1.841569371	-0.80	Clay	1*
	50.7194981	-1.841569371	-2.80	Sandy Clay	1*
	50.7194981	-1.841569371	-4.10	Sand	4.00
SZ39SW25	50.72302152	-1.56459947	-3.20	Sandy Gravel	14.00
	50.72302152	-1.56459947	-7.00	Gravel	15.00
SU40SE281	50.80499008	-1.312505452	-7.90	Sand	4.00
	50.80499008	-1.312505452	-14.80	Clay	1*
SU40SE246	50.83225589	-1.300319563	-11.90	Sand	4.00
	50.83225589	-1.300319563	-5.00	Sandy Gravel	14.00
	50.83225589	-1.300319563	-74.00	Clay	1*
SU40NW33	50.88544136	-1.387236316	-18.00	Clay	1*
	50.88544136	-1.387236316	-2.00	Gravel	15.00
SZ49NE2	50.79436201	-1.309681761	-3.00	Gravelly Sand	11.00
	50.79436201	-1.309681761	-0.73	Sandy Mud	2.00
SU40SE279	50.8040022	-1.297619264	-4.00	Clay	1*
SU50SW2	50.81511646	-1.291491036	-4.90	Sandy Gravel	14.00
	50.81511646	-1.291491036	-0.75	Sandy Mud	2.00
	50.81511646	-1.291491036	-1.10	Muddy Sand	3.00
SZ59NE17	50.77655041	-1.18342984	-5.70	Sandy Mud	2.00
			-4.30	Sandy Gravel	14.00
SZ69SW23	50.72931899	-1.119073794	-8.00	Clay	1*

SZ69NW74	50.77053302	-1.099012402	-0.30	Sand	4.00
	50.77053302	-1.099012402	-4.50	Gravel Sand and Si	6.00
	50.77053302	-1.099012402	-2.50	Sandy Clay	1*
	50.77053302	-1.099012402	-6.45	Clay	1*
	50.77053302	-1.099012402	-16.20	Sandy Clay	1*
	50.77053302	-1.099012402	-21.30	Sand	4.00
	50.77053302	-1.099012402	-9.68	Clay	1*
	50.77053302	-1.099012402	-5.41	Sand	4.00
	50.77053302	-1.099012402	-14.50	Sandy Clay	1*
	50.77053302	-1.099012402	-3.05	Sand	4.00
	50.77053302	-1.099012402	-10.10	Clay	1*
	50.77053302	-1.099012402	-1.37	Sand	4.00
	50.77053302	-1.099012402	-17.00	Clay	1*
SZ68NW4	50.70494529	-1.08370246	-5.80	Concrete	18.00
	50.70494529	-1.08370246	-0.90	Sand	4.00
	50.70494529	-1.08370246	-4.60	Gravel	15.00
	50.70494529	-1.08370246	-16.40	Clay	1*
	50.70494529	-1.08370246	-0.60	Peat	1*
	50.70494529	-1.08370246	-2.20	Sand	4.00
	50.70494529	-1.08370246	-0.60	Gravel	15.00
	50.70494529	-1.08370246	-11.60	Clay	1*
	50.70494529	-1.08370246	-9.10	Rock and Clay	18.00
SZ57NE140	50.58415697	-1.21241349	-1.25	Sandy Gravel	14.00
	50.58415697	-1.21241349	-2.75	Gravelly Sand	11.00
	50.58415697	-1.21241349	-4.40	Sand	4.00
SZ39SW44	50.7099679	-1.515433184	-3.65	Gravel	15.00
	50.7099679	-1.515433184	-1.10	Gravelly Clay	1*
	50.7099679	-1.515433184	-5.25	Clay	1*
SU60SE9	50.81530745	-1.030439819	-17.20	Clay	1*
SZ89SW10	50.74074857	-0.83951531	-5.50	Clay	1*
	50.74074857	-0.83951531	-1.20	Sand	4.00
	50.74074857	-0.83951531	-0.40	Sandy Clay	1*
	50.74074857	-0.83951531	-7.70	Muddy Sand	3.00
	50.74074857	-0.83951531	-3.50	Sandy Clay	1*
SZ89SE5	50.72494989	-0.783233101	-0.15	Gravelly Sand	11.00
	50.72494989	-0.783233101	-0.95	Muddy Sand	3.00
	50.72494989	-0.783233101	-5.10	Sand	4.00
SZ89SE11	50.73106291	-0.774431066	-0.30	Gravelly Sand	11.00
	50.73106291	-0.774431066	-0.60	Sand and Clay	1*
	50.73106291	-0.774431066	-1.10	Sand	4.00
	50.73106291	-0.774431066	-4.10	Clay and Sand	3.00
SZ89SE17	50.73818368	-0.767442592	-3.00	Gravelly Sand	11.00
	50.73818368	-0.767442592	-3.10	Sand	4.00
SZ99NW39	50.7701163	-0.693710151	-9.10	Clay	1*
SZ99NW36	50.75725867	-0.693926281	-0.60	Gravelly Clay	1*
	50.75725867	-0.693926281	-2.75	Clay	1*
SZ99NW46	50.77821101	-0.693768347	-0.80	Sand	4.00
	50.77821101	-0.693768347	-7.60	Sandy Clay	1*
TQ10SE102	50.80977831	-0.359046549	-0.61	Clay	1*
	50.80977831	-0.359046549	-4.25	Gravel	15.00
	50.80977831	-0.359046549	-5.82	Rock	18.00
TQ20SW110	50.82577054	-0.24659632	-11.00	Gravel	15.00
	50.82577054	-0.24659632	-10.50	Gravelly Sand	11.00
	50.82577054	-0.24659632	-17.00	Clay and Mud	1*
	50.82577054	-0.24659632	-5.00	Clay	1*
	50.82577054	-0.24659632	-5.50	Clay	1*
	50.82577054	-0.24659632	-5.00	Clay	1*
	50.82577054	-0.24659632	-5.00	Rock	18.00

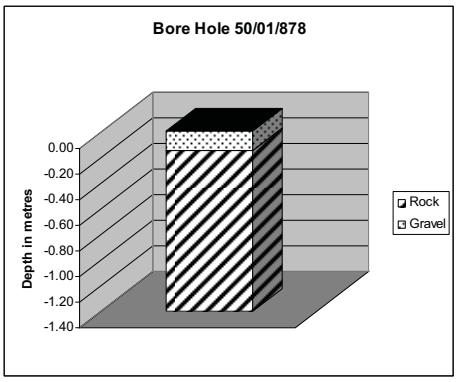
TQ30SE15	50.79027386	-0.02857162	-3.20	Rock	18.00
TQ60SW63	50.78823121	0.330875386	-6.80	Gravel	15.00
	50.78823121	0.330875386	-0.40	Sandy Gravel	14.00
	50.78823121	0.330875386	-1.00	Gravelly Sand	11.00
	50.78823121	0.330875386	-4.00	Sand	4.00
	50.78823121	0.330875386	-1.00	Clay	1*
	50.78823121	0.330875386	-4.50	Sand	4.00
	50.78823121	0.330875386	-4.60	Sand Gravel	14.00
	50.78823121	0.330875386	-2.20	Gravelly Sand	11.00
	50.78823121	0.330875386	-1.40	Gravelly Sand	11.00
	50.78823121	0.330875386	-0.50	Mud	1.00
	50.78823121	0.330875386	-1.05	Muddy Sand	3.00
TQ70NE106	50.84533511	0.517406771	-0.76	Sand	4.00
	50.84533511	0.517406771	-2.74	Mud	1.00
	50.84533511	0.517406771	-1.10	Clay	1*
TQ80NW13	50.84773154	0.580615289	-5.20	Clay	1*
	50.84773154	0.580615289	-1.20	Sandy Clay	1*
	50.84773154	0.580615289	-1.20	Rock	18.00
TR13SW29	51.0421474	1.031700774	-1.50	Sand	4.00
	51.0421474	1.031700774	-1.60	Clay	1*
	51.0421474	1.031700774	-2.10	Sand	4.00
TR33NW4	51.11116146	1.341011429	-60.90	Rock	18.00
TR33NW2	51.09354452	1.324741724	-39.30	Rock	18.00
TR33NW3	51.08404261	1.351908664	-37.80	Rock	18.00
TR53NW1	Outside Transformation Area		-0.70	Mud	1.00
	ERR: Outside Transformation Area		-1.60	Sand and Clay	3.00
	ERR: Outside Transformation Area		-1.20	Clay	1*
SZ08NE6	50.7029385	-1.916533538	-1.30	Sand	4.00
	50.7029385	-1.916533538	-0.40	Rock	18.00
	50.7029385	-1.916533538	-0.40	Clay	1*
	50.7029385	-1.916533538	-0.60	Sandy Mud	2.00
	50.7029385	-1.916533538	-3.80	Rock	1*
SZ19SW169	50.72061898	-1.80912633	-2.50	Sand	4.00
	50.72061898	-1.80912633	-0.40	Gravelly Sand	11.00
	50.72061898	-1.80912633	-12.10	Sand	4.00
SZ19SE102	50.7299082	-1.773525704	-2.00	Clay	1*
SZ19SE65	50.72193105	-1.742823182	-20.40	Sand	4.00
50/01/873	50.82944348	-1.102223949	-0.10	Sandy Gravel	14.00
	50.82944348	-1.102223949	-0.06	Rock	18.00
50/01/879	50.78388752	-1.193614759	-0.11	Gravelly Sand	11.00
	50.78388752	-1.193614759	-0.37	Rock	18.00
50/01/878	50.73693969	-1.171124298	-0.15	Gravel	15.00
	50.73693969	-1.171124298	-1.25	Rock	18.00
50/01/865	50.74194228	-1.108065216	-2.55	Rock	18.00
50/01/864	50.72305466	-1.121954111	-0.10	Sand	4.00
	50.72305466	-1.121954111	-1.15	Rock	18.00
50/01/863	50.6999911	-1.075840675	-0.10	Sand	4.00
	50.6999911	-1.075840675	-1.12	Rock	18.00
50/01/876	50.68694382	-1.059179682	-0.20	Sand	4.00
	50.68694382	-1.059179682	-2.68	Clay	1*
50/01/877	50.67833033	-1.136122128	-0.17	Gravelly Sand	11.00
	50.67833033	-1.136122128	-2.58	Clay	1*

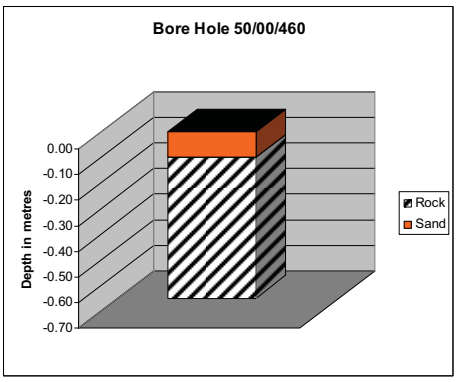
50/00/476	50.67099523	-0.931339978	-0.10	Sand	4.00
	50.67099523	-0.931339978	-3.04	Rock	18.00
50/00/477	50.69049741	-0.973001922	-0.10	Gravelly Sand	11.00
	50.69049741	-0.973001922	-0.30	Rock	18.00
	50.69049741	-0.973001922	-2.10	Clay	1*
50/00/460	50.71932566	-0.862172082	-0.10	Sand	4.00
	50.71932566	-0.862172082	-0.55	Rock	18.00
50/00/462	50.72832614	-0.856513377	-0.10	Sand	4.00
	50.72832614	-0.856513377	-0.27	Clay	1*
50/00/486	50.73016437	-0.654508812	-0.10	Sand	4.00
	50.73016437	-0.654508812	-0.77	Rock	18.00
50/00/485	50.75449558	-0.676168546	-0.10	Sand	4.00
	50.75449558	-0.676168546	-1.49	Clay	1*
50/00/484	50.8096618	-0.757345677	-0.10	Gravel	15.00
	50.8096618	-0.757345677	-0.28	Clay	1*

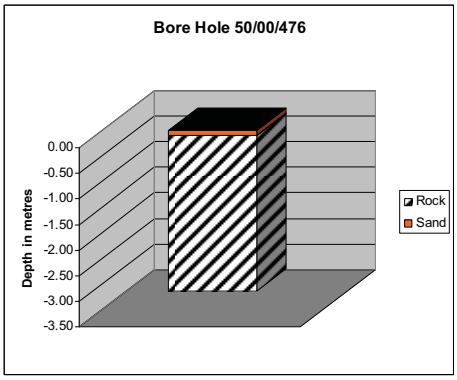
Offshore Data

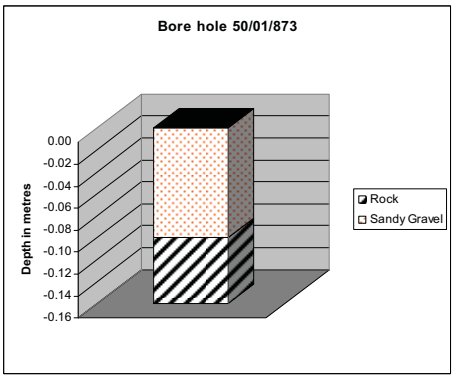
Sample	Latitude	Longitude	Layer Thickness (metres)	Sediment Type	Grading
50/00/504	50.671	0.516	0.00	Sandy Gravel	14
			0.00	Clay	1*
50/00/520	50.596	0.583	-1.00	Sand	4
			0.00	Rock	18
50/00/522	50.653	0.454	-2.00	Rock	18
50/00/523	50.664	0.468	0.00	Gravelly Sand	8
			-1.00	Rock	18
50/00/533	50.552	0.212	0.00	Gravel	15
			-2.00	Rock	18
50/01/105	50.240	0.850	-2.00	Sandy Gravel	14
			-59.00	Rock	18
50/01/106	50.524	0.331	-4.00	Gravel	15
			-5.00	No Recovery	
			-7.70	Clay	1*
			-0.80	No Recovery	
			-9.00	Clay	1*
			-36.15	Rock	18
50/02/229	50.238	1.148	0.00	Sand	4
			-2.00	Rock	18
50/02/232	50.241	1.565	-29.00	Rock	18
50/02/230	50.419	1.750	-77.00	Rock	18
50/02/242	50.630	1.092	-10.00	SAND	4
			-2.00	Clay	1*
			-11.75	Sand	4
			-7.85	Clay	1*
			-2.90	Sand	4
			-2.80	Clay	1*
			-6.60	Sand	4
			-3.10	Mud	1
			-7.50	Clay	1*
			-21.85	Rock	18
50/02/240	50.237	1.383	-14.00	Rock	18
50/02/241	50.667	1.833	-1.00	Gravel	15
			-1.00	Clay	1*
			-12.00	Rock	18
50/02/231	50.338	1.830	-1.00	Sand	4
			-4.00	Rock	18
50/02/223	50.199	1.561	-4.00	Sand	4
			-6.00	Rock	18

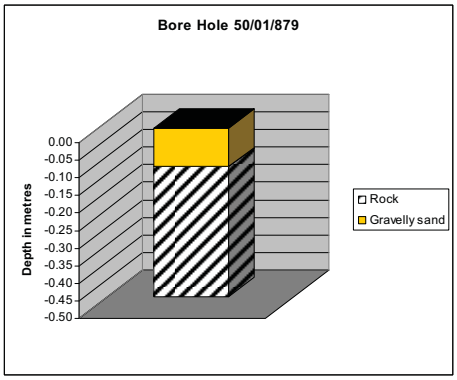
Appendix 2
Very Poor Preservation Potential: Onshore Data

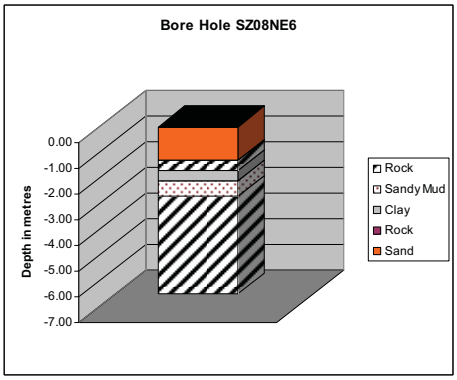


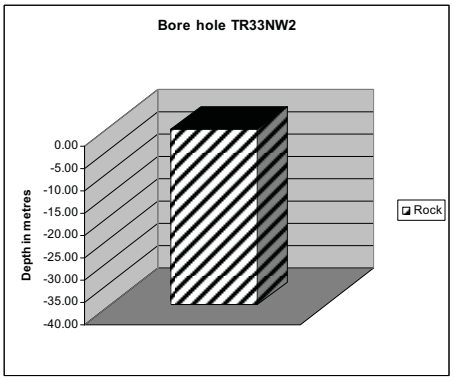


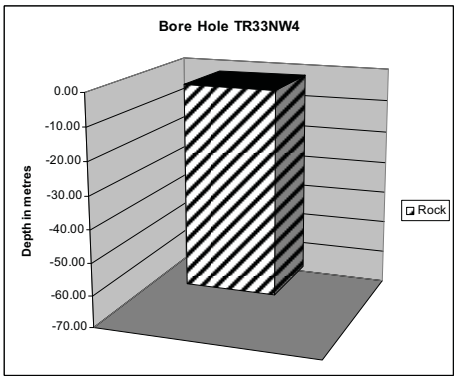


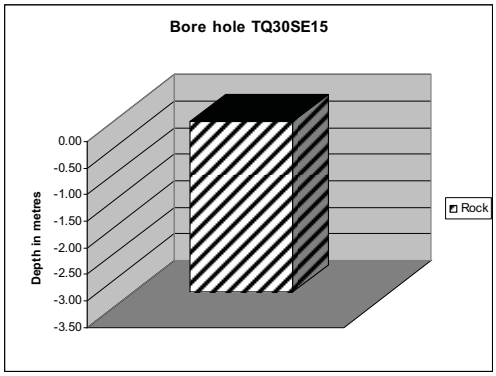


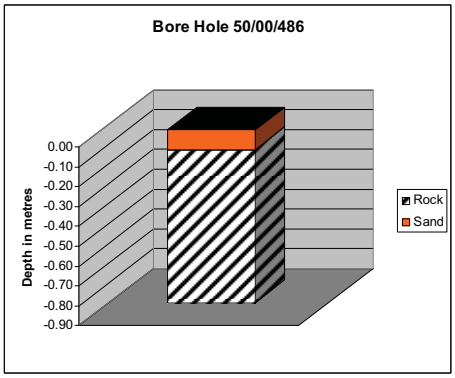


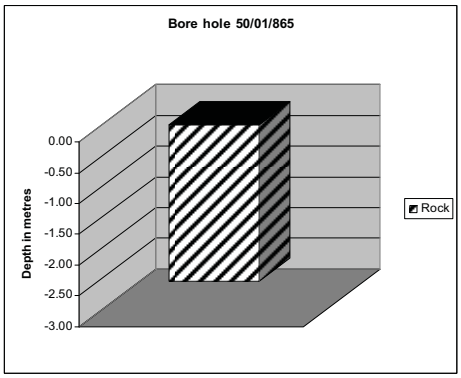


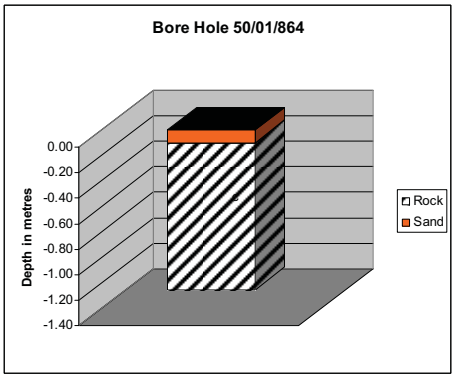


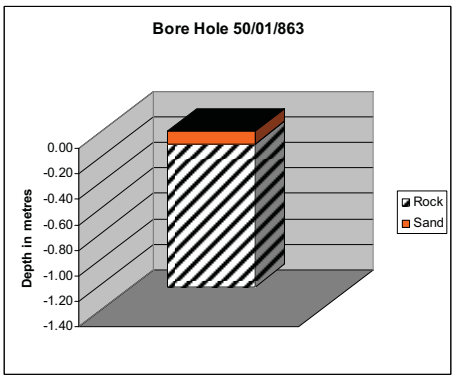


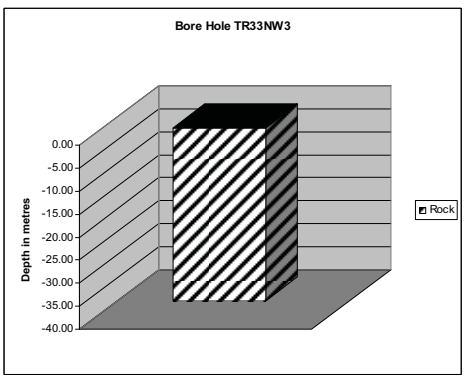




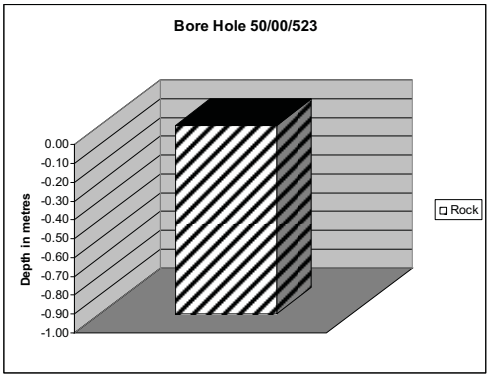


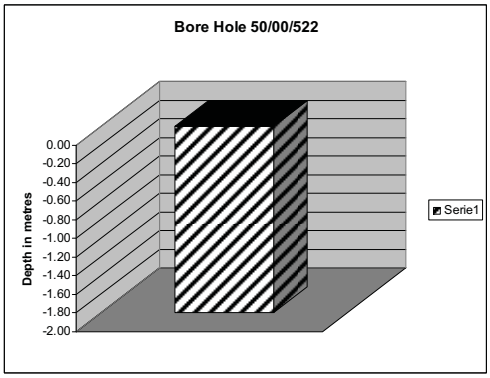


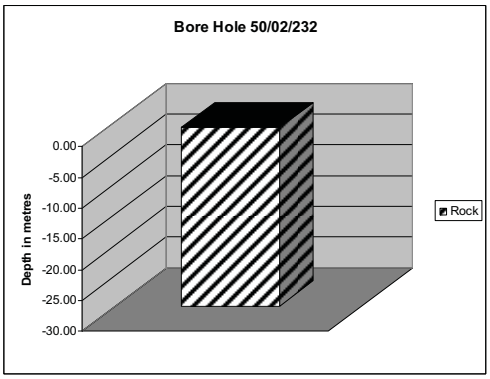


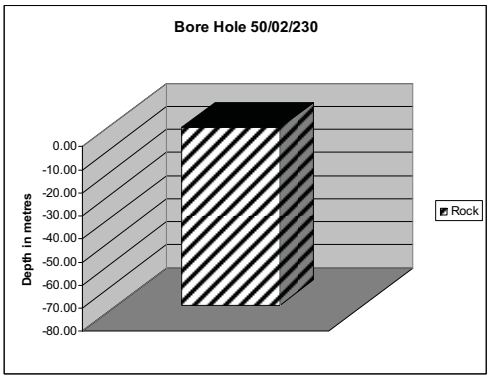


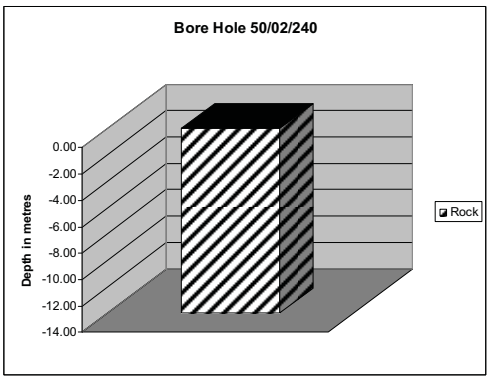
Very Poor Preservation Potential Offshore Data

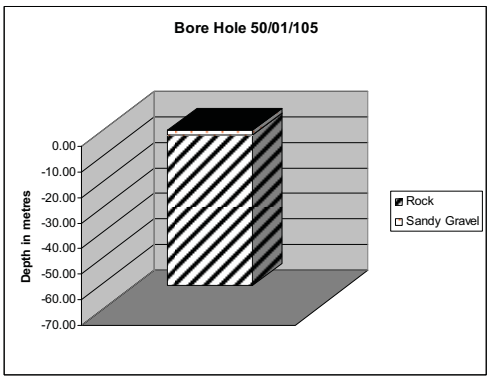


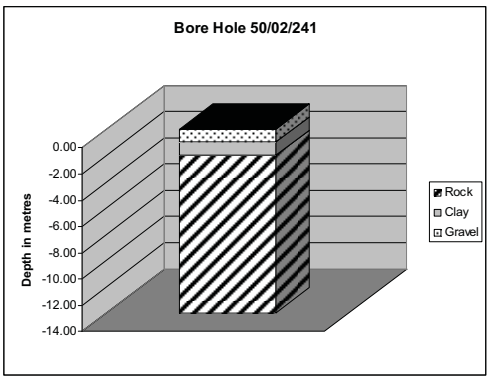


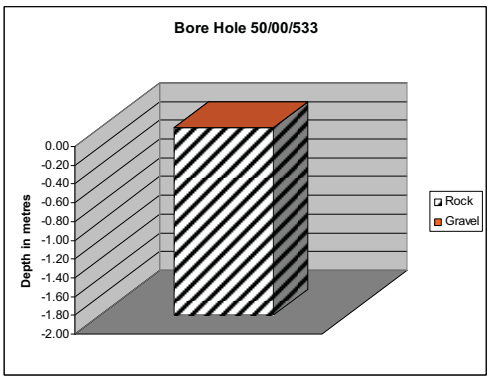


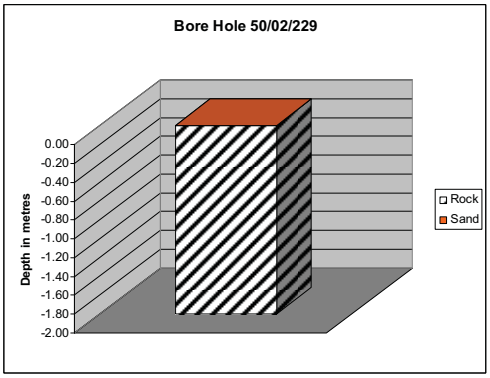








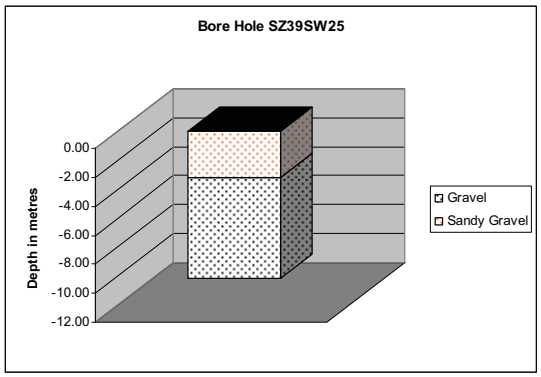


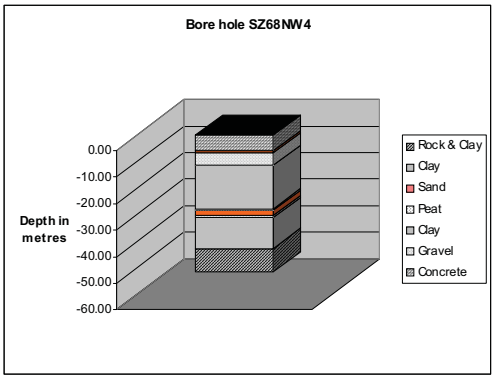


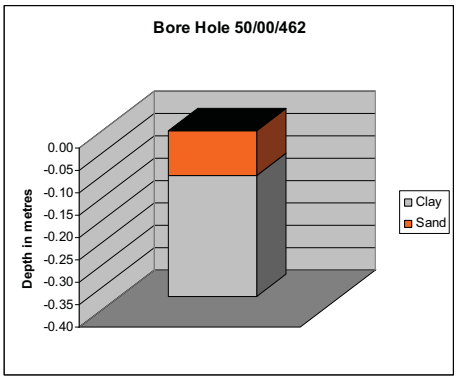
Apprendix 3 Poor Preservation Potential

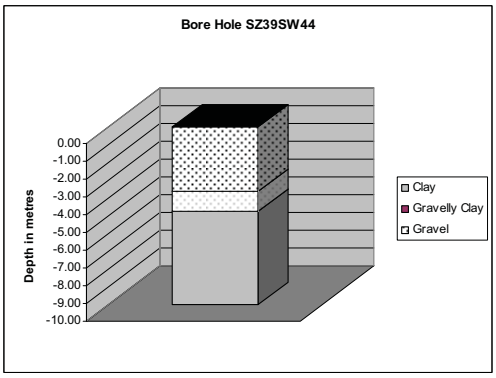
Onshore

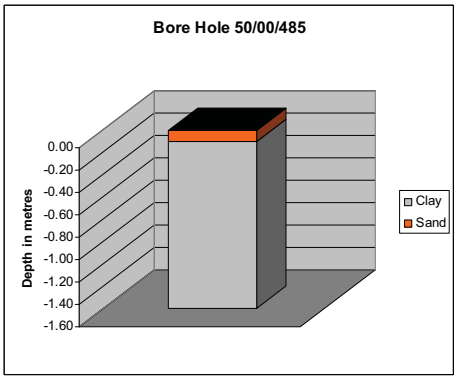
Poor Preservation

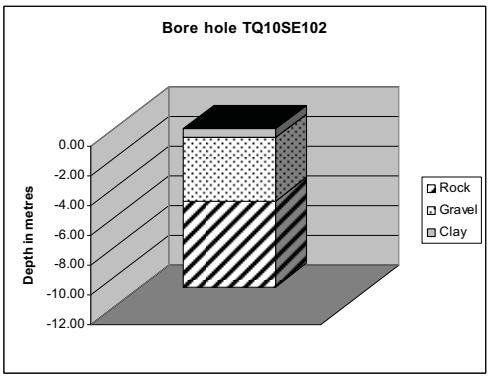


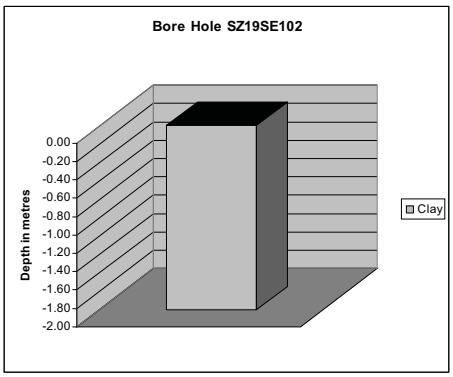


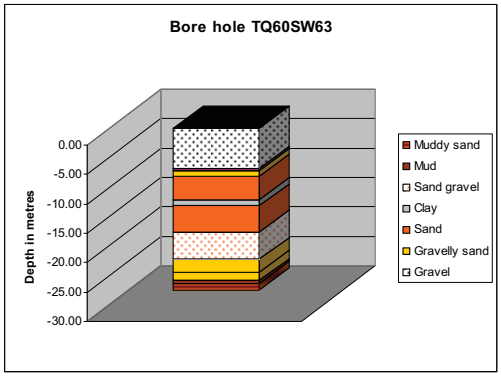


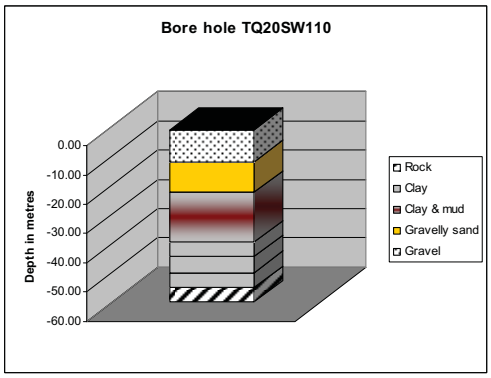


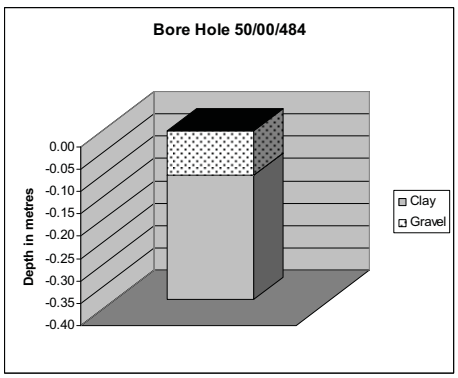




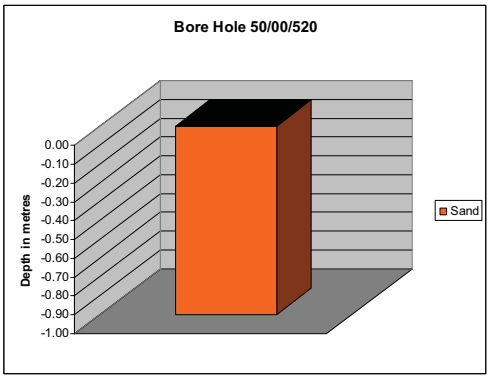


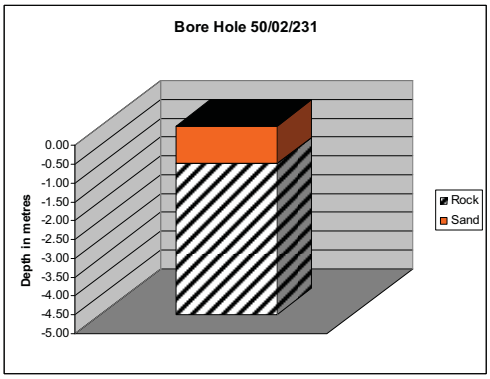






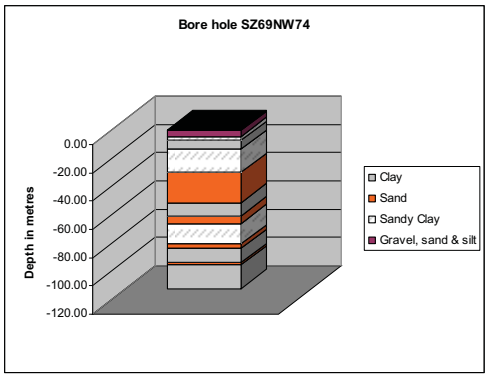
Offshore

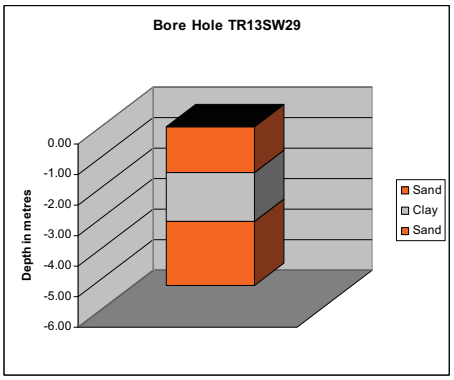


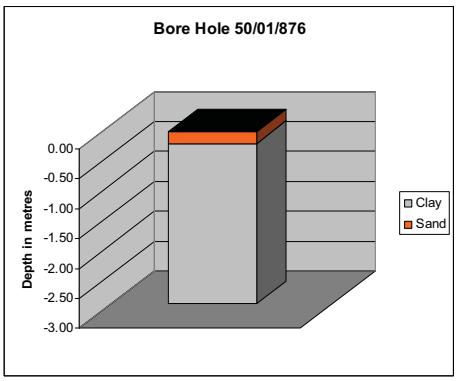


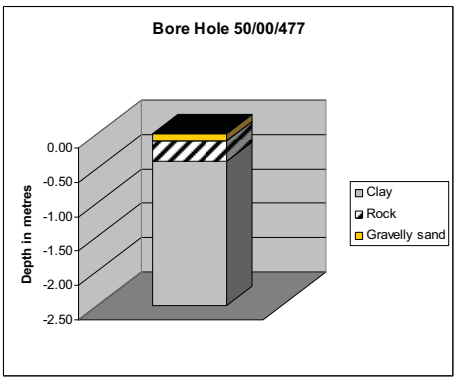
Appendix 4 Good Preservation Potential

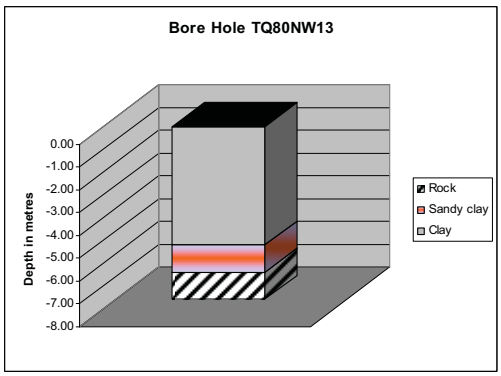
Onshore

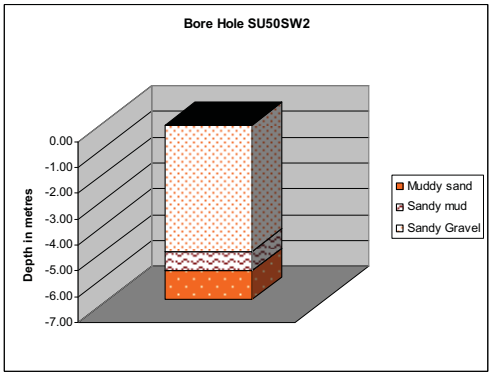


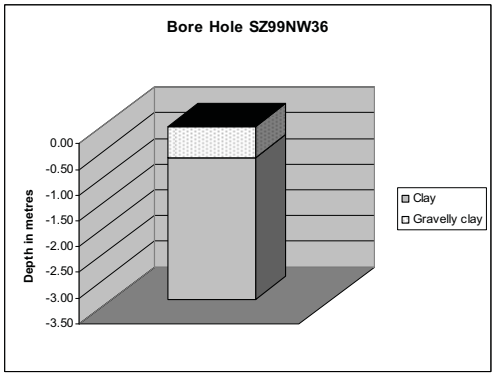


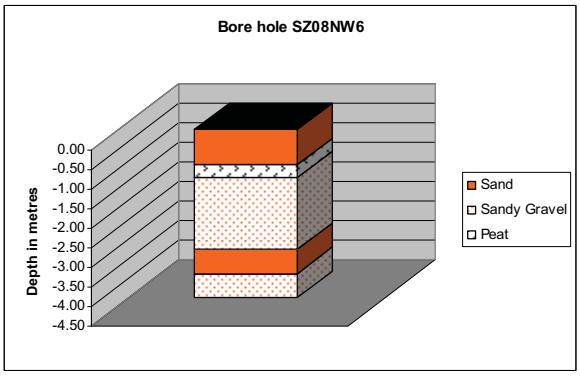


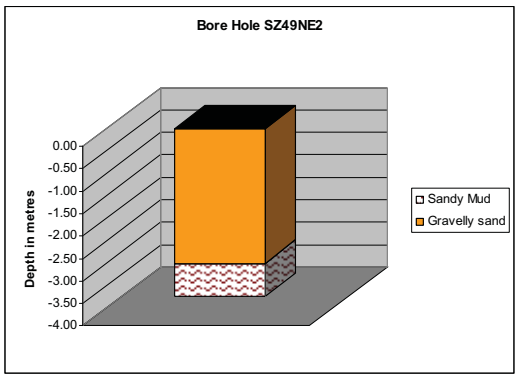


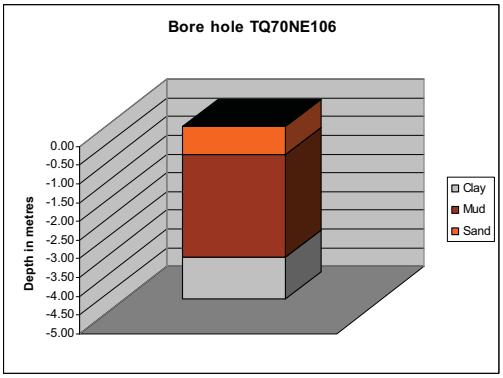


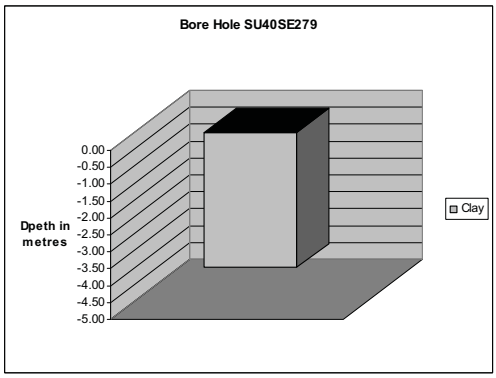


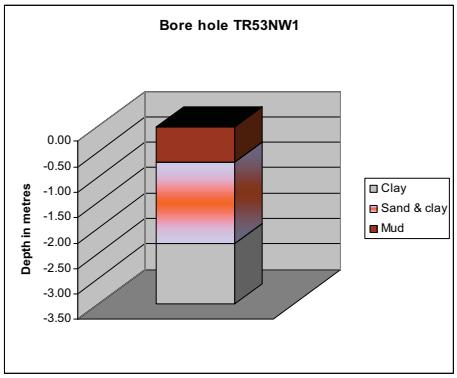


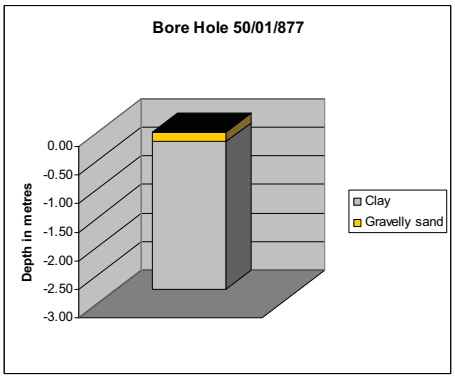


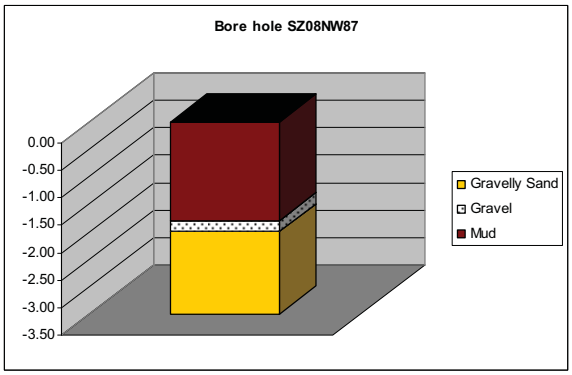




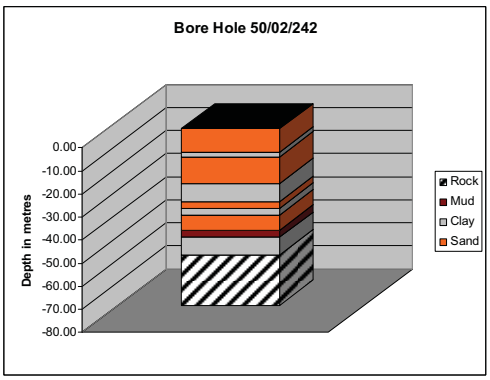


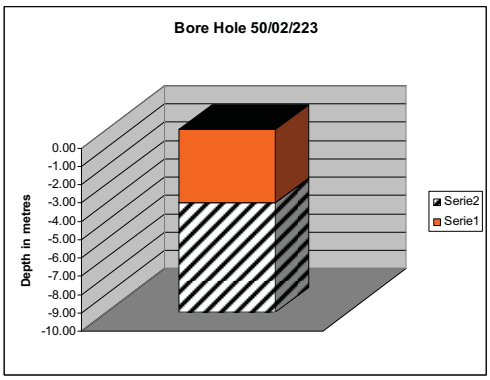






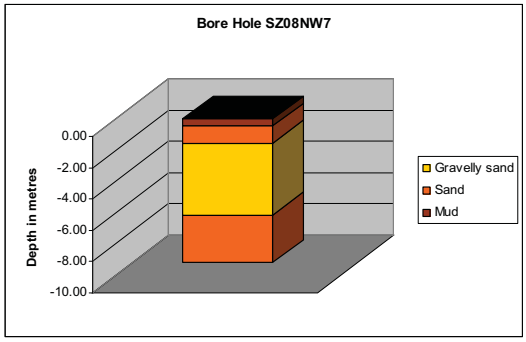
Offshore

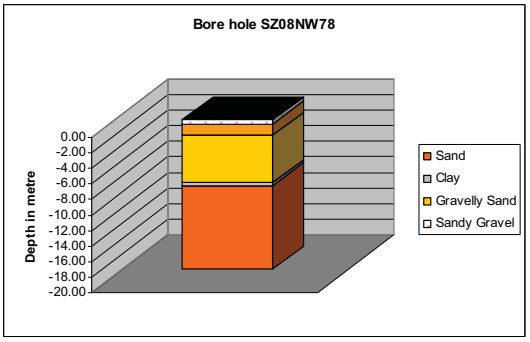


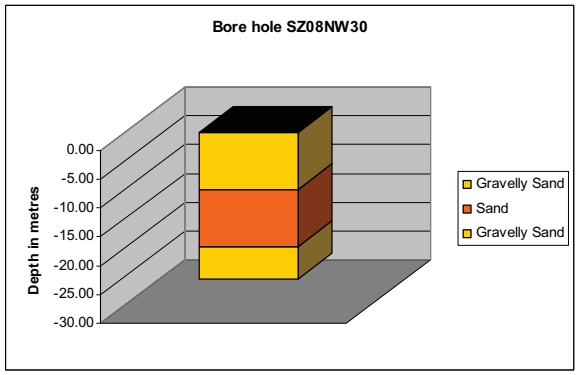


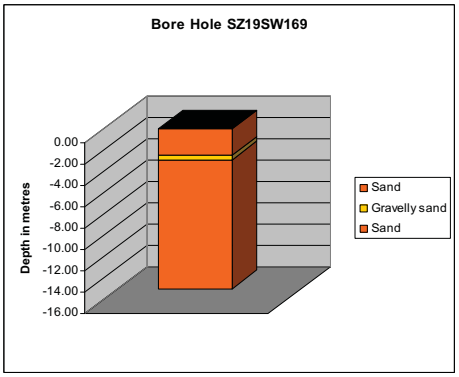
Appendix 5 Very Good Preservation Potential

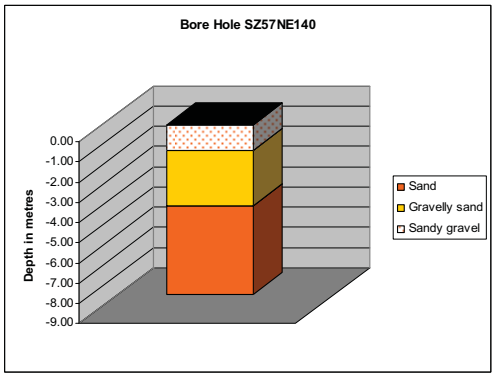
Onshore

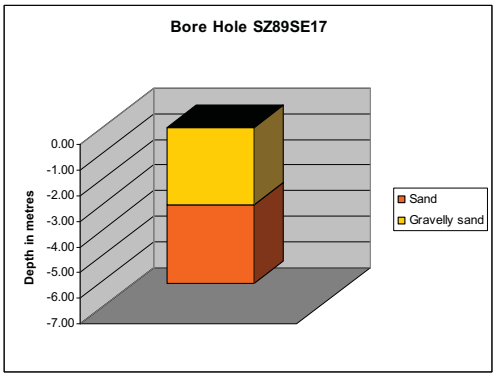


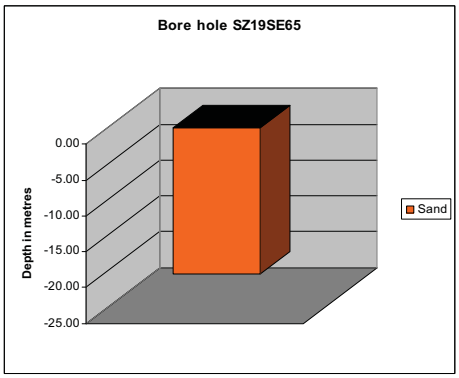








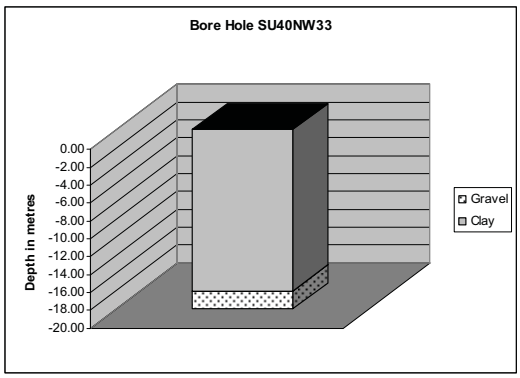


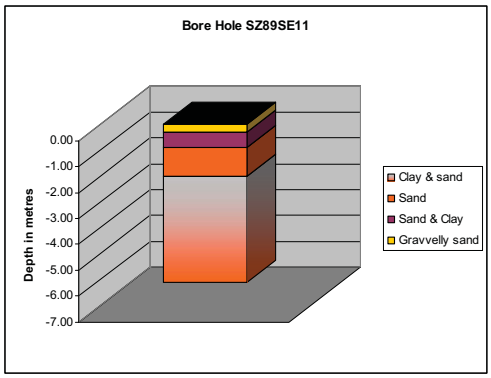


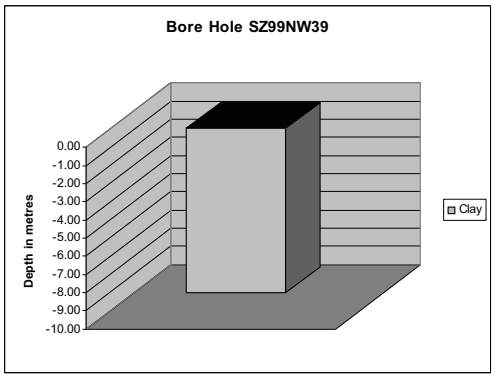
No Offshore Bores holes fitted the classification of Very Good Preservation Potential

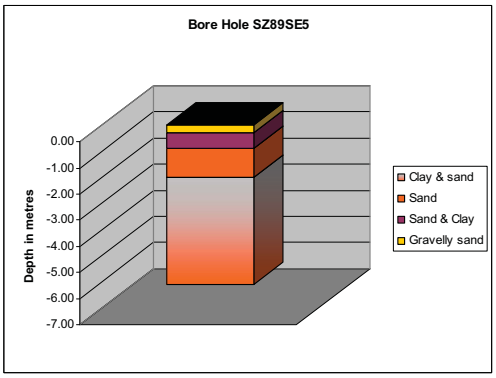
Appendix 6 Excellent Preservation Potential

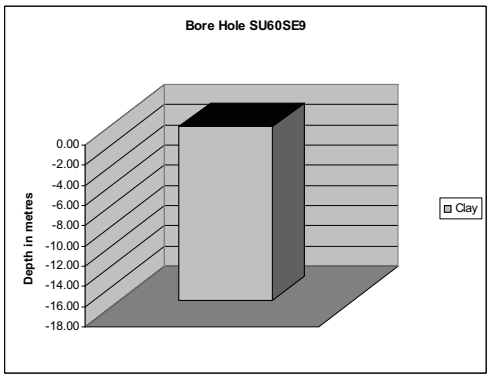
Onshore

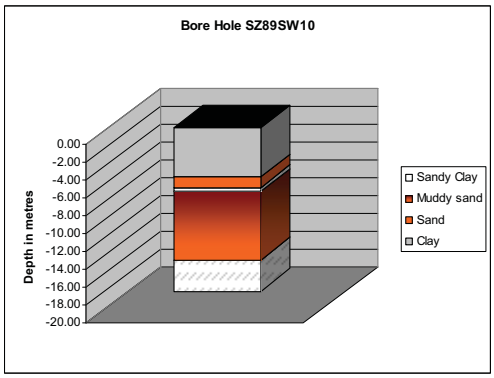


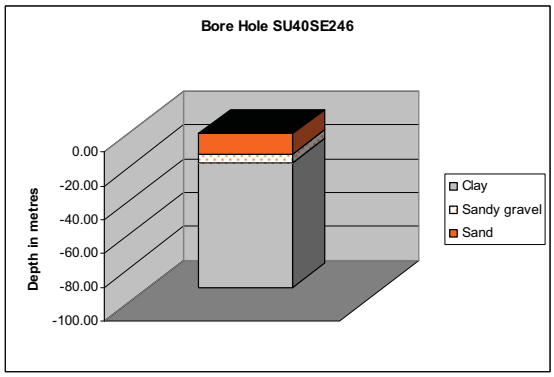


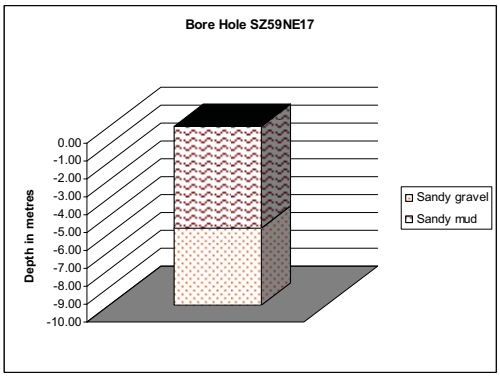


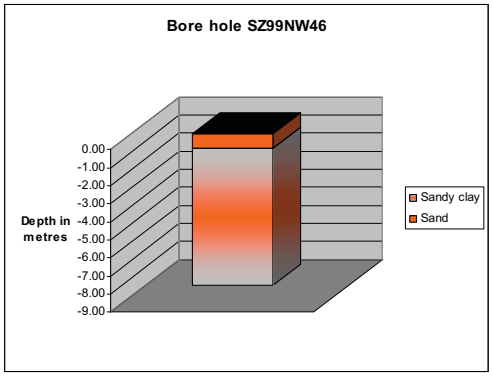


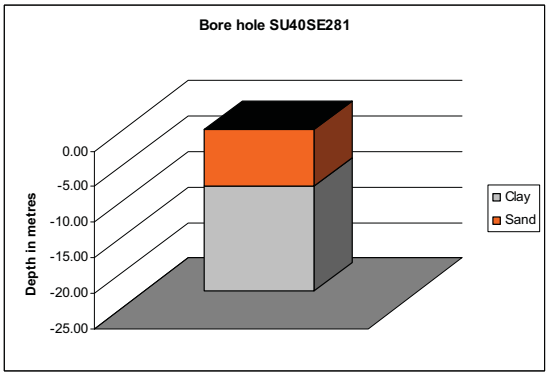


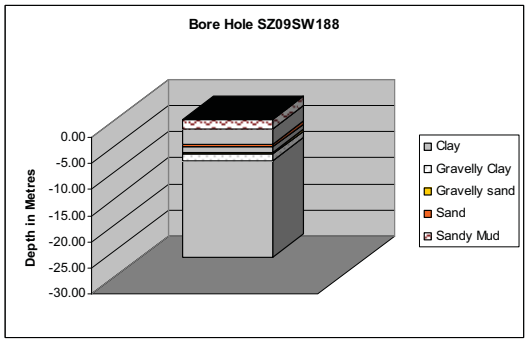


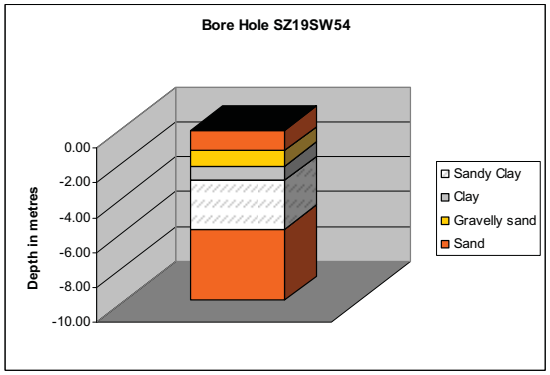


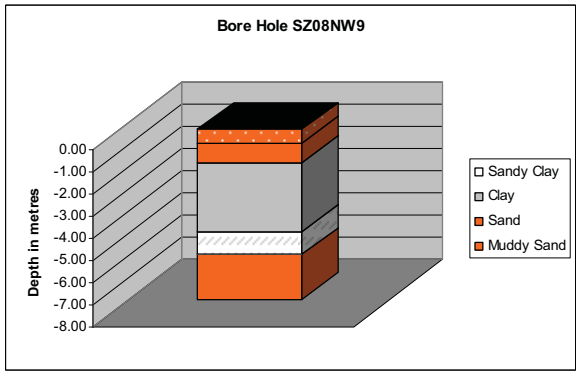


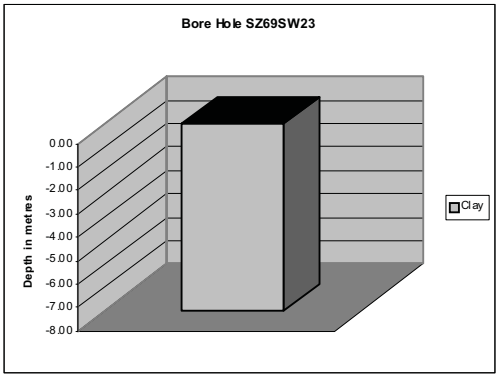


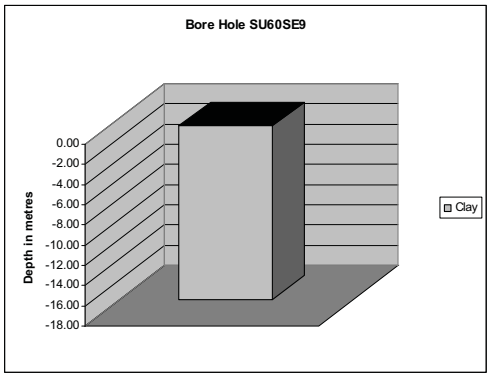




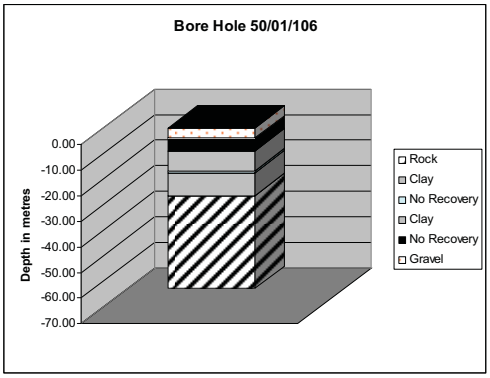








Offshore


Bore Hole 50/01/106
Depth in metres
0.00
-10.00
-20.00
-30.00
-40.00
-50.00
-60.00
-70.00
Rock
Clay
No Recovery
Clay
No Recovery
Gravel

MAPS