AMAP2 – Characterising the potential for Wrecks (5653)

Year 1 Update

Version 1.4

17/02/2011

SeaZone

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SeaZone Solutions Limited,
HR Wallingford,
Howbery Park,
Wallingford,
OXON
OX10 8BA

T: +44 (0) 870 013 0607
F: +44 (0) 870 013 0608

E: info {at} seazone {dot} com

W: http://www.seazone.com

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SUMMARY

This report outlines the interim results at the end of Phase 1 of the *AMAP2 – Characterising the Potential for Wrecks* (AMAP2) project commissioned by English Heritage via the Historic Environment Enabling Programme (HEEP) in December 2009.

The AMAP2 project aims to improve the management of the marine environment through the enhancement of baseline data for marine spatial planning and by providing the basis for a more justified assessment of potential for unrecorded wrecks. This is being sought through the development of a characterisation of the variables affecting the potential for archaeological materials to exist and survive on the seabed.

The characterisation is being developed through the integration of the methodology applied during the *AMAP1 - Refining areas of Maritime Archaeological Potential for Shipwrecks* (AMAP1) with the modelling of marine environmental data based on techniques developed by University of Southampton (UoS), to produce a considered assessment of environmental character on a national scale.

The development of the methodology has been undertaken across a pilot area encompassing the Thames Estuary and Goodwin Sands based on the EU funded MACHU project areas. The aim of AMAP2 is to enhance the methodology for the characterisation of archaeological potential for shipwrecks. This will be done through:

1 - quality testing of previous results

2 - improved baseline information enabling more accurate data analysis

3 - added expertise of staff at SeaZone and the UoS.

The phase 1 update report describes the stages taken in the development of an enhanced methodology for AMAP2 across the trial area and outlines plans for further analysis work required in Phase 2 to development an environmental characterisation of the variable affecting archaeological potential England's continental shelf.

The results of the pilot study have mostly reflected those of AMAP1 while raising some key research questions to be addressed during the main phase of analysis of the project. Similarities were identified in the age bias of wrecks and the relationships between the physical characteristics of wrecks and their environmental parameters. It is anticipated that the assessment of wreck distributions on a National scale will provide clarity in areas where the results between the two differ on a regional scale.

Since the start of the project, SeaZone have been acquired by, and now operates as a trading group of HR Wallingford Ltd, allowing SeaZone to draw upon resources and expertise in HR Wallingford as part of its team. This is proving to be of benefit to the project in a range of areas through the provision of expert input into statistical analysis and the development of sediment transport modelling by UoS.

Abbreviations

ADS – Archaeological Data Service

AMAP – Areas of Maritime Archaeological Potential

AMIE - Archives and Monument Information England

ALSF – Aggregate Levy Sustainability Fund

AMAP – Area of Maritime Archaeological Potential

BGS – British geological Survey

CRS – Co-ordinate Reference System

Defra – Department for the Environment and Rural Affairs

DNF – Digital National Framework

EH – English Heritage

EIA – Environmental Impact Assessment

ESRI – Environmental Systems Research Institute

EU – European Union

GIS – Geographic Information Systems

HER – Historic Environment Record

HTML – Hyper Text Mark-up Language

HWTMA – Hampshire & Wight Trust for Maritime Archaeology

HSC – Historic Seascapes Characterisation

IACMST - Inter Agency Committee for Marine Science and Technology

INSPIRE – INfrastructure for SPatial InfoRmation in Europe

LAT – Lowest Astronomical Tide

MEDIN - Marine Environmental Data and Information Network

MEDAG - Marine Environmental Data Action Group

MDIP – Marine Data Information Partnership

MHW – Mean High Water

MLW – Mean Low Water

MoRPHE - Management of Research Projects in the Historic Environment

UOS – University of Southampton

NHRE – National Record of the Historic Environment

OS – Ordnance Survey

OSGB36 – Ordnance Survey Great Britain 1936, the geographic datum of British National Grid

UKHO – United Kingdom Hydrographic Office

UKLS – UK Location Strategy

SHAPE - Strategic Framework for Historic Environment Activities and Programmes in English Heritage

SMR – Sites and Monuments Record

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1. PROJECT BACKGROUND

1.1 Introduction

SeaZone Solutions Ltd has been commissioned to undertake a two phase project to develop a GIS characterisation of the environmental parameters which determine the potential for wrecks to exist and survive in seabed sediments. The project is being run in collaboration with the University of Southampton (UoS).

This report outlines the results of phase 1 of the project. The *"AMAP2 – Characterising the Potential for Wrecks"* project, seeks in Phase 1 to restructure UKHO wreck data across all English Waters in order to facilitate spatial queries of wreck distributions. Further modelling of environmental data has also been undertaken by the UoS over a series of pilot areas (Goodwin Sands and Thames Estuary). The results of wreck queries applied to the UKHO and NHRE databases have been tested over these areas and compared with results from AMAP1.

This report comprises one of the two key deliverables for Phase 1 of the project, alongside the Phase 1 steering group meeting which was held on 28th July 2010.

1.2 Background

Areas of Maritime Archaeological Potential (AMAP) are areas where 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.

The *Navigational Hazards* project was an Aggregate Levy Sustainability Fund (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 the bearing capacity of different sediment groups.

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 ALSF project *"Refining Areas of Maritime Archaeological Potential for Shipwrecks - AMAP 1"* (Merritt, 2008), funded through English Heritage in 2007/08, sought to enhance the results of the Hazards project by integrating the quantitative analysis of additional marine datasets with the environmental characterization produced for the *Navigational Hazards* project. The method was developed across a pilot area encompassing the Eastern English Channel. The results suggested significant relationships between the distribution of wrecks across the area and some environmental variables. The project design for AMAP 2 was commissioned to assess the presence of these relationships on a national scale taking account of improved data availability and expertise to improve the methodology for characterising archaeological potential.

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. 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.

2. AIMS AND OBJECTIVES

2.1 Project Aims

The primary aim of the project is to improve the management of the marine environment through the enhancement of baseline data for marine spatial planning and by providing the basis for a more justified assessment of potential for unrecorded wrecks. This will be achieved through the

development of a characterisation of the variables affecting the potential for archaeological materials to exist and survive on the seabed.

The characterisation will be developed through the integration of the methodology applied during AMAP1 with the modelling of enhanced marine environmental data to produce a considered assessment of environmental character on a National scale.

2.2 Project Objectives

The main aim of the project will be met by the following objectives:

(1) To extract information from UKHO and NHRE databases for the purpose of the project to optimise attribute queries.

(2) To develop a character map of the environmental variables which affect the potential for shipwrecks to survive in different seabed environments

(3) To improve our understanding and interpretation of archaeological potential for shipwrecks during both industry-led impact assessments and strategic marine planning for aggregate extraction

(4) To develop a working methodology for encouraging a more justified interpretation of potential which may in the future, be applied to other archaeological features

(5) To disseminate the results of the project across a broad range of disciplines including the geospatial, archaeological and marine communities via a series of research papers and a published report.

2.3 Phase 1 Processes

Phase 1: AMAP METHOD ENHANCEMENT

1a. Setting Up and Familiarisation

Familiarisation of project staff with the data and methodology employed for AMAP1, with software packages and with improvements in available marine data

1b. Data Extraction

Extraction of information from UKHO and NHRE wreck data for all English waters, initially over a test area, to optimise the identification of trends in wrecks during spatial analysis.

1c. Environmental Characterisation

Application of the method for characterisation of AMAPs taking account of improved data and lessons learnt during MACHU

Development of an enhanced methodology for characterising AMAPs based on available data and expertise

1d. Trial Area Analysis

Analysis of test area wreck data in conjunction with environmental modelling over trial areas in the Goodwin Sands and the Thames Estuary to enable the relationships identified during AMAP1 to be tested and better understood.

The results of the analysis will provide a basis for the development of a methodology for the analysis and characterisation of the potential for wreck materials to survive in seabed sediments.

3. METHODOLOGY

3.1 Stage 1a: Set-up and Familiarisation

Staff required for the project were already in post within SeaZone along with the necessary data hardware and software.

Initial set-up included the familiarisation of core staff with the AMAP1 methodology and research undertaken via the MACHU project. A meeting was held between SeaZone staff closely involved with the project to discuss the project's phasing and technical requirements including the upload of NHRE data to the AMAP schema in Oracle, mapping between databases and development of bespoke tools to facilitate the extraction process. The NHRE data was uploaded to Oracle to facilitate the use of bespoke Oracle tools to extract information from the NHRE fields, and to enable mapping between the UKHO and NHRE databases to take place.

The UoS identified an ideal candidate for the Masters of Research (MRes) studentship. The student worked to the project brief under the supervision of the project manager (OM) and course supervisor (JKD).

3.2 Stage 1b: Data Extraction

3.2.1 Data Gathering

The datasets gathered for the project during Phase 1 was based on those used for AMAP 1 (Merritt 2008) and reflected a combination of shipwreck data and environmental datasets available in a range of digital and documentary formats.

SeaZone is familiar with a wide range of marine digital data and are involved in the improvement and enhancement of data and the standards used to collate them. With a combined expertise in GIS, Historic Seascape Characterisation method development, oceanography and marine archaeology, the team have a firm understanding of the relationships between human activity and the natural marine environment, and the inconsistencies which exist in available marine datasets.

The project seeks to integrate a combination of shipwreck data and environmental data as follows:

- Shipwreck Data:
    - UKHO wrecks and obstructions
    - NHRE wrecks and reported losses
- Environmental Data:
    - Bathymetry
    - Seabed sediments
    - Marine Bedrock deposits
    - Borehole data
    - Hydrographic Survey metadata
    - Sediment transport model
    - ALSF Navigational hazards

3.2.2 Shipwreck Data

As highlighted in the results of the AMAP1 project (Merritt, 2008), there is considerable scope for using physical information embedded in wreck databases as indicators of the nature of their surrounding environment. The isolation of the physical and circumstantial characteristics of wrecks can highlight relationships between the nature of wrecks and the environmental factors which determine their potential to survive. The project focussed on using data held by the National Record of the Historic Environment (NHRE) and the UK Hydrographic Office as they both provide a

consistent comprehensive coverage of digital data across England's territorial waters. The NHRE database is based within the 12nm limit while the UKHO database contains wrecks out to the limits of the UK continental shelf and beyond.

3.2.2.1 United Kingdom Hydrographic Office (UKHO) Shipwreck Data

The remit of the United Kingdom Hydrographic Office (UKHO) is primarily concerned with gathering and supplying data for navigational safety purposes. The UKHO holds a database of shipwrecks, which therefore contains accurate co-ordinates for each site, site name and date where known, and extensive information on the physical properties of each site, including survey history, information of wreck state and scatter. The data is distributed in digital format via SeaZone.

UKHO shipwreck and obstruction data delivered by SeaZone includes the Hydrospatial Wrecks and Obstructions layers and the wrecks and obstructions database upgrade. The wrecks and obstructions upgrade contains key descriptive attribute fields which contain additional information on the circumstances of loss, survey history and general comments on the state of each site the form it was originally delivered by the UKHO, and provided the basis for the extraction of information from UKHO records. The wrecks and obstruction database contains the UKHO identifiers (HOID), also recorded by the NHRE where known. This common reference enabled the UKHO and NHRE shipwreck records to be joined, to identify previously matched records.

The data was provided by SeaZone referenced to the WGS84 horizontal datum, which is an internationally globally applicable geodetic Co-ordinate Reference System (CRS) (http://www.epsg.org/; urn:ogc:def:crs:EPSG::4326).

3.2.2.2 National Record of the Historic Environment (NHRE) Shipwreck Data

NHRE records of known shipwrecks are available either as individual paper records or in a digital format from the National Monument Record office. Records of reported losses are also held. These records contain reports of ship losses for which a location is not yet recorded on the seabed. The NHRE delivered all known shipwreck records and reported losses from the AMIE database in a digital format for the purpose of the project.

The data was delivered as two shapefiles for each class of record, one for point data and the other for polygons, accompanied by five additional MS Excel spreadsheet containing additional fields.

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 labelled as either HOB_UID or UID.

Each of the files delivered by the NHRE for AMAP2 is described in the table below:

Table 1: Description of contents of AMIE records delivered for the AMAP2 project

File Name	Description	Fields
All SIT Records 11 Nov 2009_AMIEMonumentPoint.shp	Contains mapped records of known wreck sites for ships boats and aircrafts represented as point	HOB_UID, Name, Description, Mon_precis, Capture_sc, Easting, Northing
All SIT Records 11 Nov 2009_AMIEMonumentPolygon.shp	Contains mapped records of known wreck sites for ships boats and aircrafts represented as polygons	HOB_UID, Name, Description, Mon_precis, Capture_sc, Easting, Northing
Casualty Records_AMIEMonumentPoint.shp	Contains mapped records of reported losses of ships and boats, represented as point	HOB_UID, Name, Description, Mon_precis, Capture_sc, Easting, Northing
Casualty Records _AMIEMonumentPolygon.shp	Contains mapped records of reported losses of ships and boats, represented as polygons	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 NHRE. Contains the old and current UKHO identifiers	No field names

3.2.3 Environmental Data

3.2.3.1 Bathymetry & Topography

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* in the form of gridded ASCII files.

3.2.3.2 Superficial Seabed Sediments & Offshore Bedrock Deposits

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) (http://www.bgs.ac.uk/).

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 (1954) triangle classification has been used based on the gravel percentage and the sand to mud ratio (Figure 1).

The data was reclassified following the parameters first developed for the ALSF Navigational Hazards project and used during AMAP1 to reflect preservation potential (Gregory 2007). This classification used sediment grain size and the percentage of gravel content to assess the bearing capacity of the seabed.

The seabed sediment data was also reclassified following the grouping used for UKSeaMap to produce a more generalised representation of sediment grain size while employing a simplified version of the Folk classification approach which is more focussed towards the EUNIS habitat classification system and was developed for UKSeaMap as part of the MESH project (http://jncc62new.wisshost.net/pdf/UKSeaMap2010_Initial_report.pdf).

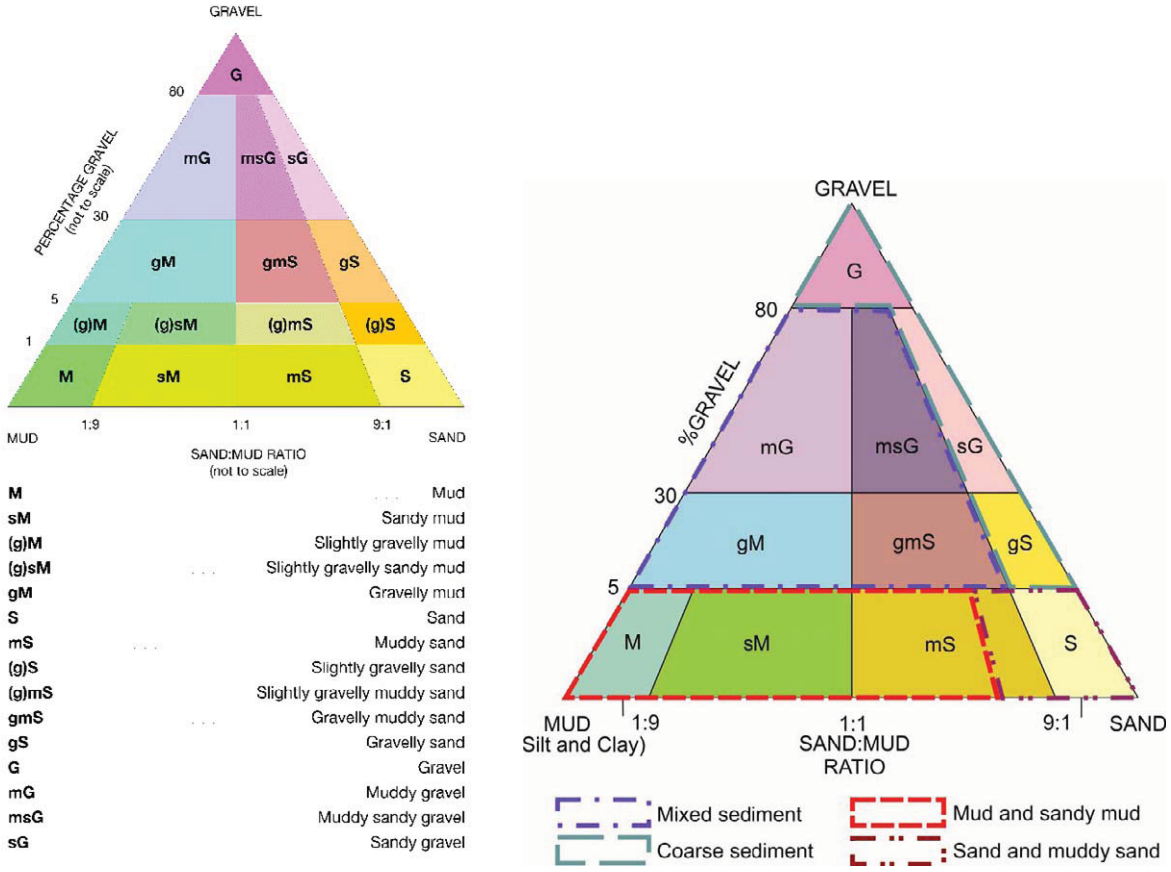
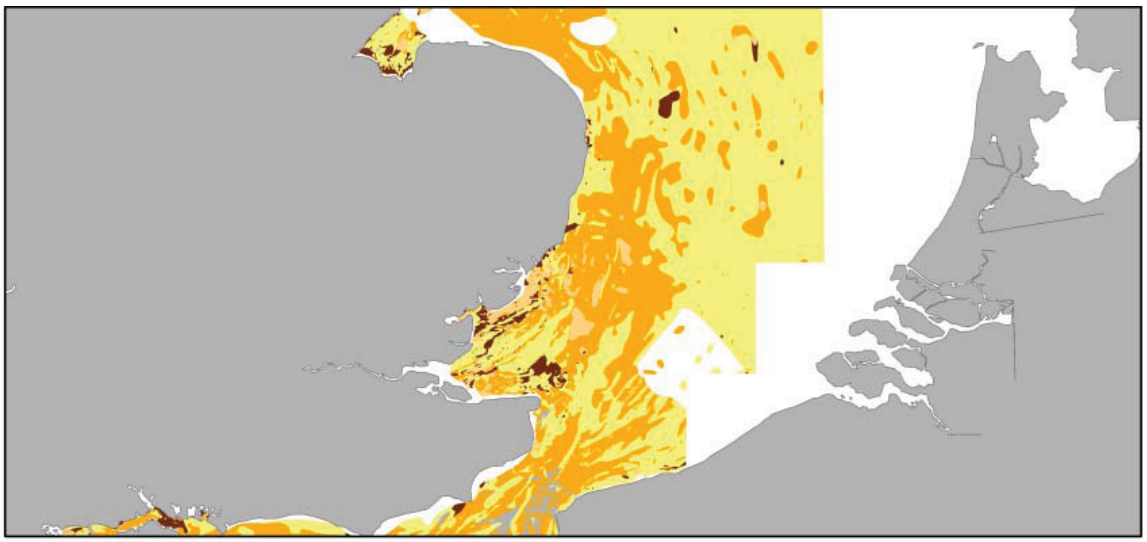


Figure 1: Diagram depicting the R.L. Folk classification (1954) for sediment types used by the BGS and the MESH reclassification



3.2.3.3 Seabed Sediment Depth

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 AMAP1 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.

At the start of the AMAP2 project, the British Geological Survey (BGS) was contacted to discuss potential sources of data for mapping sediment thickness. The BGS delivered a series of digital

scans of Sediment Thickness Inset maps which are published on the SBS & Quaternary map sheets. The map sheets were reviewed to identify those potentially containing information which could be used to produce a generalised map of sediment thickness.

The tiles required were digitised to produce a series of shapefiles containing discrete vector polygons for each tile which could be used alongside other environmental datasets in ArcGIS.

The maps provided by the BGS vary in their scale range and were therefore difficult to pull together as a single dataset.

The primary objective for AMAP2 is to differentiate between areas of very shallow sediment, too shallow to bury an intact wreck, and deeper sediment. The sediment thickness tiles were therefore classified to reflect the following categories:

- 0-1m (green)
- 1-5m (orange)
- 0ver 5m (dark orange and red)

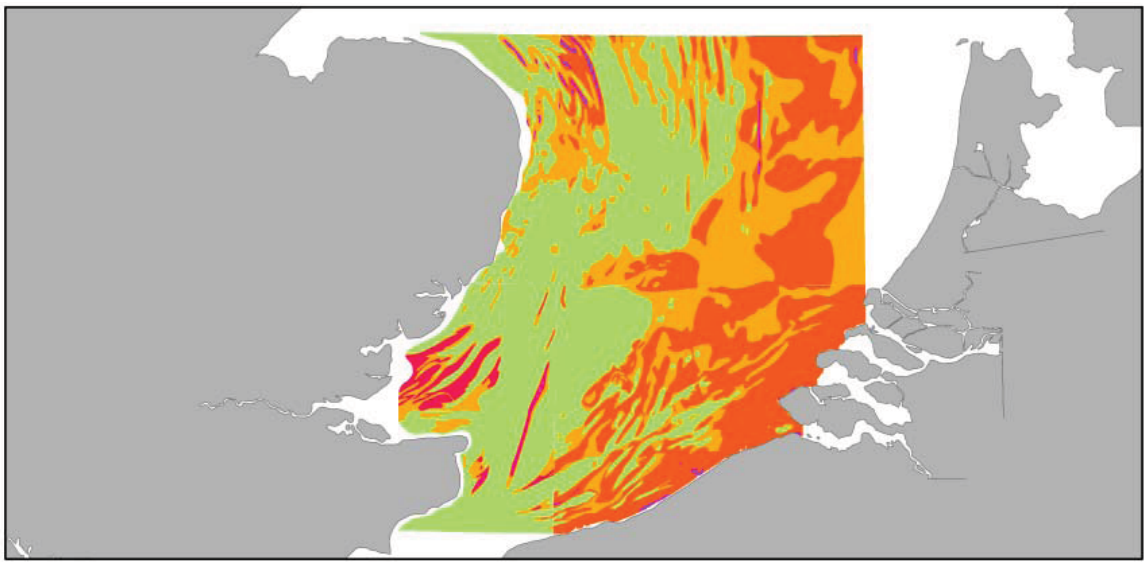


Figure 2: Seabed sediment thickness derived from BGS mapsheets.

The scale ranges do vary between tiles provided by the BGS so the classification of sediments may vary when the dataset is extended to cover the rest of England's part of the continental shelf. The primary objective of the classification is to differentiate between areas characterised by very shallow sediment and areas where sediment could be deep enough for considerable burial of large objects to occur.

3.2.3.4 Hydrographic Survey Metadata

In the initial project proposal for the AMAP1 project it was anticipated that the assessment of known wrecks and obstructions in the context of hydrographic and geophysical survey metadata may help identify biases in the wreck data due to variations in the resolution and regularity of surveys undertaken across different seabed areas. Relationships between wreck scatters and the resolution of survey were thought to occur in the results of AMAP1.

SeaZone maintain a record of Digital Survey Bathymetry extent polygons, regularly updated as new surveys delivered by the UKHO are integrated as part of SeaZone products. SeaZone have been capturing survey extents from all survey sheets used during the in-house enhancement of digital bathymetry, producing a dataset which has greatly improved since the completion of AMAP1. This hydrographic survey metadata (Figure 3) provides valuable information on the biases in survey coverage and resolution which may affect the distribution of shipwrecks identified. Such data was used during AMAP1 and is proving to be useful in assessing patterns in wreck distributions for AMAP2.

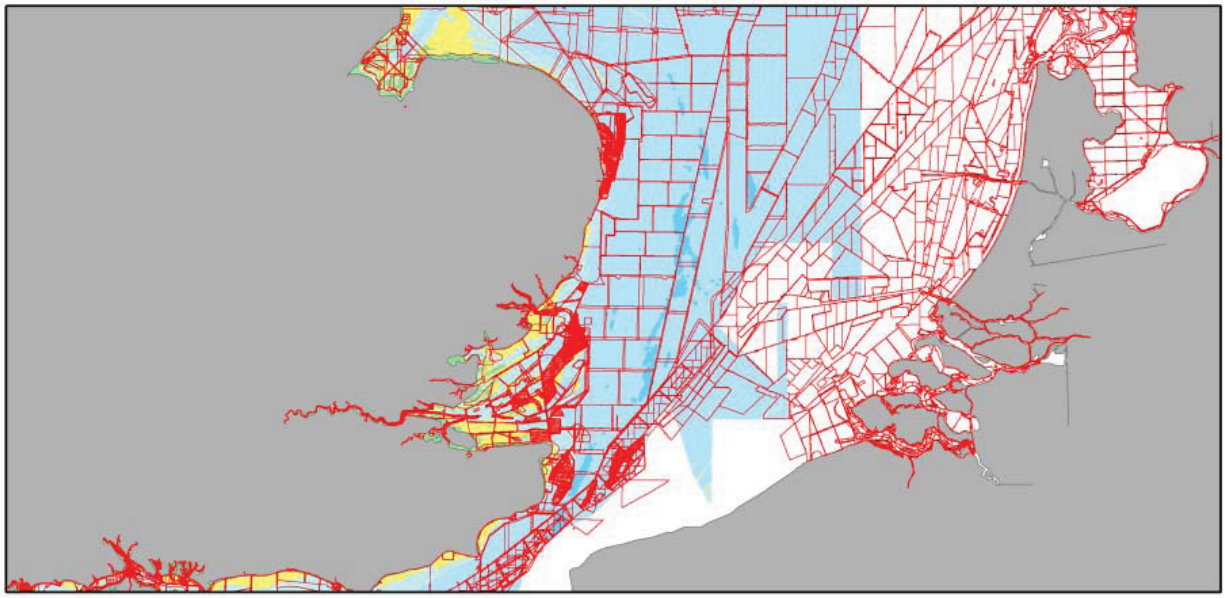


Figure 3: map showing coverage of hydrographic survey extents across the pilot area

3.2.3.5 Sedimentation-erosion model

The purpose of the numerical sedimentation-erosion model is to provide a regional scale backdrop of seabed conditions to cultural managers of archaeological sites, for use in conjunction with and as a context for guidelines developed for site scale management. The final outputs from the model are a description of the net sediment transport pathways and the nature of gross and/or sudden changes in seabed level (erosion or accumulation) as a response from either ambient tidal and wave conditions or extreme conditions (the passage of a storm through the area), as well as information of the direction and magnitude of sediment transport (e.g. Figure 4).

These outputs are derived from calibrated modelling of the direction and magnitude of tidal and wave induced currents and their interaction with different sediment fractions on the seabed. This project has used the Danish Hydraulic's Institute MIKE 21 2D hydrodynamic and sediment transport software, but the approach taken could be applied to a range of commercially available products. The MIKE 21 model produced decoupled hydrodynamic and sediment transport models (i.e. the output from the hydrodynamic model was exported and then used as input conditions to the sediment model. A coupled hydrodynamic-sediment approach is available (i.e. the two models run interactively) but the run times are considerably longer so were not used in this instance. Two versions of the hydrodynamic model were developed: a tidal current only version and a tide and wave current version.

The model requires a number of different inputs and starting parameters including: the land boundaries; bathymetry; open water tidal inputs; the seabed sediment distribution; the "roughness" of the seabed (a composite parameter of the small scale seabed morphology [e.g. ripples and sand waves] and surface grain size); the wind/wave regime; the mesh resolution to define the spatial output of the calculated hydrodynamic and sediment dynamic properties; and the time steps and time period over which the model should run.

SeaZone provided UoS with enhanced bathymetric models for the Thames Estuary and Goodwin Sands, enabling the generation of enhanced models across the AMAP2 pilot areas. A coarse model of sediment transportation was also generated across the full project area, although work to improve the resolution of this data is currently under discussion between SeaZone, HR Wallingford and UoS. Once inputs have been defined the model will require an iterative approach within the timeframe and scope of AMAP2 to model calibration and validation prior to producing the GIS compatible outputs.

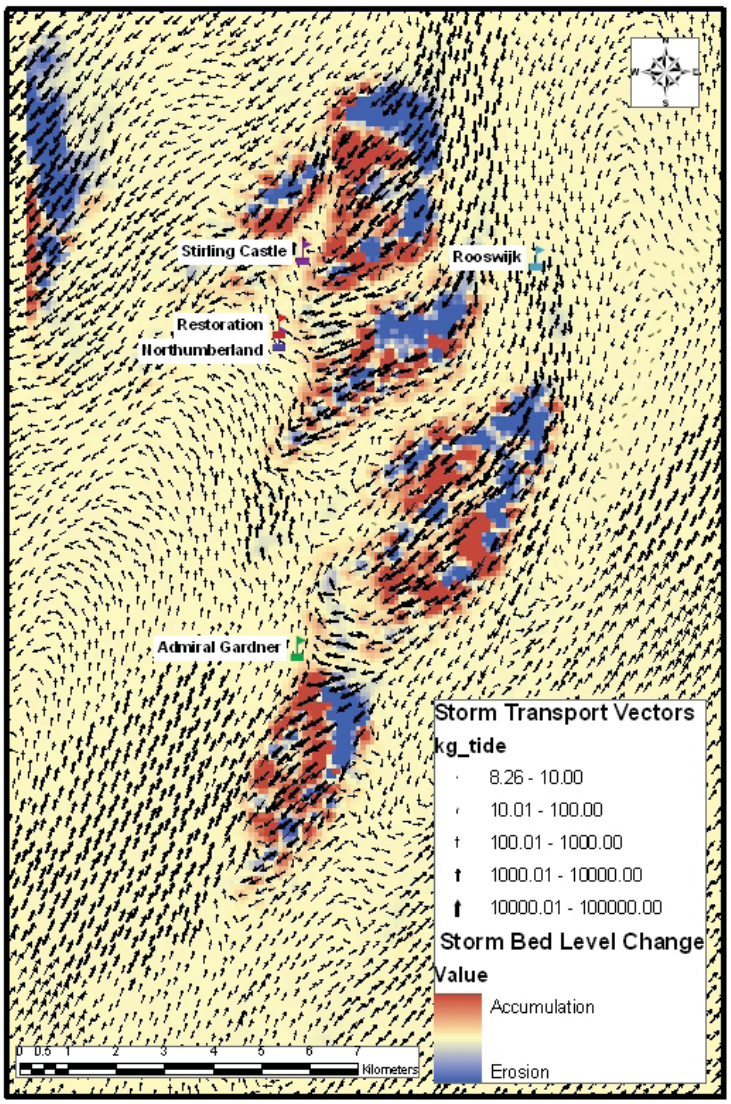


Figure 4: Bed Level Change and sediment transport magnitude and direction for the Goodwin Sands.

3.2.3.6 ALSF Navigational Hazards

The results of the Navigational Hazards project were delivered to English Heritage as an ArcGIS Map Document (.mxd) file and associated geodatabase. This data will provide the foundation for developing an enhanced GIS, using the same approach adopted for AMAP1. The database contains a characterization of areas where a high level of risk to shipping coincides with a high potential for preservation.

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.

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. There is a great deal of scope for integrating this analysis with other environmental parameters which affect site formation. Further investigation of these options will made during the second phase of the project in collaboration with the UoS.

3.2.4 Wreck Data Processing

3.2.4.1 Data preparation

To facilitate the extraction of wreck data, the information within each of the wreck databases was brought together in a project specific Oracle schema, enabling the source data to be mapped to a

structure suitable for comparing information held within common fields and integrating the best available information from the two datasets into a single AMAP wrecks attributes table (Figure 5).

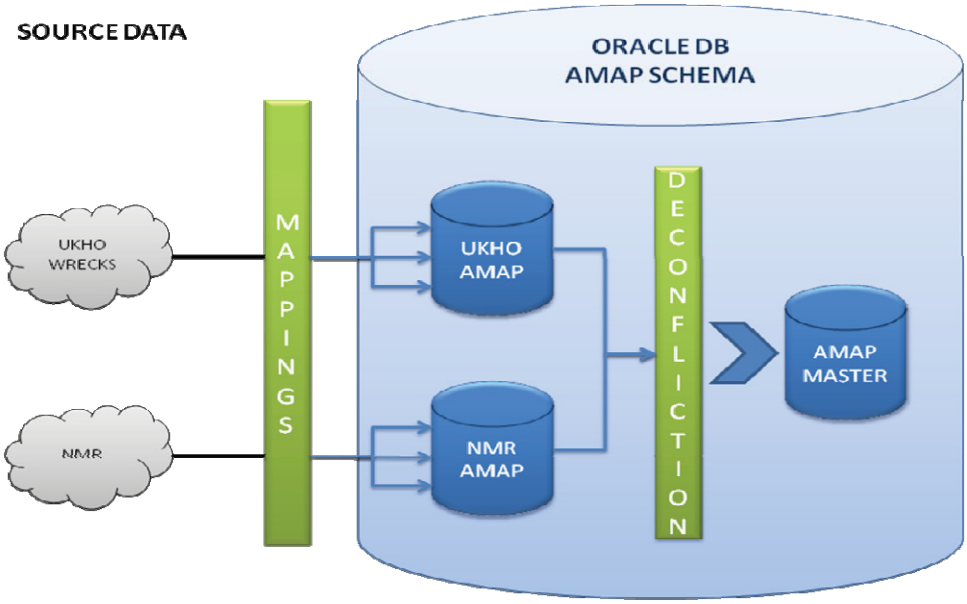


Figure 5: Diagram showing the processes required in the upload of UKHO and NHRE data to the AMAP schema

NHRE database was uploaded to the SeaZone Oracle database to enable the data to be viewed as a single flat file. The wreck data provided by the NHRE was delivered as a series of MS Excel spreadsheets which related back to unique site identifiers (HOB_UID). During the data upload, it was noted that many of the tables reflected a one-to-many relationship with the HOB_UID. Of particular note was the presence of multiple attributes within a table which relate to a single record. In most cases, these sites tended to be intertidal sites where a logboat find was accompanied by a findspot for instance. In these instance multiple dates, evidence, material and identification methods could be associated with a single HOB_UID.

The use of a site identifier rather than a feature identifier removes the presence of a unique identifier to which individual information is associated. To ensure no information was lost when joining the attributes to the AMIE points and polygons, the tabular information was divided into individual sites and given a unique identifier using changes in phase class (DAT_MAX, DAT_MIN) as an indicator of the potential for multiple sites. This approach however produced duplicate records where a record contained a value for one field but not the other.

AMIE data was uploaded to Oracle and associated to the geometries in the GIS layers provided by the NHRE, using the HOB_UID to produce the following structure:

```
ID                NUMBER(16),
NMR_NAME          VARCHAR2(100),
NMR_YEAR_OF_LOSS  NUMBER(10),
NMR_PERIOD        VARCHAR2(100),
NMR_MONUMENT      VARCHAR2(300),
NMR_VESEL_TYPE    VARCHAR2(100),
NMR_PROPULSION    VARCHAR2(100),
NMR_CARGO         VARCHAR2(300),
NMR_MATERIAL      VARCHAR2(300),
NMR_CONSTRUCTION  VARCHAR2(100),
NMR_LOSS_EVENTS   VARCHAR2(300),
NMR_CONDITION     VARCHAR2(100),
NMR_BURIAL        VARCHAR2(100),
```

```
NMR_DETECTION     VARCHAR2(100),
NMR_HOBUID        NUMBER(10),
NMR_DESCRIPTION   VARCHAR2(4000),
SEED_ID           NUMBER(20),
UPDATED           DATE,
OBJL              NUMBER(10),
GEOMETRY          SDO_GEOMETRY,
HOID              NUMBER(10));
```

Once both databases were uploaded to the Oracle database, they were mapped to a project-specific schema following a data specification designed for the AMAP2 project. This involved identifying equivalent fields between UKHO and NHRE databases and the structure of data fields required for AMAP (Table 2). This highlighted fields of information shared by both databases and those which were unique to one or the other.

Table 2: Relationship table between key fields held within the UKHO, NHRE and AMAP wreck databases

UKHO	UKHO_AMAP	NMR	NMR_AMAP	AMAP_MASTER
NAME	UKHO_NAME	NAME	NMR_NAME	AMAP_NAME
DATE_SUNK	UKHO_YEAR_LOSS	MIN DATE (WHERE EMPTY, USE MAX DATE)	NMR_YEAR_LOSS	AMAP_YEAR_LOSS
		PERIOD	NMR_PERIOD	AMAP_PERIOD
SZ_FEATURE	UKHO_MONUMENT	MONUMENT TYPE	NMR_MONUMENT	AMAP_FEATURE_TYPE
TYPE_OF_OBSTRUCTION	UKHO_VESSEL_TYPE	MARITIME CRAFT TYPE	NMR_VESSEL_TYPE	AMAP_VESSEL_TYPE
TYPE_OF_OBSTRUCTION	UKHO_PROPULSION	PROPULSION	NMR_PROPULSION	AMAP_PROPULSION
CARGO, CIRCUMSTANCES OF LOSS	UKHO_CARGO	CARGO	NMR_CARGO	AMAP_CARGO
CIRCUMSTANCES_OF_LOSS	UKHO_MATERIALS	OBJECT MATERIAL	NMR_MATERIAL	AMAP_MATERIAL
		CONSTRUCTION	NMR_CONSTRUCTION	AMAP_CONSTRUCTION
CIRCUMSTANCES_OF_LOSS	UKHO_LOSS CAUSE			AMAP_LOSS1
CIRCUMSTANCES_OF_LOSS	UKHO_SECONDARY_ACTION	MANNER OF LOSS	NMR_LOSS2	AMAP_LOSS2
WATER_LEVEL_EFFECT	UKHO_EXPOSURE			AMAP_EXPOSURE
GENERAL_COMMENTS	UKHO_CONDITION	EVIDENCE	NMR_CONDITION*	AMAP_CONDITION
GENERAL_COMMENTS	UKHO_BURIAL	EVIDENCE	NMR_BURIAL*	AMAP_BURIAL
GENERAL_COMMENTS	UKHO_INCLINE			AMAP_ORIENTATION
GENERAL_COMMENTS	UKHO_SCOUR			AMAP_SCOUR
GENERAL_COMMENTS	UKHO_GEOMORPHOLOGY			AMAP_GEOMORPHOLOGY
TYPE_OF_OBSTRUCTION	UKHO_FUNCTION			AMAP_FUNCTION
ORIGINAL_SOURCE	UKHO_SOURCE	EVIDENCE	NMR_DETECTION*	AMAP_DETECTION
~~HOID~~	~~UKHO_HOID~~	~~HYDROGRAPH~~	~~NMR_HOID~~	~~AMAP_HOID~~
~~SZID~~	~~UKHO_SZID~~	.	.	~~AMAP_SZID~~
.	.	~~HOB UID~~	~~NMR_HOBUID~~	~~AMAP_HOBUID~~
GENERAL_COMMENTS	UKHO_GENERAL_COMMENTS			
CIRCUMSTANCES_OF_LOSS	UKHO_CIRCUMSTANCES_OF_LOSS			
		DESCRIPTION	NMR_DESCRIPTION	

The wreck data review undertaken for AMAP1 (Merritt, 2007) highlighted the range and quality of information which could be drawn from the databases. Some fields are structured around controlled vocabularies (based on S-57 standards for the UKHO database and INSCRIPTION for the NHRE database) while others contain descriptive texts.

The AMAP1 method was built upon through the generation of additional data fields, including one recording geomorphological characteristics where possible and through the addition of new terms. The schemas were developed using controlled vocabularies where possible and developing controlled values for newly created attributes and fields. These have been highlighted in the table below (Table 3).

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

AMAP_CONDITION	AMAP_BURIAL	AMAP_INCLINE	AMAP_SCOUR	AMAP_GEOMORPHOLOGY	AMAP_MATERIALS	AMAP_LOSS_TYPE	AMAP_SECONDARY_ACTION
Intact	Exposed	Upright	Yes	Sandwaves	Wood	Military	Abandonment

AMAP_ CONDITION	AMAP_ BURIAL	AMAP_ INCLINE	AMAP_ SCOUR	AMAP_ GEOMORPHOLOGY	AMAP_ MATERIALS	AMAP_ LOSS_TYPE	AMAP_ SECONDARY_ACTION
Mainly intact	Partly buried	Inverted	No	Bedrock	Steel	Accidental	Capsize
Partly broken	Mostly buried	On side		Fine sediment	Iron	Other	Drifting
Well broken	Buried	Broken up		Coarse sediment	Metal		Salvage
Debris field		Listing		Mud	Aluminium		Capture
					Concrete		Dispersed
					Composite		Collision
					Plastic		Grounding
					Fibre glass		Explosive charge
					Ferro-concrete		Structural failure
					Wood-iron		Explosion
							Cargo shift
							Founder
							Fire
							Torpedo
							Gunfire
							Scuttling

3.2.4.2 Data Extraction

The classification of UKHO and NHRE wreck data was undertaken for all English waters to optimise the extraction of trends in wrecks during spatial analysis and ensure that the results are reflected on a national scale.

A great deal of useful information held within the UKHO database is embedded within descriptive string fields such as "GENERAL_COMMENTS" and "CIRCUMSTANCES_OF LOSS". An Oracle based tool was developed internally to facilitate the extraction of data from such fields (Figure 6).

The tool enabled the contents of fields to be checked for spelling. Key words can then be searched for via SQL queries or using a search box to identify all records containing specific terms or phrases within a chosen field. This process essentially formalises the approach taken for the AMAP1 project where SQL queries were applied directly to shapefiles via ArcGIS. The results were fed directly into the UKHO_AMAP table within the schema.

Once the optimum level of information had been extracted from both databases and structured according to the AMAP schema, the databases were linked via the UKHO identifier recorded within both datasets.

Attribute queries were applied to the data using ArGIS to filter out wrecks of shared characteristics, such as all records of vessels recorded as buried and partially buried or all records of vessels recorded as broken up and dispersed.

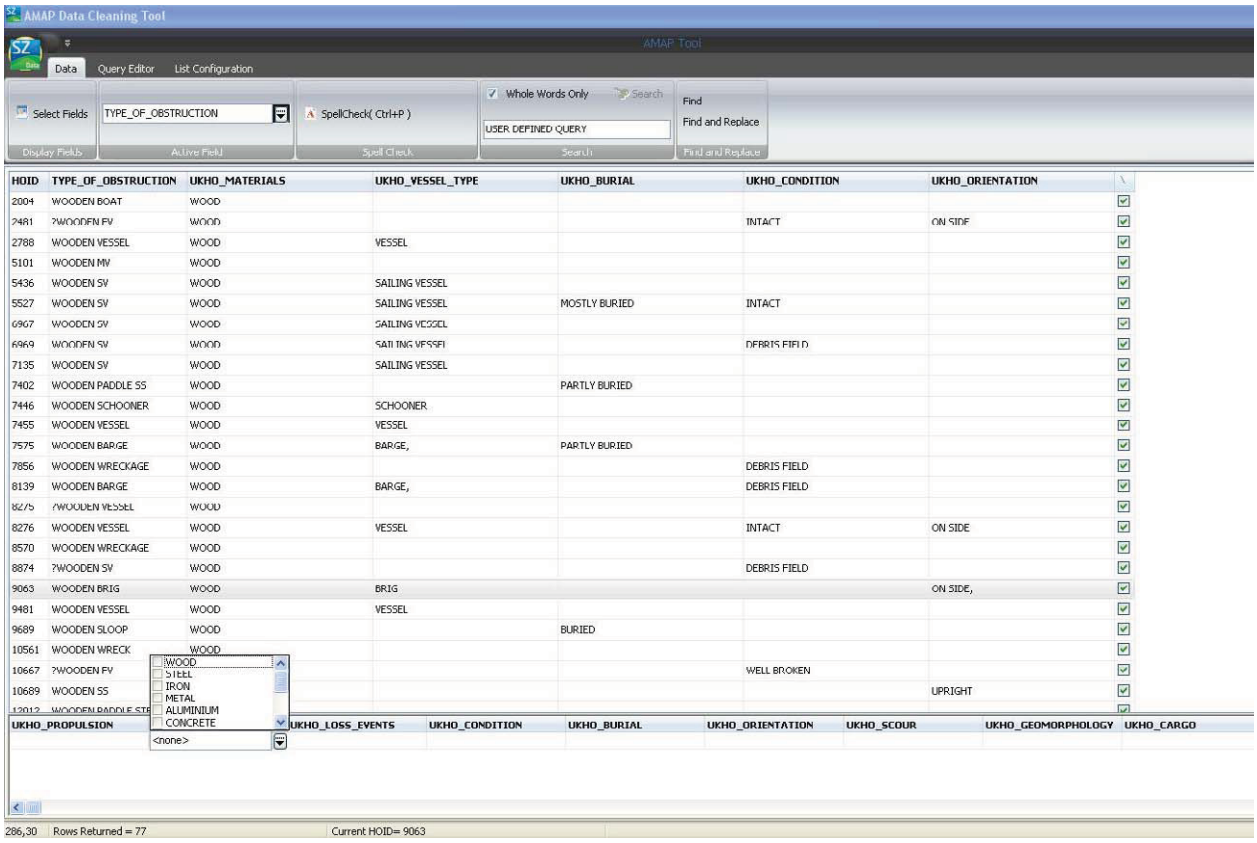


Figure 6: Data extraction tool used to spell-check, then filter valuable information out of the UKHO database and into the AMAP schema

Where information was held exclusively by only one data provider, queries were run on that dataset alone, as per the method used for AMAP1. Where information was drawn from both databases, the values had to be compared to ensure that the best available data was available before spatial analysis. This improved the method used during AMAP1 where queries were run on the largest datasets possible where comparable information existed, due to the complexities of deconflicting the data. Where conflicts cannot easily be resolved, these will be fed back to the *Enhancing the NMR* project for resolution during its second phase.

3.3 Stages 1c: Environmental Characterisation

The modelling of environmental marine data was undertaken by the UoS via an MRes student. This has enabled the project team to further develop the methodology employed for MACHU across the Goodwin Sands and Thames estuary, while providing opportunity for a suitable candidate to undertake original research under the close supervision of a range of experts.

The aim of this stage was to enhance the modelling of environmental data for AMAP, and compare the results with density analyses of wreck data during the analysis stage (1d.) The environmental characterisation during phase 1 was undertaken via the following stages:

1 – Review new environmental data available from BGS, SeaZone and MACHU project

2 – Train the researcher in the range of software packages required to undertake the work, including MIKE21, ArcGIS, Cadcorp SIS and BathySIS

3 – Identify research questions to guide the enhancement of environmental models, in communication with project staff

4 – Undertake modelling of environmental data in project pilot areas

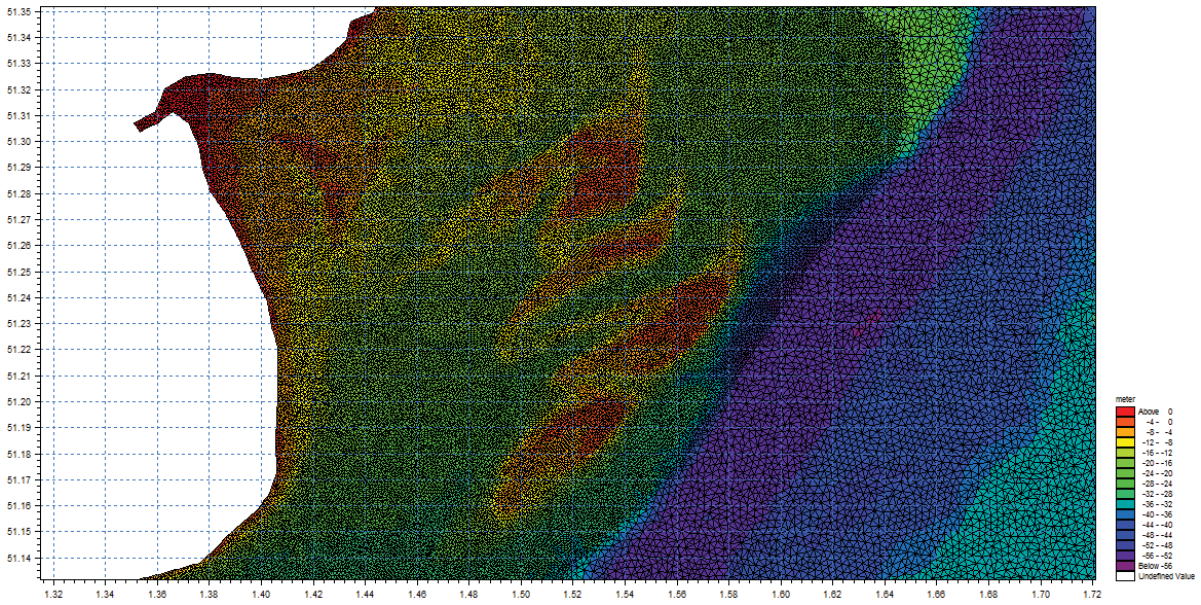


Figure 7: Output of sediment transport model across the Goodwin sands showing direction and amplitude of sediment movement

3.4 Stages 1d: Trial Area Analysis

Following the extraction of information from the wreck data during stage 1b, density maps reflecting different trends in shipwreck characteristics were produced. This analysis highlighted concentrations in the spatial distribution of wrecks which for instance, were timber built or whose physical remains are scattered.

The density analyses of wrecks were compared with environmental data for the Goodwin Sands and Thames Estuary pilot areas. The results were also compared with those from AMAP1 to proof test the original relationships identified between trends in the condition and state of wrecks on the seabed and the environmental parameters which affect them.

The analysis of wreck data building on the AMAP1 methodology provides an assessment of spatial relationships on a broad scale, looking at distributions of shipwrecks on a national level and comparing them to often low resolution environmental datasets.

The sediment transport models generated by UoS enable a much higher resolution assessment of bed level changes in the marine environment and allow the relationships between the sediment movement and the characteristics of shipwrecks to be compared on a much smaller scale.

The biases in information drawn from the wrecks databases restricts the assessment of wrecks on too local a scale as the information held on the condition and characteristics of wrecks remains absent from many records. The approach used for MACHU resolved this issue through the investigation of sites designated under the Protection of Wrecks Act 1974, for which a much greater level of data is usually available.

The analysis of data across the pilot area focused 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 (Figure 1). The methodology for characterising AMAPs has been further developed by looking at a more quantative approach to analysis using statistical analysis and spatial regression analysis to better demonstrate relationships between wrecks and their environments.

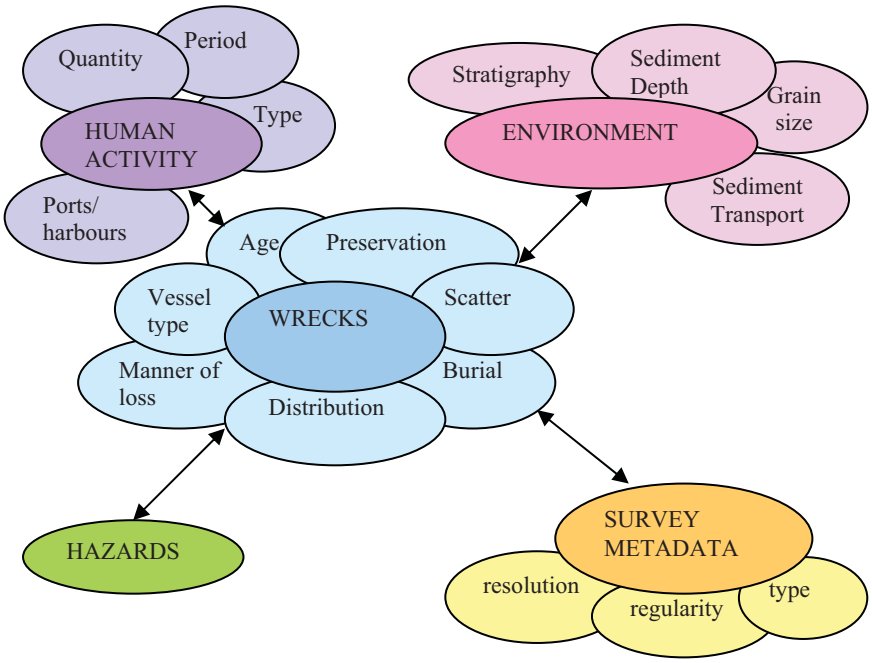


Figure 8: Diagram demonstrating the network of relationships between the available datasets and wreck data which affect the potential for wrecks to exist and survive on the seabed.

The methodology used for data analysis is based on the approach used during AMAP1. Therefore, following the integration of NHRE and UKHO wreck databases and separation of historical and environmental attributes into new field structures via the AMAP schema, a series of attribute queries were run to highlight wrecks with similar characteristics. The queries used across the pilot areas are as follows:

- iron or steel vessels
- wooden vessels
- vessels recorded as being intact
- vessels recorded as being broken up or dispersed
- vessels recorded as buried or partially buried
- vessels recorded as exposed or mostly exposed
- wrecks by period
- ships by manner of loss

The results of these queries were processed using the ESRI ArcGIS Spatial Analyst Density tool to generate raster density maps of wrecks shared characteristics.

The results were compared with the environmental data collated using a similar approach to that employed during. These datasets will be collated with the aim of reflecting the following environmental variables:

- Sediment type/grain size
- Sediment depth
- Sediment transport
- Water depth

The environmental characterisation will be generated later in the project following the review of spatial and statistical relationships identified across the full project area.

4. RESULTS

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 refinement of AMAPs has been undertaken through the quantitative analysis of groups of wrecks as outlined below in the context of environmental and circumstantial variables.

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 8. The distribution of wrecks was also assessed by overlaying wreck point data and running attribute queries to gain an understanding of their distribution in relation to physical and environmental parameters.

Following the analysis of relationships between wrecks and their parameters over the pilot areas, the environmental data collated will provide a basis for producing an environmental characterisation of the parameters affecting wrecksite formation processes with wreck density analyses.

4.1 Data Analysis

4.1.1 Introduction

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. In the first instance, records

Two approaches have been used to assess relationships between wreck related parameters. Statistical analysis of the relationships between the physical characteristics of wrecks was undertaken using simple relationship tests such as Spearman Rank and regression analyses.

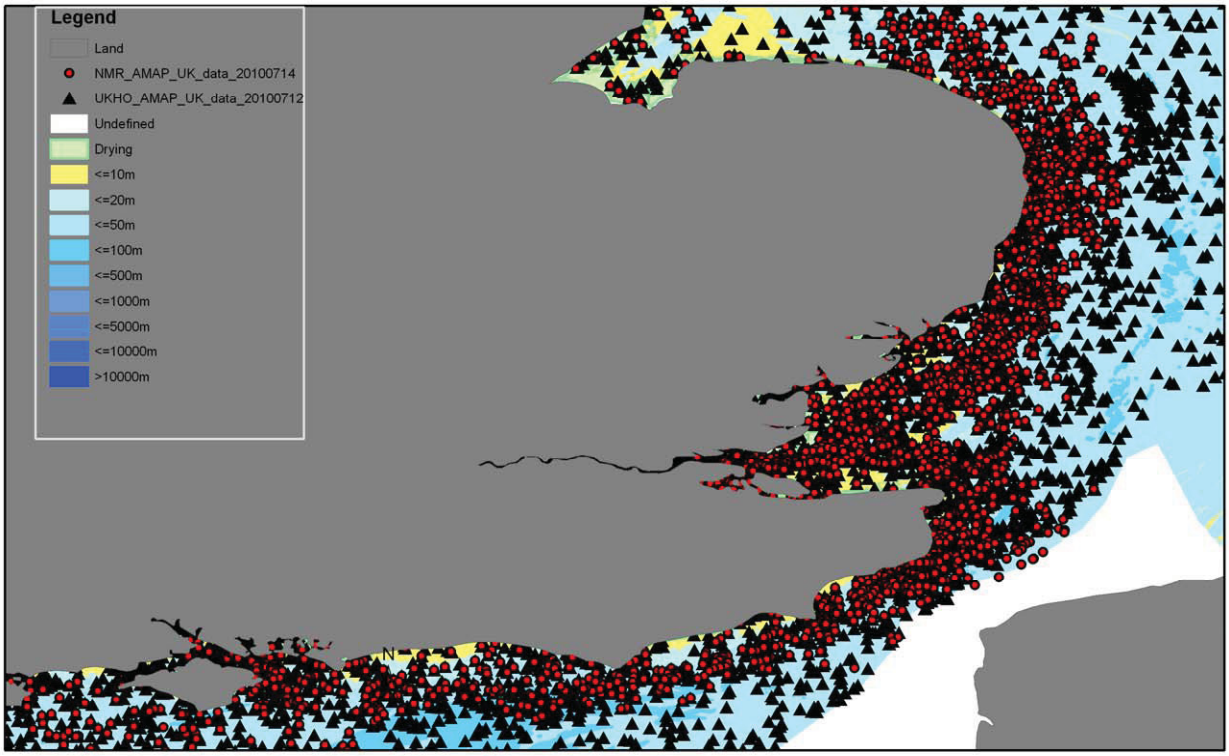
The spatial analysis was then applied between wreck properties and environmental parameters. The refinement of AMAPs has been undertaken through the quantitative analysis of the available datasets outlined bellow within the project study area in order to identify the relationships between them. The coverage of the two databases differs as the UKHO record wrecks lying in UK territorial waters and beyond, while the English Heritage remit include English waters out to the 12nm limit (Map 1a).

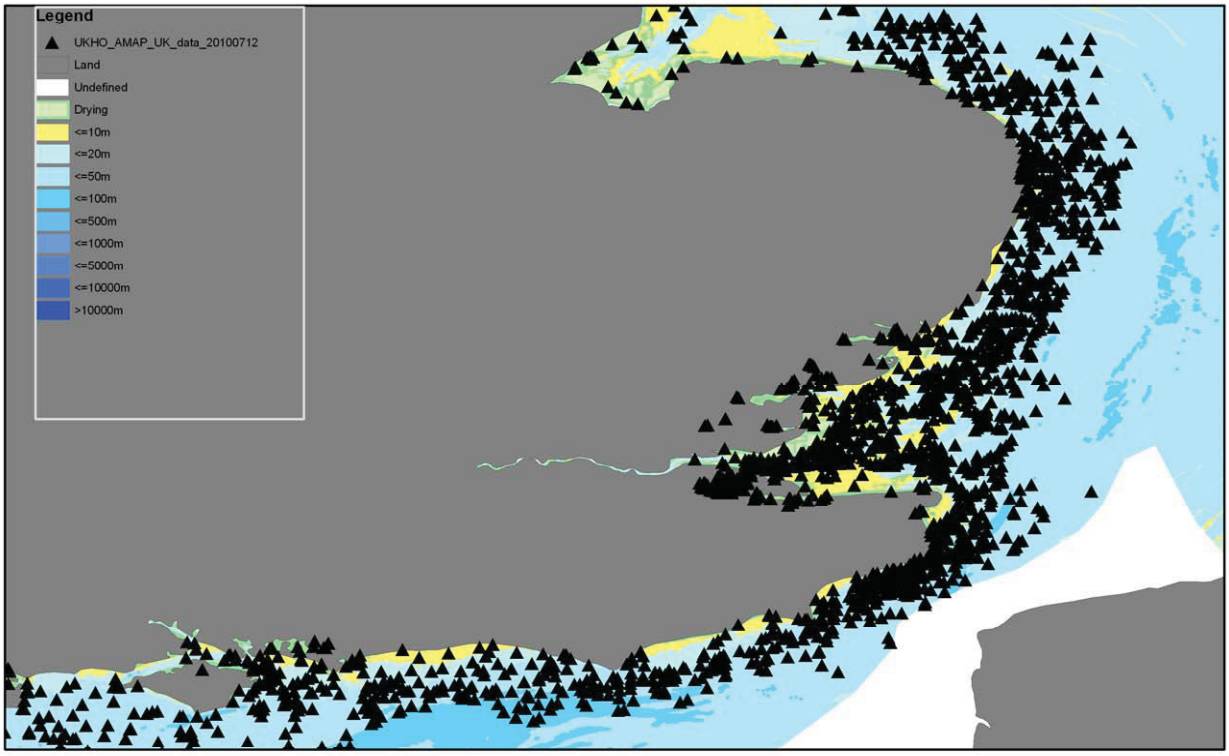
4.1.2 Wreck Data Assessment

During the initial joining of UKHO and NHRE wreck databases in the AMAP schema using the commonly recorded UKHO unique identifier (HOID), an assessment was undertaken of the quality of available matching records (map 1b). The results were used to inform the project regarding estimated best available results, to identify areas where data overlapped or conflicted and to feed the results back to the *Enhancing the NMR* project run in parallel by Maritime Archaeology Ltd. The figures below provide insight into the number of errors on a national scale, providing context to the results of the work undertaken across a series of case-study areas by Maritime Archaeology Ltd (see Dellino-Musgrave 2010).

The analysis was undertaken using the same methodology employed for the AMAP1 Shipwreck Data Review (Merritt, 2007) and the first phase of the *Enhancing the NMR* project (Dellino-Musgrave 2010). The results are summarised as follows:

National scale data joins: HOID):		**Relationship counts (HOBUID :**	
UKHO wrecks	23025	1:1	4774
NMR wrecks	5799	2:1	97
Total HOBUIDs linked	4788	1:2	14
Total HOIDs linked	4749		
No. NMR Obstructions	138		
No. Linked with different name	3656		





Map 1a - UHKO and NMR wreck distributions and coverage
Map 1b - Coverage of matched UKHO and NMR records
Characterising the Potential for Wrecks - AMAP2

October 2010

N

0 20 40 80 Km

Scale (1:2,500,000 @ A4)

Coordinate Reference System:
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

The results showed that a large proportion of records held in AMIE in English waters have a recorded equivalent UKHO record (4991/5799) (Map 1b). The analysis did highlight cases of one-to-many relationships existing in both directions between the databases, making the numbers of matching records difficult to verify. The assessment suggested that a total of 4774 records could be matched via a 1:1 relationship while the total number of UKHO records with a match is 4749 and the total number of AMIE records with equivalent UKHO UIDs was counted at 4788. A further 138 UKHO obstructions were recorded as having equivalent AMIE records.

An assessment of the number of matched records with exact matching names was comparatively low as also shown via the *Enhancing the NMR* project and previously in AMAP1. This is primarily due to variations in the recording standards for site names and vessel types between the UKHO and NHRE. However, cases of errors in the association between two records have been identified, where vessels had an entirely different name and date of loss.

The results of the analysis undertaken during this project supported those of the *Enhancing the NMR* project. The latter took place across a series of case-studies, leading to the submission of a further round of project research to investigate and resolve where necessary potential inconsistencies between the UKHO and NHRE databases (see Dellino-Musgrave 2010).

4.1.3 Wrecks by Period and Construction

Wrecks were first queried to highlight their distribution with respect to their age. Wrecks were grouped using the following categories:

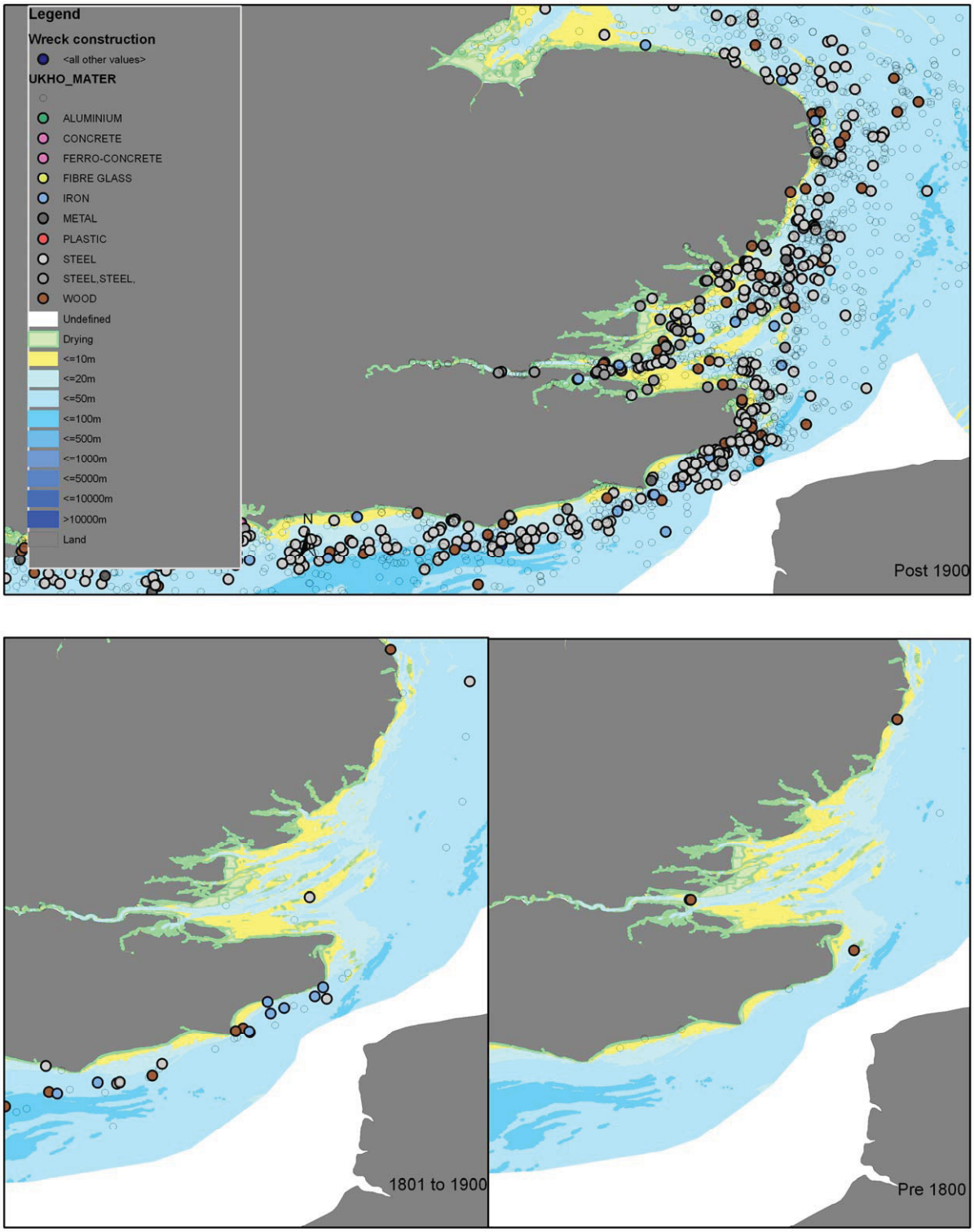
- 1900 onwards
- 1800 to 1899
- Pre 1800

The results reflected those of AMAP1, showing a strong correlation towards modern vessels. When displayed by their primary construction materials, the results showed a bias towards wooden construction for pre 1800 wrecks. This however was not so clearly reflected in modern vessels (Map 2).

The correlations identified spatially were verified using statistical correlation tests which confirmed the bias and relationships between material construction and age.

The comparison between the results along the South Coast of England bounding the Eastern English Channel with those in the Thames Estuary and Goodwin Sands showed a distinct lack of pre-1900 wrecks in the Thames Estuary. It was anticipated that this could have been due to channel maintenance leading to the removal of many sites. However, the number of wrecks recorded by the UKHO as having been removed (STATUS=LIFT) was also very low. The proportion of wrecks recorded as DEAD, meaning that following initial identification during hydrographic survey, they were not found during subsequent surveys. This may be due to the dynamic nature of the seabed in the Thames Estuary and approaches leading to repeated exposure and re-burial which may have increased the process of degradation and scattering of the remains of older wooden vessels. This hypothesis will be assessed in the next phase through the comparison of the distribution of older vessels in similar environments such as other Estuaries with a high level of sediment transport.

The lack of older records in the AMAP2 trial area provided an unsubstantial basis for comparing the AMAP 1 results of distributions of wrecks by their material type and age. For AMAP1 the older wooden wrecks tended to be concentrated inshore. It was assumed that they were likely to break up at a faster rate than iron or steel wrecks, at that the increased potential for fragmentation followed eventually either by burial in some environments (fine grained sediments, stable) or dispersal and degradation in others (dynamic, coarse grained or exposed bedrock) may explain why far fewer wooden wrecks are identified through hydrographic survey (Merritt, 2007). In the entrance to the Thames Estuary, there were more wooden wrecks documented that there were iron/steel vessels. All tended to lie in the main channel itself rather than on sandbanks or in shallower water.



Map 2 - Wreck distribitions by Period and Counstruction materials

Characterising the Potential for Wrecks - AMAP2

October 2010

N

0 20 40 80 Km

Scale (1:2,500,000 @ A4)

Coordinate Reference System:
Geographic Coordinate System: GCS_WGS_1984
Datum: D_WGS_1984
Prime Meridian: Greenwich
Angular Unit: Degree

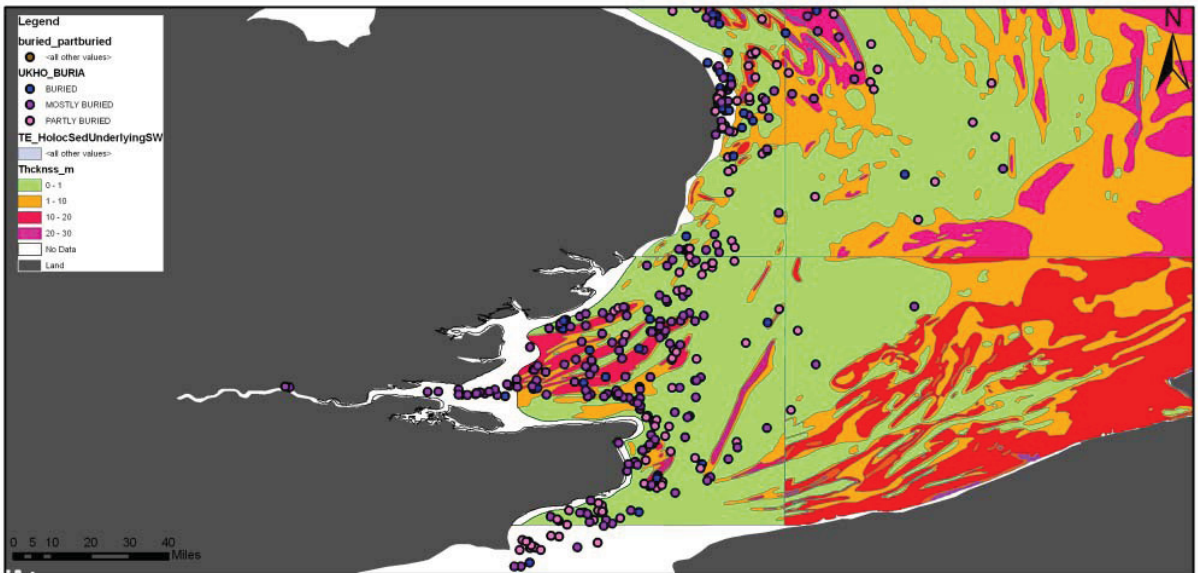
4.1.4 Wrecks by their degree of Burial

The AMAP2 wrecks database was filtered to display wrecks where their degree of burial in seabed sediments had been recorded. These were then compared with environmental variable anticipated to affect the burial of wreck sites.

The density map of wrecks recorded as partially or mostly buried across the entire AMAP database suggests a correlation with the approaches to large estuaries and rivers (Map 3). This may be due to the similarity in environmental conditions within these areas, or could also be a result of a greater resolution and regularity of hydrographic survey and maintenance dredging.

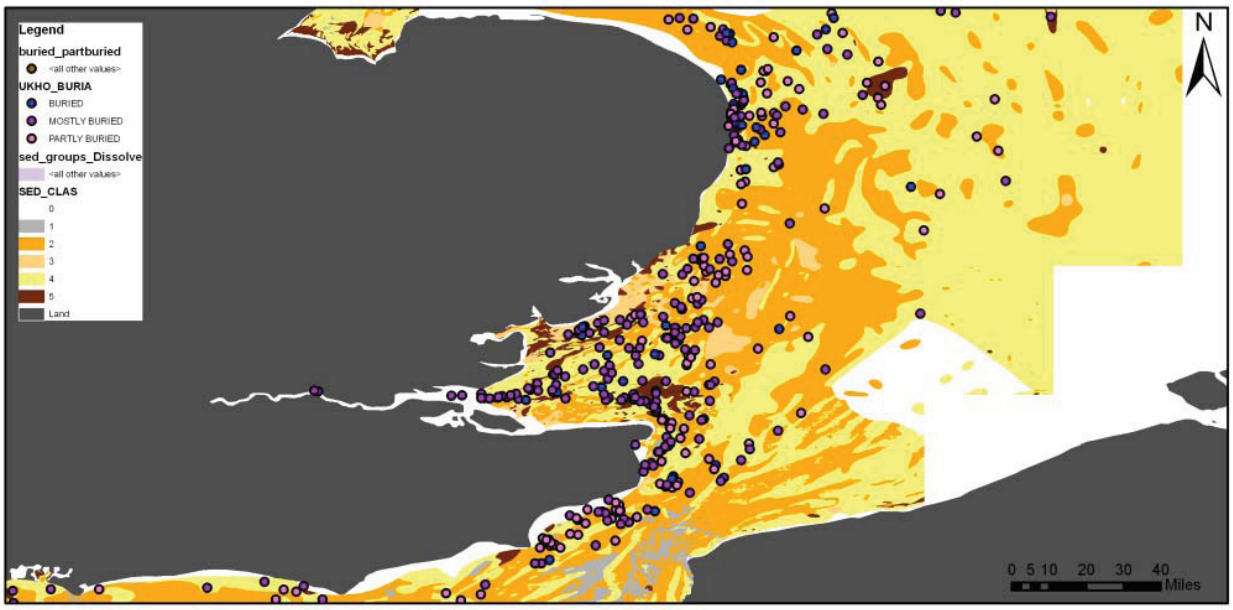
Map 3: Density analysis showing concentrations in the distribution of wrecks recorded as being partly or mostly buried

Most deep sediment areas in the Thames Estuary are due to the presence of large sandbanks and sandwaves. In studying the pilot area, it was found that most wrecks recorded as experiencing a notable degree of burial were not necessarily recorded in areas characterised by deeper sediments. A similar trend was seen during AMAP1. Although a large number of sites exhibiting some degree of burial have been recorded in deeper sediments in the mouth of the Estuary, several concentrations of *partially buried* wrecks lie in areas where the sediment is less than 1m thick (Map 4).



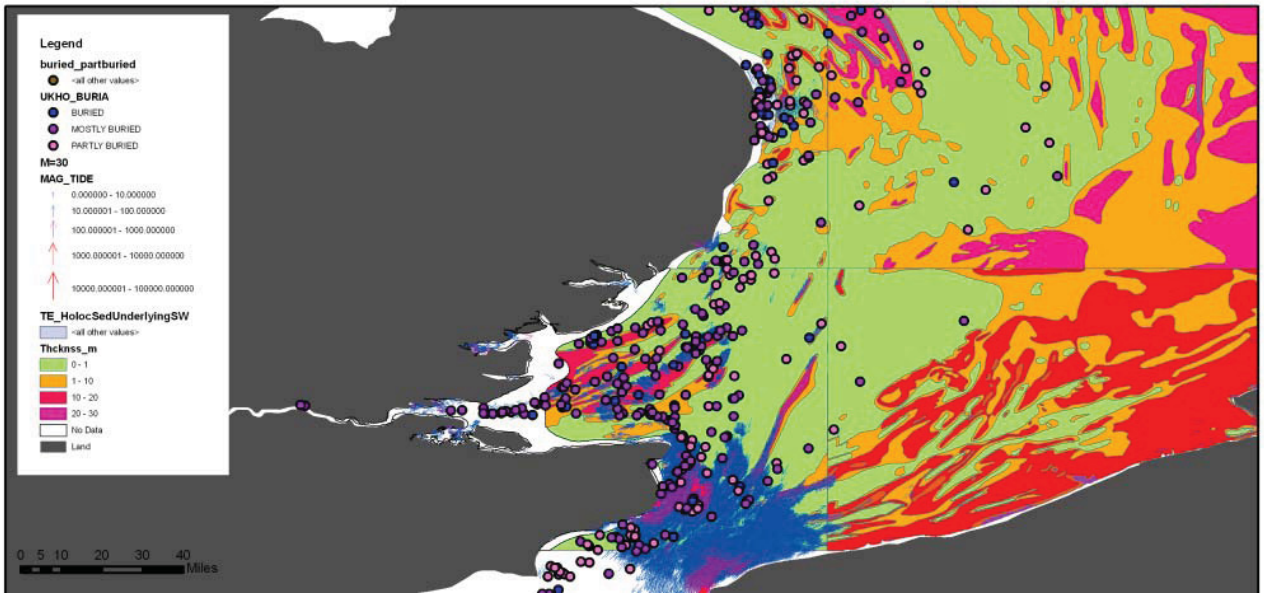
Map 4: Partially and mostly buried wrecks compared with sediment thickness

The distributions seen in Map 4 do however suggest that wrecks recorded as experiencing a high degree of burial, recorded in the database as *buried* or *mostly buried,* do however tend only to occur in areas of deep sediment or in close proximity to them, also characterised by a high level of sediment transport.



Map 5: Wrecks recorded as partly or mostly buried compared with sediment type/category of grain size

A comparison of the degree of burial affecting sites and the type of sediment around them showed that wrecks recorded as experiencing some burial, ranging from those recorded as *partially buried* to *mostly buried* and *buried,* tended to lie in areas of fine grained sediment, characterised by a high level of sediment transport (Map 5). Some wrecks were recorded in areas of coarser sediment but these tended to remain in close proximity to dynamic fine grained areas of seabed (map 6).



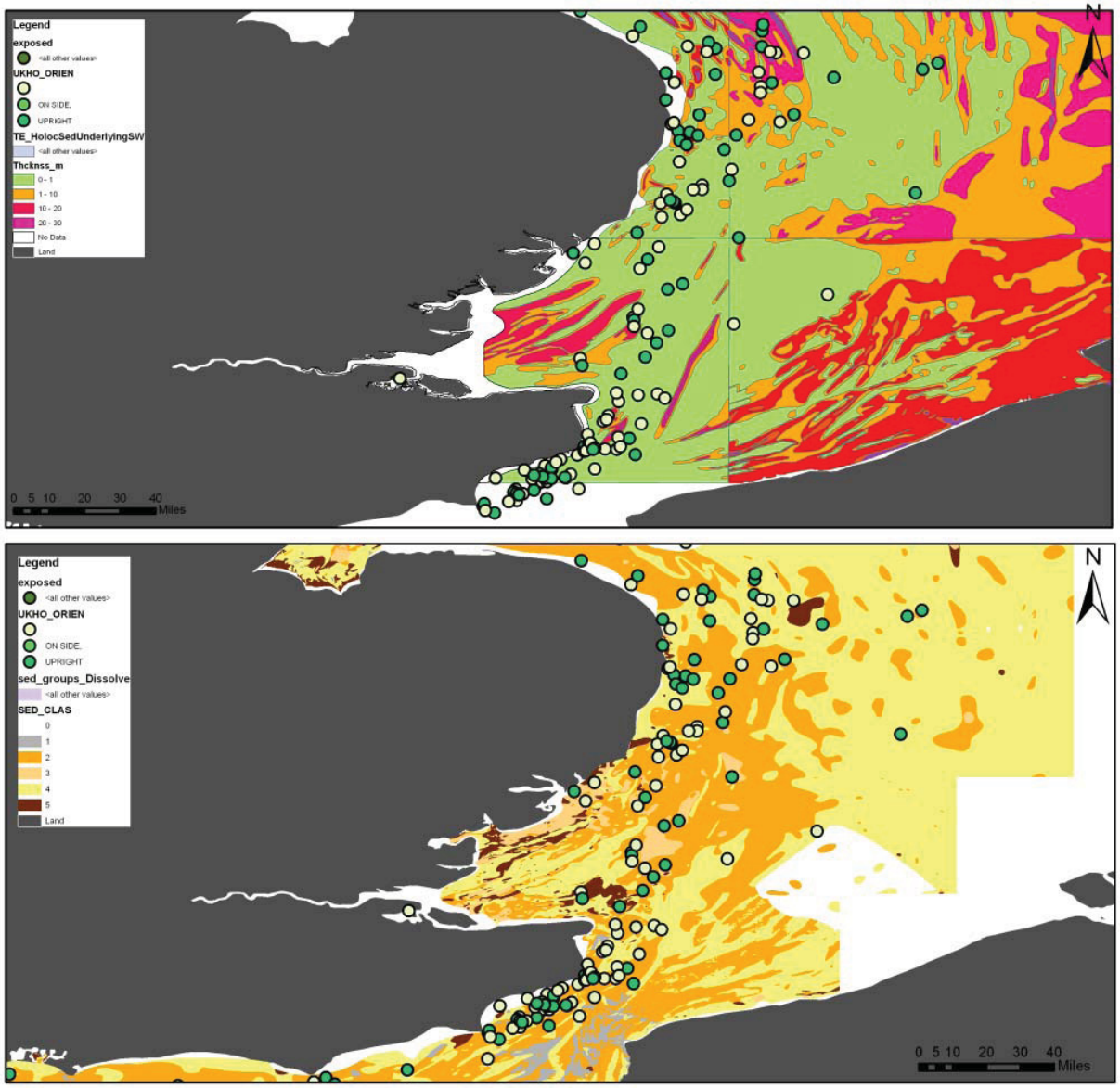
Map 6: Wrecks recorded as partly or mostly, buried compared with sediment thickness and transport

An observation of wrecks experiencing marginal levels of burial, recorded in the database as *Exposed* or *Mostly exposed,* tended to lie in areas of shallow coarse grained sediment (Map 7a).

They are also often recorded in areas of dynamic seabed, suggesting very limited transport of coarse grained sediments even in high energy environments (Map 7b).

AMAP suggested a predominance of buried wrecks in dynamic areas of both fine and coarse grained sediment. The variability in results will be further investigated in the assessment of the full project area and through the review of case studies.

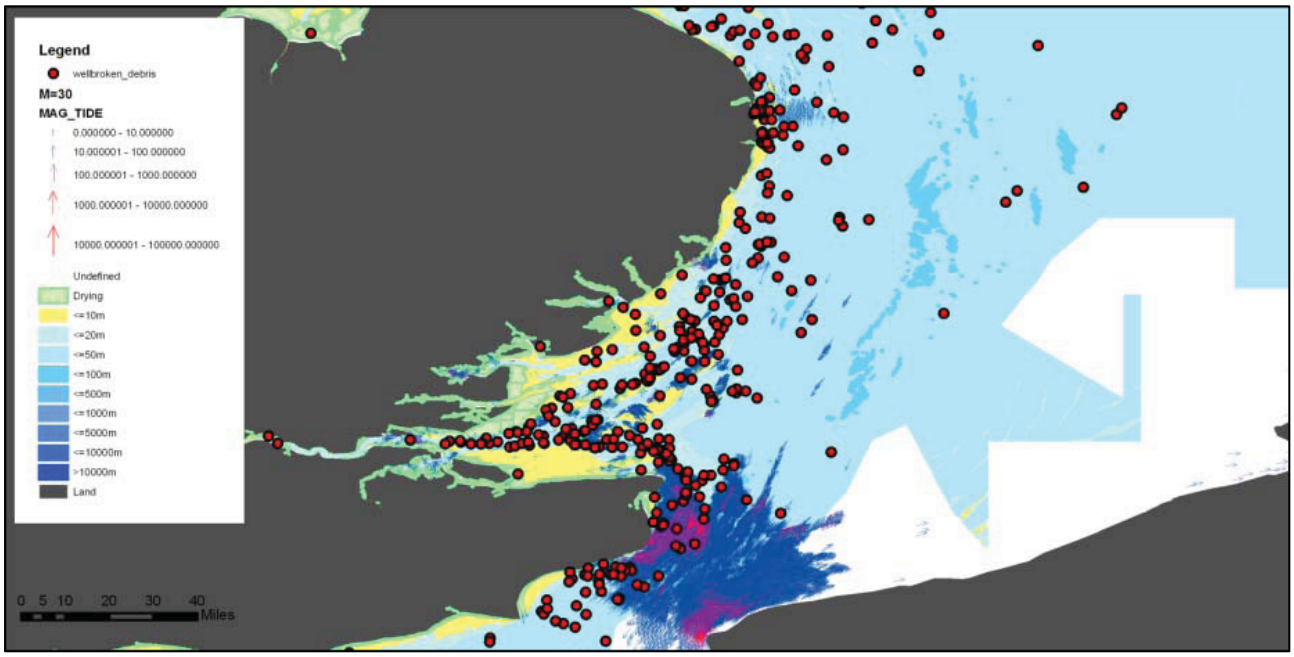
AMAP1 assessed the age and construction of wrecks recorded as buried, finding that most buried wrecks to be of iron/steel construction with only as small proportion constructed from wood Merritt, 2007). The same analysis, applied to the AMAP2 pilot area showed few records of buried sites containing information on construction materials. The few identified were primarily of wooden construction.



Maps 7a&b: Wrecks recorded as experiencing little or no burial, overlaid with sediment type/grain size and sediment thickness maps

4.1.5 Wrecks by Condition

The analysis of potential physical and environmental factors expected to have an impact on the deterioration in the structural condition of shipwrecks was assessed across the pilot area.

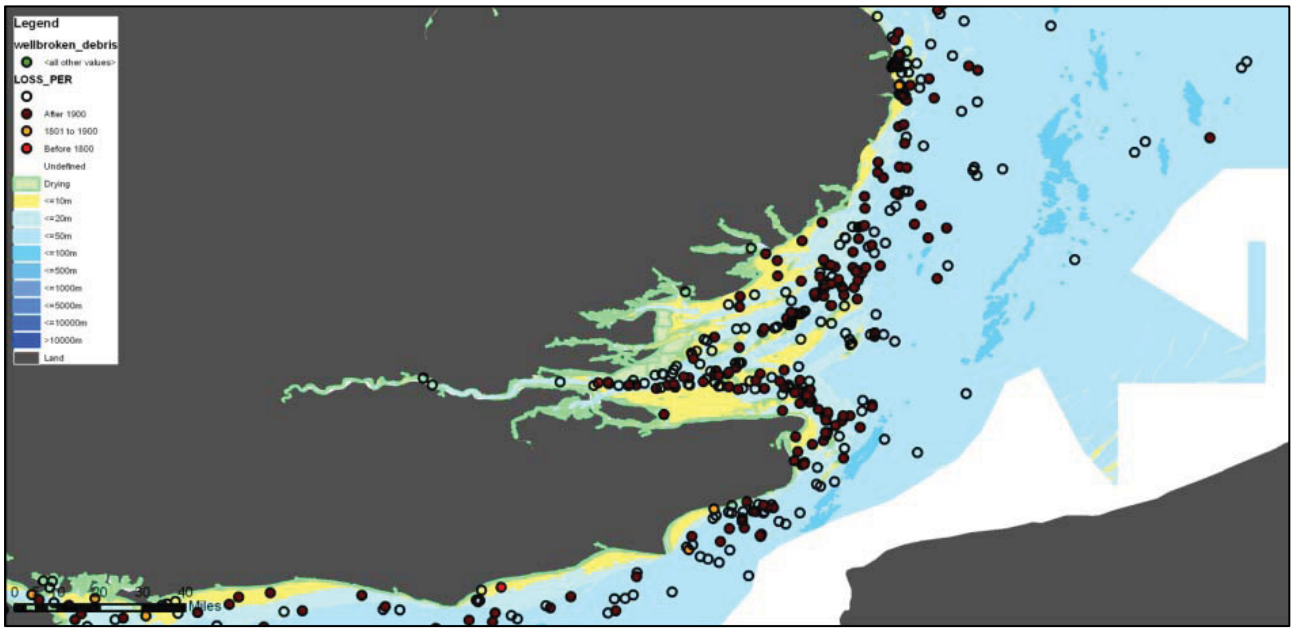


Map 8: Distribution of wrecks recorded as highly fragmented or broken up, compared with water depth and sediment transport

The statistical analysis of relationships between the physical condition of a wreck and its material construction using the open source statistical package "R" suggested a demonstrable correlation between the two physical attributes. No correlations could however be demonstrated across the pilot area between the physical properties of wrecks and the environmental variables.

The Spatial analysis has suggested a spatial relationship between condition, the depth of water and the dynamic nature of the environment and degree of sediment transport. The results showed a bias in wrecks recorded as broken up and dispersed in areas of shallow dynamic environments (Map 8).

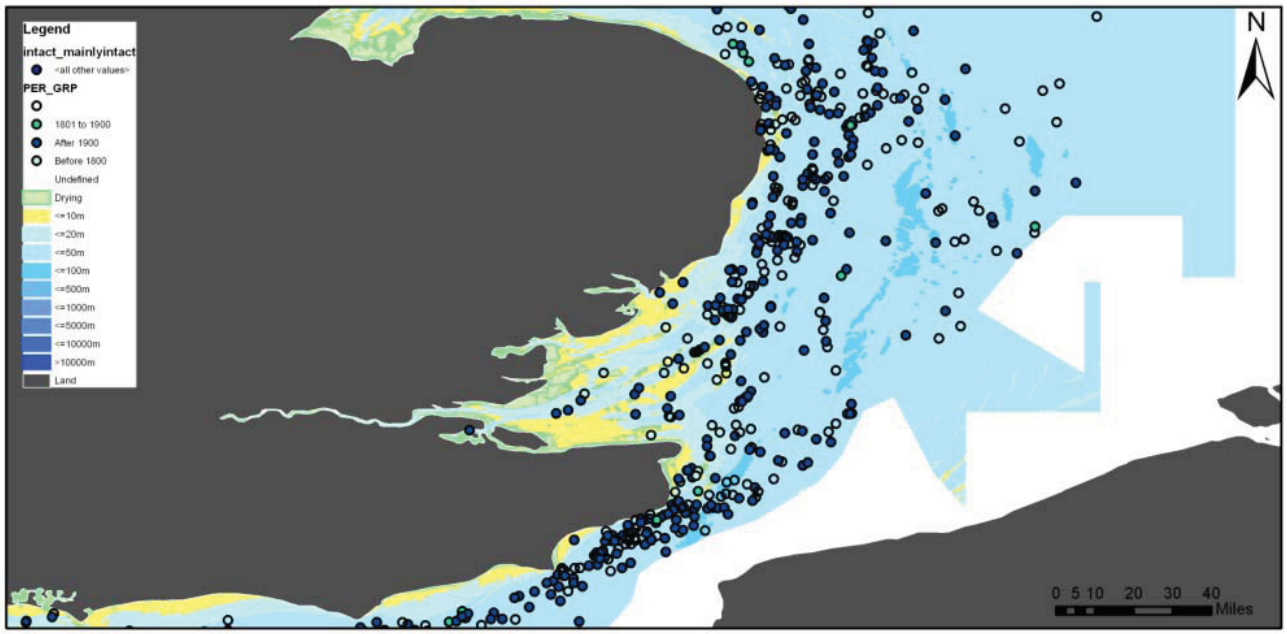
The display of well broken wrecks by their age group showed that the bias towards shallow dynamic areas of seabed bore no relation to age, but appeared to be reflected in modern as well as older wrecks (map 9).



Map 9: Map showing distribution of well broken wrecks symbolised by age group

The number of wrecks recorded as intact was surprisingly high. The distribution of wrecks recorded as intact shown in Map 10 suggests greater concentrations in areas of deeper water, irrespective of the degree of sediment transport recorded. This may suggest that sediment transport has a greater impact of structural integrity of wrecks when combined with shallow depths.

AMAP1 showed little difference between the distributions of intact and scattered wrecks. Both groups contained records lying in areas characterised by shallow sediments and medium/high sediment transport, with less sites recorded in deeper sediments offshore (Merritt, 2007).



Map 10: Map showing distribution of wrecks recorded as intact or mostly intact tending towards deeper offshore areas.

4.1.6 Wrecks by Manner of Loss

The results of the assessment of wrecks grouped by their manner of loss produced similar results to those of AMAP1. The same categories of loss were employed to group the sites, categorising them as either military losses, groundings or collisions.

The distribution of wrecks lost due to grounding however showed a predictable correlation with shallow water depth, and tended to be recorded as scattered similarly to those assessed for AMAP1. The majority of wrecks lost due to collision were dated from the late 19th century onwards and the majority were steam powered.

Similarly to AMAP1, vessels lost through military action showed that by far the largest number of vessels lost in the pilot area were due to mines, with a concentration clearly visible off the south Kent Coast outside Dover. The next highest number of wrecks were due to torpedo attacks. No relationship was either found between the manner of loss and the degree of scatter.

5. DISSEMINATION

5.1 Project Steering Group Meeting

A project steering group meeting was held to gather feedback on the methodology developed and results produced for the pilot area. The meeting was held to ensure the project met the requirements of project stakeholders. The meeting was attended as a joint event between SeaZone and MA Ltd, to disseminate the Phase 2 results of the Enhancing the NMR project and the pilot area results for AMAP2. The meeting was attended by English Heritage staff to ensure both projects met the requirements of English Heritage and the NHRE and to discuss further work.

The meeting resulted in the production of a third Phase to the Enhancing the NMR project and an agreement by SeaZone to seek out opportunities for contributions to wreck data enhancement work via MEDIN.

5.2 Project Outreach

The start of the project was announced via the SeaZone website http://www.seazone.com/newsNews.php?id=114 .

A project flier has been produced by SeaZone for dissemination of the project at GIS corporate events http://www.seazone.com/uploads/news-SZPR%20AMAP2%20090310.pdf .

A project summary, based on the flier, was disseminated to a range of industry websites and attracted considerable interest. The summary was published on several GIS industry websites including GISCafe, The Hydrographic Society, Geo: International, GeoInformatics, Ocean News & technology, Hydro International and by MEDIN in Marine Data News.

An article was also published in Geoconnexion International, raising awareness of the project on a global scale.

6. CONCLUSION

The aim of the AMAP2 project is to the test the results of AMAP1 across a substantial area of seabed and further develop the methodology with an aim of characterising 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.

The analysis of the AMAP2 pilot areas using a similar approach to that employed for AMAP2 strengthened many of the trends apparent in the Eastern English Channel. A summary of the results of the analysis of relationships between the physical properties of shipwrecks and the variables in their marine environment has suggested the following results:

Wrecks queried by period show a strong bias towards 20-21st and a very low number of known sites from the 19th century or earlier centuries in both the AMAP1 project area and the AMAP2 pilot area. The analysis in the Thames Estuary for AMAP2 showed a particularly notable lack of pre 1900 records which could not be explained by removal of wrecks through channel maintenance. This localised trend could therefore either be due to complete burial, rapid degradation and dispersal, or a combination of factors.

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 tended to be constructed of wood. This trend was reflected in both project results. The number of earlier sites in the Thames estuary was particularly low in comparison to the distributions seen in the Eastern English Channel. The reason for this will be further investigated during the following phase of the project.

For AMAP1 both intact and scattered vessels tend to exist in areas of shallow seabed sediments and medium/high sediment transport. This may be explained partly through the more limited potential for wrecks to be buried, but in AMAP1 was also reflected through biases in survey metadata.

These biases were not so apparent in AMAP2. There appeared to be a greater number of wrecks recorded as scattered in shallow, dynamic marine environments while wrecks recorded as intact tend to be distributed in deeper waters although not necessary in low energy environments. However, for AMAP1, buried vessels tended to be found in dynamic areas of fine grained and coarser sediments. Many of these sites lay in areas where sediment thickness remained very low.

In the Thames Estuary, most heavily buried wrecks lay in or very near moderate to high energy areas characterised by deeper fine grained sediment. Wrecks recorded in areas of coarser grained sediment tended to be recorded as experiencing a low degree of burial. Exposed wreck tend to lie in shallow coarser sediment.

In both cases, the majority of buried wrecks are modern and of iron/steel construction while very few older wrecks recorded as buried.

7. NEXT STEPS

The next stage of this project will investigate the research questions raised from the comparison of results summarised from AMAP1 and AMAP2 with an aim to building a characterisation of available spatial data which are implemental in determining the potential for wrecks to exist and survive in different marine environments.

The following topics will be investigated during stage 2:

1. The recording of wooden wrecks as DEAD in highly dynamic, shallow fine grain sediments. The UKHO database records a wreck as DEAD where following initial identification of the site, it has not been picked up later surveys, suggesting that the site is no longer visible from survey data.
2. Look at smaller combinations of variables using statistical analysis:
    a. Intact wrecks and water depth
    b. Exposed wrecks and sediment depth/grain size
    c. Manner of loss
3. The distributions and densities of historic wrecks in areas sharing a similar environment to the Thames Estuary
4. Burial in relation to erosion and accretion on individual sites and around sandwaves

A quality assurance process will be applied to the sediment transport model by comparing it to models produced by HR Wallingford across similar areas as part of the Southern North Sea Sediment Transport Model (HR Wallingford, 2002). The assessment will seek to review the relationships between sediment transport models on both a national and regional scale. Bringing together the results of the two projects will not only enhance the methodology for AMAP2 but will also demonstrate the applications of the MACHU project sediment transport modelling techniques to other areas of research such as site stability assessments for submerged features or the interpretation of archaeological potential for other types of archaeological assets.

The results are expected to identify areas of new research and requirements for data accessibility, while investigating the scope for applying the results of AMAP in context of English Heritage's responsibilities towards the long term management of the marine historic environment through providing an improved understanding of the potential impacts of marine environmental variables to specific groups of wrecks. It is anticipated that a greater understanding of the relationships between wrecks and their environment may provide valuable insight into the identification and prioritisation of sites at risk.

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