2. Methodology

This section of the report provides information on the various data sets used by the project partners and the methods used to assess this data on how it can contribute towards an understanding of coastal change. For the four main data sets; archaeology/palaeoenvironmental data, historic photos, historic artworks and maps/charts, ranking systems were developed in order to identify and rank the potential value of the data to the study of coastal change. See Section One for an introduction to the project.

Once the data had been collected it was entered onto a project database and ranked using the agreed ranking systems, this data could then be viewed geographically along with the results of the ranking in order to enable detailed analysis and comparison of the results across the partner study areas. In the UK, France and Belgium fieldwork was also carried out in areas identified as having high potential, this involved in-depth inter-disciplinary research, fieldwork, scientific dating and analysis of significant sites and areas of coastline in the partner countries.

2.1. Data Sources

The Arch-Manche project looked at archaeological and palaeoenvironmental data, historic paintings, historic photographs, maps and charts from case study areas in England, France, Belgium and the Netherlands. This section provides an overview of the sources consulted in order to obtain this data.

2.1.1. Archaeology and Heritage Features

An initial desk based survey of maritime heritage and archaeological and palaeoenvironmental sites was carried out. Areas of the coastline which have archaeological or palaeoenvironmental information that can help tell the story of past change were identified i.e. monuments, fishtraps, shipwrecks, submerged landscapes or defensive structures. Data was gathered and ranked using the methodology outlined below, this was then added to the project database and GIS.

2.1.1.1. UK

In the UK data collection for the Arch-Manche project involved repositories of historic environment records across the case study areas, details are provided in Table 2.1. Information on sites and finds varied in quantity and quality between the individual county records, sites were therefore later ranked based on their potential, with further research carried out where necessary. Several literary sources were also consulted in order to provide the general archaeological and historical background of the case study areas and to contribute to the data sources listed below when further research was required, these are listed in the references section.

Data group	Format	Supplier
Sites and Monuments records (National)	Digital, GIS Shapefiles	NRHE, National Record of the Historic Environment
Sites and Monuments records (County Based)	Digital, GIS Shapefiles	HER, Historic Environment Records
Wrecks	Digital, GIS Shapefiles	UKHO, United Kingdom Hydrographic Office
Palaeoenvironmental Data	Access Database	English Heritage Peat Database
Sites and Monuments records (Coastal Specialist)	Digital, PDF reports	RCZA, Rapid Coastal Zone Assessments
Sites, Monuments, Wrecks, Palaeoenvironmental	Digital	MAT, Maritime Archaeology Trust archives

Table 2.1 List of data sources for the UK archaeological and palaeoenvironmental data

All data was transformed into British National Grid co-ordinates (OSGB 1936) prior to querying in ArcGIS. Data was then cleaned, this involved removing records which fell outside the limits of the case study areas and a buffer of 500 metres inland from the high water mark was also used so all sites further than 500m inland were removed. In order to prevent duplication of data the GIS shapefiles from the various data sources were overlaid, any duplicate points were then identified on a site-by-site basis and the dataset with most comprehensive details was used.

Unfortunately, despite several attempts it was not possible to obtain GIS data for several of the Rapid Coastal Zone Assessments (RCZA's). In some areas any new information obtained from the RCZA had already been incorporated into the relevant HER. However, for the Solent region the only RCZA data available was from the New Forest in Hampshire.

After the data was cleaned, sites were then added to the project database and ranked. Details of the database are available in section Data Management.

2.1.1.2. France

The archaeological and palaeoenvironmental data presented in this report has been obtained from the Atlas des Patrimoine (Culture Ministry), available online, (http://atlas.patrimoines.culture.fr/atlas/trunk/), and from the databases of scientific research groups: AMARAI (Association Manche Atlantique pour la Recherche archéologique dans les Îles) association, and CeRAA (Centre regional d'Archéologie d'Alet, Saint-Malo). Extensive documentation was also provided by the Archéosciences laboratory of the Rennes1 University, which is a component of the federative research group Unité Mixte de Recherche 6566 du CNRS-CReAAH (Centre de Recherche en Archéologie, Archéosciences, Histoire). Another important resource centre for maritime history, and especially shipwrecks studies, is the ADRAMAR (Association pour le Développement de la Recherche en Archéologie MARitime) which provides an important documentary set, now available online (Atlas Ponant et Atlas des 2 mers: http://adramar.fr/atlas/). Several books concerning the history of the region have been consulted and used (see the references), there is an abundance of historical literature for this region, due to it past rich history and popularity with tourists.

2.1.1.3. Belgium

For the Belgian case study reports, no extensive desk based survey of maritime heritage, archaeological or palaeoenvironmental sites was carried out. There are available inventories of these kind of sites (or artefacts), a number of websites and publications. However, specific information on the *intertidal* area remains scarce. A selection of source include:

Information for the whole of Flanders (BE) can be found at:

- http://cai.erfgoed.net (database of archeological finds in Flanders)
- https://dov.vlaanderen.be (database of subsoil in Flanders, including numerous corings etc.)
- https://inventaris.onroerenderfgoed.be (database for built heritage)

Maritime information can be found at:

- www.maritieme-archeologie.be (contains a database of shipwrecks)

- www.a2s-geoportal.eu (sites in the Channel and North Sea areas, as well as in the intertidal zone)
- www.sea-arch.be (project regarding archeological heritage in the North Sea)

Specific information for Raversijde can be found in:
- PIETERS, M. et al., 2013. *Het archeologisch onderzoek in Raversijde (Oostende) in de periode 1992-2005,* Brussel, AOE. (Ordering through www.onroerenderfgoed.be).

Specific information for the Waasland polder area can be found at/in:
- www.a-d-w.be (Archeological Facility Waasland)
- CROMBÉ, P. (ed.) 2005. *The last hunter-gatherer-fishermen in Sandy Flanders (NW Belgium); the Verrebroek and Doel excavation projects.* Gent: Academia Press.

2.1.1.4. Netherlands

In the case study areas from the Netherlands no desk based research and ranking was carried out, the focus here was on the use of evolution maps created by Peter Vos from the research institute Deltares. Results from archaeological fieldwork carried out on two sites, Vergulde Hand West and Yangtze Harbour were also used within the project analysis. This work was conducted on several campaigns by several institutions including Deltares, City of Vlaardingen, TNO Geological Survet and Utrecht University.

2.1.2. Art

The art case studies focussed on England and France (together with a sample of artworks from the Dutch and Belgian coastlines). In order to establish the art resource available for this study it was necessary to review the topographical paintings, drawings and prints held by the principal national, regional and sub-regional collections covering the coastal frontages in these countries. To achieve this objective, on-line reviews, literature searches and some visits were made in order to identify the most relevant paintings, drawings and prints. These are detailed below.

2.1.2.1. England

This section summarises the national sub-regional and private collections reviewed as part of the project.

Primary National Collections		
Name	**Location**	**Brief Description**
The National Maritime Museum	Greenwich, London	Collections include cartography, manuscripts, public records and maritime art.
The Victoria and Albert Museum	London	Collections include prints, drawings and photographs. Also houses the National Art Library, with over 750,000 books.
The Tate Britain	London	UK's national museum of British art from 1500 to present day.
The British Museum	London	National collection of prints and drawings from the 14th century to the present day.
The National Gallery	London	Collections of over 2,300 paintings from the mid 13th Century to 1900.
The Witt Library	Courtauld Institute, London	Collections of reproductions from 1200 to the present day.

Table 2.2. UK National Collections of art assessed for the project.

Primary Sub-Regional Collections	
Name	**Case Study Area**
Norwich Castle Museum & Art Gallery	East Anglia
Great Yarmouth Museum	East Anglia
The Mo, Sheringham	East Anglia
Aldeburgh Museum	East Anglia
Dunwich Museum	East Anglia
Colchester & Ipswich Museums	East Anglia
Canterbury City Council Museums & Galleries	East Kent
Dover Collections	East Kent
Folkestone Museum	East Kent
Maidstone Museum & Bentlif Art Gallery	East Kent
Turner Contemporary, Margate	East Kent
Margate Old Town Local History Museum	East Kent
Ramsgate Museum	East Kent
Kent Record Office	East Kent
Hastings Museum and Art Gallert	Hastings
Hastings Library	Hastings
Hastings Fishermen's Museum	Hastings
Royal Pavilion & Brighton Museum	Hastings
East Sussex Record Office	Hastings
Southampton City Art gallery	Solent & Isle of Wight
Southampton City Council Archive Service	Solent & Isle of Wight
The Cope Collection, University of Southampton	Solent & Isle of Wight
Portsmouth City Museum and Archives	Solent & Isle of Wight
Royal Naval Museum, Portsmouth	Solent & Isle of Wight
Hampshire County Council Art & Museum Service	Solent & Isle of Wight
Island Heritage Service, Isle of Wight Council	Solent & Isle of Wight
The Russell Cotes Museum, Bournemouth	West Dorset & East Devon
Dorset County Council Archives	West Dorset & East Devon
Dorset County Museum	West Dorset & East Devon
Lyme Regis Museum	West Dorset & East Devon
Devon Record Office	West Dorset & East Devon
The Royal Albert Museum & Art Gallery, Exeter	West Dorset & East Devon
Plymouth City Museum & Art Gallery	West Cornwall
Falmouth Art Gallery	West Cornwall
Cornwall County Council Record office	West Cornwall
The Cornish Studies Library	West Cornwall
Penlee House Gallery, Penzance	West Cornwall

Table 2.3. Sub-Regional UK art collections assessed for the project

Private collections

A number of yacht clubs hold coastal paintings. Most commonly these are yacht paintings but some collections hold coastal artworks together with books and albums of watercolours and engravings. Many of the works held by the yacht clubs are essentially yacht portraits but their background setting against the coastline can, in some instances provide, useful information on topography and coastal scenery particularly where works are executed by some of the best known coastal painters in Great Britain.

Literature Sources

The literature sources relating to works exhibited are comprehensive and comprise reviews of the artists and their works exhibited at principal London exhibitions (Graves, 1901), together with catalogues and dictionaries published by the museums themselves or interested publishers such as The Antique Collectors Club. The published works of this kind do, therefore, represent a considerable resource of assistance to this study (Wood, 1978; Russell, 1979; Archibald, 1980; Lanbourne *et al.*, 1980; Mallalieu, 1984; MacKenzie, 1987).

In relation to antiquarian and more recent publications for each of the case studies key works were consulted including, for East Anglia (Parkin, 1788; Beatniffe, 1809; Dickson, 1811; Stark, 1828/34; Clarke, 1921; McInnes and Stubbings, 2010); for East Kent (Gilpin, 1804; Moses, 1817; Unknown, 1813); for Solent and Isle of Wight (Tomkins, 1796; Pennant, 1801; Gilpin, 1804; Woodward, c.1848; Mudie, 1840; King, 1845; Brannon, 1821-76, Turley, 1975, 1977; McInnes, 2008). Finally, for West Dorset-East Devon and the West Cornwall case studies (Hutchins, 1774; Borlase, 1769; Englefield, 1816; Britton & Bayley, 1832; McInnes & Stubbings, 2011). More recently a comprehensive review has been undertaken of the oil paintings contained in public collections for all the English Counties and major art galleries (Ellis (Ed.), 2004).

Online Sources

As part of research the Public Catalogue's Foundation (PCF) volumes and BBC Your Paintings online resource was used www.thepcf.org.uk and www.bbc.co.uk/yourpaintings. The PCF was launched in 2003 as a registered charity and based in London (www.thepcf.org.uk). Over the last seven years the PCF has been photographing oil paintings and collating information about each painting. In doing so it has been working closely with collections across the United Kingdom. This provides access to some of Britain's large publicly owned collections of oil paintings held national collections, galleries, civic buildings, regional and local museums, and heritage centres.

Initially the PCF's main focus was publishing a series of hard copy catalogues with thumbnail images of the oil paintings in each collection; over 40 of the planned 90 catalogues have been published. In 2012 the task of photographing the nation's 212,000 oil paintings was completed. Then the focus turned to publishing on-line. Through a partnership with the BBC all the paintings can now be viewed on-line at www.bbc.co.uk/yourpaintings. On-line access allows users to search paintings by various criteria and to view larger images, whilst collections will be able to update their painting records website.

2.1.2.2. France

The rich art history of France, including landscapes and coastal scenes of Brittany, can be seen displayed in the great national collections of Paris and of some of the other major cities these are outlined in table 2.4 below.

National Collections	
Name	**Brief Description**
Paris Musée D'Orsay	Forward programme of the *Painters' Trail in Cornwall*: Paul Gauguin (La Belle Angele), Paul Sérusier (Talisman), Emile

	Bernard, Claude Emile Schuffeneckers, Charles Lavai Charles Filiger, Jan Verkade and Maurice Denis
Saint-Germain-en-Laye Musée du Prieuré	The property presents works of symbolism and including paintings by Nabis Maurice Denis, Paul Gauguin, Emile Bernard, Charles Filiger Paul Sérusier, Jan Verkade and M. Luce
Rennes Musée des Beaux-Arts	A large collection of paintings from the fourteenth century through to the various contemporary movements. Paintings from the nineteenth and early twentieth centuries include works by Eugène Boudin, Jules Noel, Henri Moret, Charles Cottet, Maurice Denis, Lucien Simon, Jean-Julien Lemordant, Georges Lacombe, Émile Bernard, Paul Sérusier and Maxime Maufra
Loches Musée Emmanuel Lansyer	The museum contains paintings by Lansyer Emmanuel (1835-1893).

Table 2.4. National Collections in France assessed for the project

The collections reviewed at the Sub-Regional level focussed on Brittany. Brittany has numerous excellent art collections held in the museums and art galleries of its larger cities and towns. The dramatic coastal scenery, the regional culture and history created tremendous interest among painters attracted by the sea in motion, the open skies as well as the local customs and costumes; many of these artworks contain a wealth of topographical information. Important collections are highlighted in tables 2.5 and 2.6 below.

Sub-Regional Collections	
Name	**Brief Description**
Brest Musée des Beaux-Arts	17^{th} – 20^{th} Century depictions, including the School of Pont-Aven.
Morlaix Musée Des Jacobins	Museum of Fine Arts, French and foreign works from 16^{th} – 20^{th} Century.
Nantes Musée Des Beaux-Arts	French, Italian, Flemish and Dutch paintings, particularly from 19^{th}-20^{th} Century but also from 1250 to present day.
Saint-Brieuc Musée D'histoire De Saint-Brieuc	Paintings and sculptures
Vannes Musée De La Cohue	Paintings, drawings and prints

Table 2.5. Sub-regional collections in France assessed for the project

Museums on the 'Road of Painters'	
Name	**Brief Description**
Quimper Musée Des Beaux-Arts	The collections include significant Flemish and Dutch paintings of the seventeenth and eighteenth centuries. Two rooms are devoted entirely to the School of Pont-Aven and inspirational Breton paintings of the nineteenth and twentieth centuries.
Quimper Musée Départe-mental Breton	Housed in the former bishop's palace, the museum is dedicated to temporary exhibits illustrating the history of the Breton regional company until today. Archaeology, history (furniture, advertising materials, photographic backgrounds, tiles), ethnography (furniture, costumes).
Le Pouldu Maison De Marie Henry	Reconstruction of the house of Mary Henry. The house includes documents relating the history of joint Pouldu, Mary Henry, the Buvette de la Plage and painters who lived there (Gauguin, Meyer de Haan, Sérusier Filiger, Maufra, Lavai).
Locronan Musée De Locronan	The museum has a permanent collection of paintings and sculptures (Beaufrère, Chief Iron Knight-Kervern, Dauchez, De Lassence, Desire-Lucas, Eschbach, Floc'h, Labitte, Lawrence Sidaner, Morchain, Simon).

Loctudy Musée De Kérazan	Manor Kérazan presents paintings and drawings from the sixteenth to the twentieth centuries, landscapes and seascapes. A small room is devoted to landscapes and characters of Cornwall and Vannes, a large room with paintings and drawings by Auguste Goy (1812-1871), valuable evidence of the Breton life in the last century. Among the collection of art are works of Maurice Denis, Charles Cottet, Georges Desvallières and Lucien Simon; in the grand salon paintings of the nineteenth and twentieth centuries include eight Breton subjects.
Pont-Aven Musée De Pont-Aven	Established in 1985, the museum is mainly dedicated to temporary exhibitions to publicize the painters who have distinguished themselves in Pont-Aven in Brittany and the late nineteenth to early twentieth century. The media room has an exhibition explaining the significance of the School of Pont-Aven.

Table 2.6. List of museums on the 'Road of Painters' assessed for the project

Art resources used for the Brittany case studies were drawn from various sources, either books (Delouche 2003), private and public galleries and, importantly, useful information was provided by online resources, in particular the Jocande database containing artworks and other objects from public & private museums (www.culture.gouv.fr).

For all the case study areas of Brittany, the art approach benefitted also from the academic work led in the Rennes 2 University by E. Motte (Motte, 2013, under the direction of H. Regnauld, with assistance from M.-Y. Daire and R. McInnes. The theme of the dissertation was: "*Representation and Evolution of the Shoreline: What do regional paintings teach us about the Breton coastal environment*").

2.1.3. Maps and Charts

The focus of historic maps and charts focused on collections in Belgium and the Netherlands, however, some sources were also consulted in England and France. The data sources are described below.

2.1.3.1. Belgium and the Netherlands

Maps of the coastal region of Flanders and the Waasland (polder) area were reviewed for these case studies. Coastal Flanders and the Waasland area have been extensively mapped, often linked to the numerous embankment enterprises. Early examples of land surveys of coastal Flanders include references as early as 1190 in Furnes and from 1282 in Bruges (Janssens, 2006:89). The oldest cartographical products date from 1307 and 1358 and concern a depiction of the "moershoofd" (peat reclamation axis) East of Aardenburg and Oostburg-IJzendijke (Gottschalk, 1955-58). Regular land surveying, however, remained absent for a long time (Janssens, 2006). The Waasland area also had an early tradition of land surveying. In the aftermath of the famous "Slijkkoop van Aendorp" (concerning the selling of tidal marsh and peat lands by Duke Filips the Good as Lord of Beveren) the land was extensively measured. Trial documents from 1469 mention two different measurements of the entire area, and an additional third one requested by the trialing parties (Archives Beveren).

Over following centuries numbers of land surveyors grew, but this increase could not keep up with the large demand for measurements and maps (often related to embankment practices). In 1696, the shortage of land surveyors in the Waasland area was clearly demonstrated by the desperate advice of the aldermen to the "Secret Council" to try to increase the number of land surveyors (Janssens, 2006).

The combination of the rapid development of mapping techniques, the need for measurements for new embankments and the certified quality of land surveyors resulted in a large number of maps of the coastal plain and the Waasland area. Luckily, numerous maps have been preserved. It is important to note that the most interesting maps are not often found in open access internet databases, but in (local) archives, for instance the (State) Archives in Brussels, Ghent, Beveren and Middelburg. Some of these are small scale maps or maps with very low reliability (depending on the purpose of the map), but one type of map proved to be particularly interesting for our study area; proceeding almost every embankment, various maps depicting the tidal channels were made. Many of these maps were ordered by or linked to the Arenberg family (who obtained most of the former Seigneury of Beveren) since they took part in the embankment of the Oud-Arenbergpolder (finished in 1688) and fully directed the embankment of the Nieuw-Arenbergpolder (finished in 1784) and Prosperpolder (finished in 1846) (Verelst, 2002).

In summary the maps were chosen out of a database of around 300 historical maps, found in the (State) Archives of Brussels, Ghent, Beveren and Middelburg. Many maps were found in the Arenberg Archives, a subsection of documents within the State Archives of Brussels.

Online inventories include:

- http://www.arch.be/ for the (State) Archives of Brussels, Ghent and Beveren.
- http://www.zeeuwsarchief.nl/ for the Archive of Middelburg.

2.1.3.2. UK

Within the scope of the project, research into historic maps and charts of the UK case study areas was restricted to online searches. The main sources consulted are detailed below.

A primary source for the Hastings case study area was through a project coordinated by the University of Portsmouth Geography Department entitled *Old Sussex Mapped*. The aim of the project is to create a database for old maps covering the counties of the UK. This builds on the *Old Hampshire Mapped* project started by Jean and Martin Norgate through which maps of the Solent and Isle of Wight case study area were also obtained. Other maps from the Solent and Isle of Wight case study area were provided by Professor Robin McInnes.

The primary resources for Suffolk were Hodskinson's Map of Suffolk in 1783 (a complete map of the county) and a 1st edition Ordnance Survey (OS) map from 1880-1890. OS maps have been used in several case study areas, these were available from *Digimap* an online service where maps can be downloaded for use in ArcGIS. Ordnance Survey is the UK's national mapping authority and in 1995 they digitised 230,000 maps of Britain.

Although not possible in the scope of Arch-Manche, further detailed studies into historic maps of the UK will provide more information on changes to the coast, potential sources include;

- United Kingdom Hydrographic Office (UKHO) archives
- National Archives
- National Maritime Museum
- Admiralty Library
- British Library

2.1.3.3. France

The main source of maps and charts for Brittany has been the online Gallica database, where the Maps and Charts department is extensively represented (http://gallica.bnf.fr/html/cartes/cartes). Most of the old marine charts are related in particular to trade, but also military defences. They often tell us about harbours, shelters, and watering places, but also the pitfalls of anchorages, rocks and major landmarks for navigation (e.g. coastal shipping). Defensive points along the coast are highlighted on the maps created during the wars (e.g. 17th and 18th c.), particularly those which included major offshore sailing (especially in the 19th century).

The Cassini family father and son, between 1750 and 1815, made the first topographical map of France. Charts before the eighteenth century are imprecise and difficult to exploit. However, one of the most informative for the coastal landscapes of this area is the "*Carte(s) des Ingénieurs géographes du Roy*" (18th century), which provides very accurate details especially along the coasts. The origins of these charts is linked to the fact that France had surveyors or topographic engineers before any other European army.

2.1.4. Photographs

Historic photographs were primarily collected for case study areas in France and the UK, with a smaller sample from Belgium. The data sources are outlined below.

2.1.4.1. France

The photographic postcards consulted for the project belong either to private or public collections (Biet & Bouze 2007), as well as the Regional ancient postcard conservatory (http://www.cartolis.org/).

As a major documentary resource, the documentary set of the ancient Laboratoire d'Anthropologie de Rennes (created by P.-R. Giot during the 1950's) includes negative and positive photos on plate glass, films, slides and paper photos, the oldest of which date from the second half of the 19th century. These pictures represent an exceptional information source for the comprehension of the emerging prehistory and archaeology in Brittany. The documentation used in the project is limited to pictures belonging to the period from the late 19th century to about 1939 and feature a link with the coastal areas (Lopez-Romero & Daire, 2013).

2.1.4.2. UK

All historic photos for the UK case study areas were found through online searches. Some key national sites include the *Francis Frith Collection*, the collection was founded in 1860 by the Victorian photographer Francis Frith, the site now contains over 365,000 photographs from 1860-1970. Another useful resource is from the *Britain from Above* project, the website contains images from the Aerofilms collection and includes thousands of aerial photographs dating from 1919 to 2006. More local collections were also searched, such as the Carisbrooke Castle Museum Image Library where historic images are being digitised and added to the website, this site contains many images of the Solent and Isle of Wight case study area.

2.1.4.3. Belgium

A small number of photographs were assessed in the Belgian case study areas of Raversijde and Scheldt polder. These were obtained through online searches. Photographs from the Raversijde area were found at http://beeldbank.oostende.be/, this image library includes collections of photographs and postcards as well as drawings, maps and prints of Ostend which have been digitised by the Municipality of Ostend. For the Scheldt polder area the following website was used; http://www.waaserfgoed.be/. This database contains a selection of photographs, newspaper pages and historical records obtained from local history groups, archives, libraries and private collections from the Waasland region.

2.2. Ranking Methodologies

In order to assess the reliability and accuracy of historic paintings, maps and charts a ranking system was developed. For historic photographs the ranking system was used to assess the potential of an image to provide information on coastal change, and for archaeological and palaeoenvironmental data the ranking system provided a relative value on the potential of each site to provide information on coastal change. All the data was ranked and entered into the database and project GIS. The methodology used to rank each dataset is outlined below.

2.2.1. Aims, Objectives and Implications of using the Ranking Criteria

The aims of the ranking criteria are to consider the attributes of all types of archaeological and palaeoenvironmental sites, finds and deposits, art works, photographs, map and charts, to assess their ability to provide information relating to processes or causes of coastal change. The ranking and ranking system has been used to highlight sites or sources of evidence so that their value can be readily assimilated in the revision and implementation of coastal management strategies. It should be noted that the rank assigned does not place particular archaeological, cultural or artistic values on sites or sources that have been listed on the coast.

The purpose of the ranking was to assess the potential of a range of types of data sources to inform the decision-making of coastal managers. While it might be considered contentious to attempt the ‘grading’ of sites in certain circumstances, it was deemed appropriate to test such a system for answering specific queries on what could be a measurable occurrence – coastal change.

Some key benefits of the use of ranking criteria are:

- Providing a standard against which all sites and data sources can be judged.
- Securing an overview of the collection of archaeological and palaeoenvironmental sites, art resources, photographs, maps and charts.
- Providing an accountable system for the assessment of sites and sources in relation to coastal change.
- Highlighting areas or sites that should be prioritised by coastal managers.
- Identifying archaeological and palaeoenvironmental evidence that will clearly demonstrate the nature of long-term coastal change to a range of audiences.

Some limitations of the use of ranking criteria are:

- Achieving a universal consensus on the ranking system proposed can be difficult, particularly when dealing with a relatively large geographical area and a large number of potential ‘end-users’.
- It is not easy to devise a ranking system that allows for flexibility while avoiding potential misinterpretation.
- The ranking system can only test present knowledge of the archaeological and palaeoenvironmental resource. The ranking, and possibly the system, will require review and change as knowledge develops.
- Ranking systems are always reliant on the ‘scorer’. Consequently, they are still prone to subjectivity.

Despite these caveats, the project ranking criteria have provided a workable assessment of the available data sources in the partner case study areas.

2.2.2. Archaeological and Palaeoenvironmental Ranking

Initial project data gathering focused on the acquisition of key sources and the assessment of a broad range of historical and palaeoenvironmental data sets available in the case study areas. Further details on the data sources consulted are available in section Data Sources . An initial process of data cleaning was carried out in order to assess the potential of the data to contribute to understanding of climate change. The remaining sites and features were then ranked in order to provide a relative value on the potential of each site to provide scientific information that may be beneficial to practical decision-making in the long-term management and protection of the coastline. Particular importance has been attached to potential information concerning the past behaviour of the coastline and to chronological information concerning the nature, scale and pace of sea level rise and coastal change.

Ranking has also taken account of the fact that rates of change vary between different parts of the partner case study areas. Experience of a rise in sea level will also vary at different locations. Such contrasts arise from differences in coastal geomorphology and from variations in 'down-warping' or crustal behaviour within the deep geology of the Channel coasts.

In areas of coastal instability, archaeological and palaeoenvironmental sites have a particular role to play in establishing proven histories of localised ground movement. These are particularly valuable in sectors subject to landslide movement and other coastal changes. Thus the ranking criteria sought to identify those sites that might best offer evidence for measuring the magnitude and rate of coastal change. Ranking has also considered the value of sites where further research might strengthen current understanding of causation and periodicity.

2.2.2.1. The Criteria Explained

The ranking criteria have been developed to quantify the value of an archaeological or palaeoenvironmental site for its potential to inform coastal managers of past changes to the coastline. Below is a description of each ranking criteria used.

Sea Level Change

- *Does the site contain evidence of changes in sea level?*

The sea level is continually fluctuating. During the period since the last Ice Age (The Holocene) the dominant trend has seen a rise in sea level. Each site, whether it is archaeological, palaeoenvironmental material or a coastal heritage feature has the potential to inform on sea level changes. Indicators can include, artefacts, sediments, diatoms, foraminifera and marine induced features.

An initial review of each site determined either 'yes', 'no' or 'don't know' on whether the site contains evidence of changes in sea level. Then each site that had a 'yes' response was ranked on the potential of the information it contains, this is based on a 1 to 3 score.

Rank	Level	Example
1	Low	A low score was given to items that have not been static very long or do not have secure contexts, so have limited amounts of information on relative sea level change. Examples include: • A modern hulk or shipwreck which would not be old enough to demonstrate change in water levels if recently abandoned.

		• A dated but unstratified find which only provides broad potential dating evidence at a particular period
2	Medium	A medium score was given to sites that have the potential to provide an index point for sea level at a point in time. This provides a fixed reference point and can help calibrate the sea level curve for a region. Examples include: • A stratified artefact or site dating from a period when sea level was lower e.g. a Neolithic trackway or medieval oyster bed. • A datable coastal defence feature • A dated wreck site • A dated abandonment of a building, site or structure due to a rise in sea level
3	High	A high score was given to material that can demonstrate a record of changing sea level. This includew evidence indicating rising, static or falling sea levels. Examples include: • A good quality core through Holocene sediments which were deposited during rising sea level. This would need to have datable evidence such as vegetation horizons. • A set of coastal prehistoric trackways which show changes in location depending on sea level. • A historic building with datable adaptations for sea level rise.

Table 2.7. Archaeological Ranking for Sea-Level Change

Environmental Change

- *Does the site/ feature/ deposit provide evidence of environmental change?*

Since the last Ice Age, local environmental conditions have been adapting to a fluctuating climate, the underlying trend has been global warming. Assessment of environmental material and sources of data can demonstrate the nature of a landscape at a point in time. Indicators within archaeological material include, soils, sediments, insects, pollen, flora, fauna and snails. Material from related periods which can be assessed may provide a picture of the environmental and geomorphological evolution. This would demonstrate how an area has adapted to a rising sea level and changing climate. The drivers behind the change could be natural or human impacts, so for more recent periods the extent of human impacts is likely to be more extensive. There are also more extensive sources of data for more recent changes such as aerial photographs which can be combined with physical evidence to determine changes to local environments.

As with the previous criteria an initial review of each site determined either 'yes', 'no' or 'don't know' on whether the site contains evidence of environmental change. Then each site that had a 'yes' response was ranked on the potential of the information it contains, this is based on a 1 to 3 score.

Rank	Level	Example
1	Low	A low score was given to sites with little datable material that were able to tell us about past environments. Examples include: • A coastal feature such as a gravel spit which has developed as a result of long term environmental change, but does not have specific information on date or environment • Evidence of coastal salt working without specific dating
2	Medium	A medium score was given to a site that has the potential to provide an indicator of the environment at certain period. Dates available for the material or artefacts would be broad rather than absolute. Examples include: • Coastal Bronze Age occupation site with information on land use, diet etc.

		• A core through a deposit that has been dated by relative comparison rather than scientific dating • A dated wreck site where there is a monitoring program in place to provide evidence of sediment changes
3	High	A high score was given to material that can demonstrate a record of the changing environment through a long period of time. Examples are: • A good quality core from submerged or buried terrestrial deposits having dated material, archaeological evidence and a well preserved range of environmental material associated with mineragenic deposits.

Table 2.8. Archaeological Ranking for Environmental Change

Temporal Continuity

- *Does the site contain material that could provide evidence of temporal continuity?*

Temporal continuity is the link that relates past events to each other and the yardstick against which we can assess change. For sites most relevant for understanding of coastal change this is likely to include those which show a relationship to changing shoreline conditions over time.

As with the previous criteria an initial review of each site determined either 'yes', 'no' or 'don't know' based on whether the site contains evidence of temporal continuity change. Then each site that had a 'yes' response was ranked on the potential of the information it contains, this is based on a 1 to 3 score.

Score	Level	Example
1	Low	Sites, palaeoenvironmental material or artefacts which contain evidence from single events or are datable to one period only.
2	Medium	Sites which are known to contain datable evidence of changing sea level, environmental, or climatic change but have yet to be analysed.
3	High	Sites with long datable sequences which have been analysed. Sites would provide evidence of changing sea level, environmental, or climatic change over a period of time that straddles a series of geomorphological events.

Table 2.9. Archaeological Ranking for Temporal Continuity

Non-ranking Criteria

The following criteria are descriptive terms which helped provide a physical and managerial context for the ranked material.

Site Status

- An indication of current status

This criteria provided information on whether sites, features or deposits are known to still be in existence and whether the site includes remains that are above or below the ground, or both.

Code	Level
EA	Site/ deposits exists and are above ground
EB	Site/ deposits exist and are below-ground
EAB	Site/ deposits are both above and below ground
D/R	Site has been destroyed (or recovered)
UN	Don't know

Table 2.10. Current Site Status for Archaeological/ Palaeoenvironmental Data

Coastal Context

- Coastal context indicating the spatial relationship of the site to the coast line

ID	Term	Description
1	Marine (below low water)	Sites that are fully submerged at all states of the tide
2	Intertidal	Sites which become uncovered during low tide
3	Above High Water	Sites which are fully terrestrial
4	Estuary	Sites within estuaries which are fully submerged, distinct from Marine as can be a substantial distance from the sea coast
5	Hard Cliff	Generally expected landward of Mean High Water
6	Soft Cliff	Generally expected landward of Mean High Water
7	Barrier beach	Generally expected landward of Mean High Water
8	Dunes	Generally expected landward of Mean High Water
9	Lagoon	Generally expected landward of Mean High Water
10	Saltmarsh	Generally expected in intertidal area
11	Sandy foreshore	Generally expected in intertidal area
12	Rocky foreshore	Generally expected in intertidal area
13	Sandflats	Generally expected in intertidal area
14	Mudflats	Generally expected in intertidal area
15	Coarse sediment plains	Generally expected in marine area
16	Fine sediment plains	Generally expected in marine area
17	Mud plains	Generally expected in marine area
18	Mixed sediment plains	Generally expected in marine area
19	Sand banks with sand waves	Generally expected in marine area
20	Exposed bedrock	Generally expected in marine area
21	Unknown	

Table 2.11. Coastal Context for Archaeological/ Palaeoenvironmental Data

2.2.2.2. Conclusions

The ranking methodology was integrated into the project database and GIS allowing sites to be ranked as they were entered, the results were then presented spatially in the project GIS with the size and colour of the dot reflecting the rank. This facilitated analysis allowing areas of high potential to be clearly seen, the portal could also be queried in order to see the results of the ranking, see the individual case study reports in Section 3 for the results. The total score was normalised to a value with a maximum of 100 enabling comparison with results from the other ranking systems.

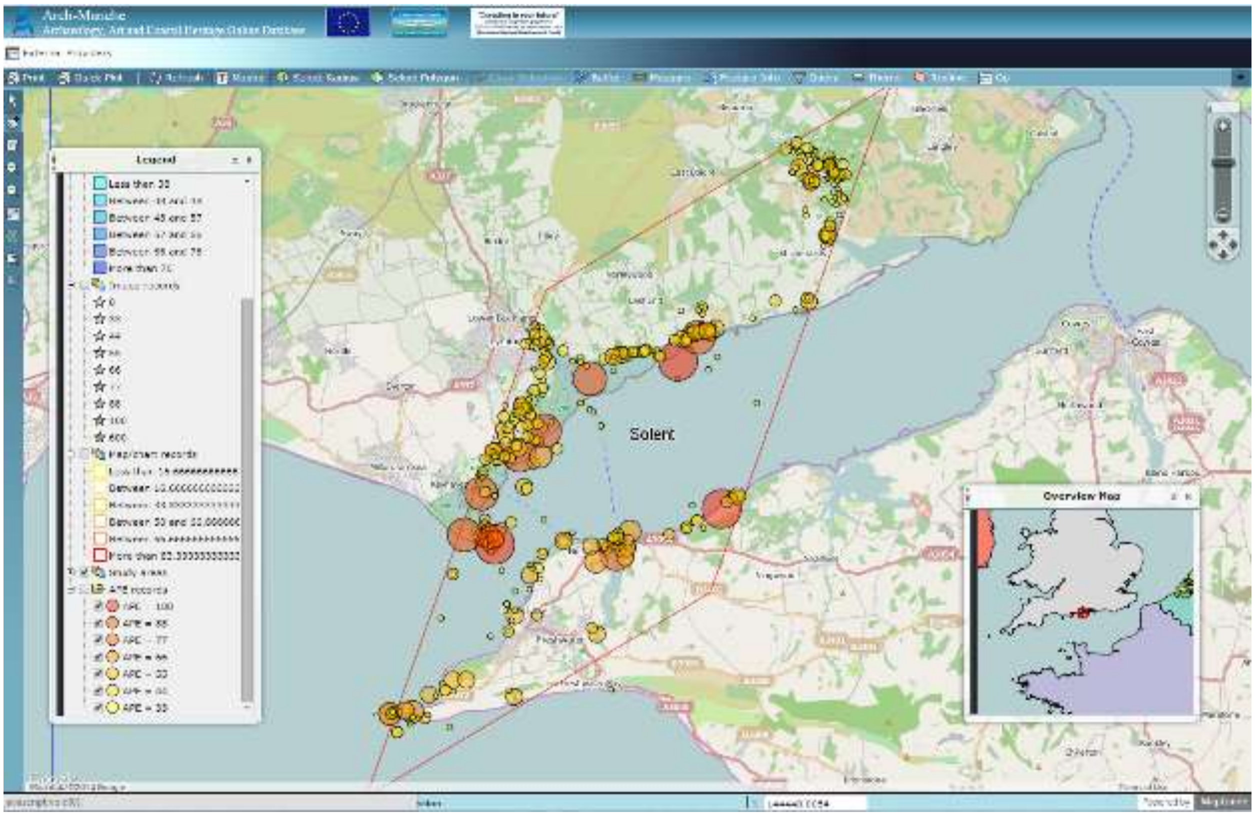

Figure 2.1. View of the Western Solent case study area, the larger red dots have a higher rank

Some difficulties were encountered during the ranking these included:

- Data sets significantly vary in detail between and within the partner countries, some contain a single line description which can be a poor basis for ranking.
- There is a requirement for an experienced archaeologist to undertake the ranking as the process does need a well-rounded background in the historic environment.
- Staff in each partner country carrying out the ranking could occasionally score sites differently depending on subjective interpretation of the criteria.
- It is possible to overlook a site that scores 'low' as a single example yet, taken with others nearby, a higher collective significance might be recognised.

Positive aspects of the ranking included:

- The creation of a database that has broad scope for interrogation and interpretation on a number of themes and issues related to coastal management.
- Enabling the review of large volumes of data against a set of criteria.
- The highlighting of individual sites of high potential.
- Identifying site types that are most capable of providing information on coastal change.

Although the process of ranking is subjective it has led to specific areas and environments where questions concerning the links between past and present coastal behaviour can be positively pursued. The ranking process has helped to identify particular gaps in shoreline knowledge, these can be bridged in each of the study areas as knowledge improves.

This study has revealed that certain types of site and deposit can gain consistent positive scores for their potential to inform on coastal change. Some of these sites can represent single and short-lived episodes. These might include a shipwreck or a prehistoric camp site. Sites of this kind can occur at a particular height, location or time that is pertinent to the understanding of shoreline-change. Other sites can offer a broader range or sequence of chronological and environmental information. They can include biostratigraphical evidence such as pollen records in peat deposits, diatoms in accrued marine sediments and plant macro-fossils in river valley alluvium.

Where short and single-line descriptive texts have been entered into external datasets, it is very easy for some of these qualities to escape assessment. In some instances, old and poorly recorded find-spots may suggest the presence of a greater archaeological or palaeoenvironmental resource, even though no such evidence has yet been documented. This can be the case where a scatter of artefacts has been loosely recorded from a floodplain or from a submerged landscape on the coast.

Overall the ranking process has allowed a large dataset to be reviewed and highlights sites and areas with high potential to inform coastal management.

2.2.3. Art Ranking System

The concept of using historical works of art to support coastal management developed from a visit to Tate Britain in 2007 after examining the painting by William Dyce of '*Pegwell Bay, Kent – Recollections of 5th October 1858'* from the point of view of a geologist and coastal scientist. In particular it appeared that the detailed portrayal of the chalk cliff geology, the wave cut platform on the foreshore, the beach and the coastal defence structures could form a reliable record coastal conditions at this location on that exact date. This raised the question as to how many paintings, watercolours and prints existed for other coastal locations, and were they true representations of the coastline?

In order to test the validity of the concept of using art to provide information on the changing coast it was necessary to develop a ranking system for the various types of artworks, which would allow the development of a list of those artists whose works proved to be consistently accurate in terms of recording coastal change. The objective was to develop a readily available tool for use by those professionals interested in increasing their knowledge of the coast, which would also support existing scientific approaches available for measuring coastal change (McInnes, 2008).

2.2.3.1. The Criteria Explained

In order to assess the reliability and accuracy of the historic artworks the art was assessed against four criteria.

Accuracy of Artistic Style

Varying artistic styles contribute to topographical accuracy to a lesser or greater degree in terms of their portrayal of the coastal environments. Five style sub-categories were considered, namely: *Caricaturist and Genre works, Picturesque Landscapes, Marine and Shipping Subjects, Topographical Artworks including beach and coastal scenery*, and, finally, *Topographical Artworks including beach and coastal scenery with a Pre-Raphaelite influence.*

For the *Caricaturist and Genre* category, including works by artists such as James Gillray (1757-1815), George Cruickshank (1797-1878), John Nixon (c.1750-1818) and Thomas Rowlandson

(1756-1827) and for the *Genre artists*, for example, some of the works of the Newlyn School and Brittany Plein-air artists, their interest usually lay more in human and social subjects rather than physical or historical aspects. These works do not usually contain enough detail to make a significant contribution to understanding of the coastal conditions at particular time; in view of this, such works scored one point out of a total of five in this category.

The second category relates to views of *Picturesque Landscapes* favoured by those artists and illustrators who were producing works in the manner of the Italian landscapes popularised by those returning from the Grand Tour. Often the picturesque views, such as those promoted by William Gilpin and produced by Thomas Walmesley, Francis Jukes and others, comprised aesthetically pleasing, but sometimes exaggerated or adjusted landscapes, with hillsides and cliffs appearing more 'Alpine' and precipitous; the desire of the artist was to depict the local scenery in the manner of a classical landscape to satisfy the tastes of their patrons. Whilst the *Picturesque* style is less concerned with topographical accuracy, it can provide at least some indicators of the nature of the landscape at the time. For example, the proximity of development to the coast, the nature of the coastal topography, and the presence of watercourses and other physical features, can inform coastal study in a broad sense. For this reason, the *Picturesque* works scored two points out of the maximum of five points.

Marine and Shipping subjects depicting coastal shipping and craft form a significant component in terms of coastal art. Many yachting, fishing and other shipping scenes include the coastal scenery as a backdrop. Whilst those paintings that are set further away from the coast are less interesting in this context, some works do actually provide a detailed topographical background. Often works produced by naval officers or others who had served on board ship, prove to be particularly accurate. Taking account of the contribution of these paintings a ranking of three points is allocated for this category.

The fourth, and by far the largest category, *Topographical Art including Beach and Coastal Scenery,* comprises coastal landscape paintings, watercolour drawings and prints. This is a rich resource and most of the Channel-Southern North Sea coast is very well illustrated in this respect. In fact there is great interest in the coastal towns and fishing villages located both on the open coast as well as on the tidal creeks, estuaries and harbours. There are, therefore, many works in this category that can inform us of what the coastal landscapes and environments were like at the time they were painted, and, so, such works were awarded four points out of a maximum score of five points.

The final category includes *Topographical Artworks including Beach and Coastal Scenery, which exhibit Pre-Raphaelite detail.* Artists such as William Dyce RA HRSA (1806-1864), John Brett ARA (1830-1902), and Edward William Cooke RA (1811-1880), and followers such as Charles Robertson RWS RPE (1844-1891), Henry Moore RA RWS (1831-1895) and Frederick Williamson RWS (fl.1856-1900) have provided us with precise images of coastal scenery in the mid-to-late nineteenth century. On account of the detail and accuracy of the subjects, with artists seeking to depict nature in a very exact manner, these works form a particularly valuable resource, and were, therefore, awarded the maximum score of five points.

Figure 2.2. Bonchurch, Isle of Wight, UK. Edward William Coooke RA, oil on canvas c1850. Private Collection

Most Advantageous Medium

The second ranking category relates to the most advantageous medium used for illustrating coastal scenery. Six categories were identified – first, *'Copper Plate Engravings'*; second*, 'Oil Paintings';* third*, 'Oil Paintings by Norwich School and Pre-Raphaelite Artists'*; fourth *'Steel Plate Engravings and Aquatints'*; fifth *'Lithographs, Fine Pencil drawings and Watercolour Drawings'*. Finally, sixth, *'Watercolour Drawings by Pre-Raphaelite Artists and their Followers'.*

Although some publishers and artists achieved remarkable success with *copper plate engraving* generally the softness of the copper plates meant that views were not as suitable for recording fine detail. As a result copper plate engravings were awarded a score of one point.

Oil paintings were considered to be rather more valuable as they could provide a greater level of detail and were ranked with a score of two points. Oil paintings by Pre-Raphaelite artists and their followers ranked more highly on account of their precision and the level of detail captured, and such works achieve a score of three points.

Figure 2.3. 'A Beach Scene at Southwold, Suffolk' by Thomas Smythe (1825-1904). Oil on canvas.

Steel Plate engravings and Aquatints were often published individually or as sets; others were contained in topographical books in the pre-Victorian period and through the early-to-mid nineteenth century. The Arch-Manche coast benefits from a wealth of such works, for example the views by Daniell (Daniell & Ayton, 1814) and the Finden Brothers (Finden, 1838). In view of the richness of this resource and the fine detail that could be achieved, combined with the benefits of colouring of some of the views, four points were awarded also for this category.

Lithographs, *Fine Pencil Drawings and Watercolour Drawings* were capable of achieving extremely fine detail. There are excellent examples produced by artists such as Robert Carrick RI (fl.1829-1904) and George Elgar Hicks RBA (1824-1914). The quality of some of the hand-coloured lithographs equates almost to that of watercolour drawings; as a result, lithographs are given a score of five points, the same score as for watercolour drawings. Not only is there an extensive resource of fine watercolour drawings covering most parts of the Channel-Southern North Sea coast, but the detail achieved using this technique is extremely helpful by providing information on cliff and slope geology, the nature of beach conditions, coastal vegetation patterns, as well as the extent of coastal development at the time.

Those watercolours by *Pre-Raphaelite artists and their Followers* score a maximum of six points on account of their often even more detailed appreciation.

Figure 2.4. The coastline at Luccombe, Isle of Wight. A watercolour by the Pre-Raphaelite follower, Frederick Williamson (1878). The cottages below the cliff were destroyed by a landslide in 1910. Private Collection.

The Value of the Subject Matter

This third ranking category was obviously of prime importance to those interested in studying and evaluating coastal change. As a result, a weighting factor of x2 was applied over three categories. First, *General coastal view,* which contributes to an overall appreciation of the coastal geomorphology and character of the landscape scored one point. Second, *More detailed works* providing information on the nature of the beach, the cliff line and hinterland, as well as perhaps information on land usage and environmental conditions, would score two points. Finally, the highest ranking category was for those *Works providing a detailed appreciation* of many aspects of the coast, including the geology, vegetation patterns and coastal development, which scored three points. As a result of the weighting in this category, a maximum of six points could be scored.

Figure 2.5. 'The Old Undercliff Road, Niton, Isle of Wight' by George James Knox. Watercolour, 1866. Image courtesy R.McInnes.

Value of the Time Period

The final ranking category represented the *Value of the time period* in which the artist was working. Three time periods were identified, *1770-1840* (ranking one point); *1840-1880* (ranking two points), and, finally*, 1880-1930 (*ranking three points). The exceptional oil paintings of the Dutch Golden Age merit two points on account of the detail they provide. The rationale behind these scores is that the early works are generally of slightly less interest to coastal scientists than the Victorian landscapes contained in the second category, which illustrate the coastline immediately before the start of, and through much of the Victorian seaside development period. Whilst there may be some information that can be gained from works of the earlier period in terms of depicting the undeveloped and unaltered coast, it is believed that the works covering the period 1840-1880 and, even more so from 1880-1920, where major coastal development changes were taking place, are of greater significance for the coastal engineer and scientist. As a result a maximum of three points was awarded in the category for the time period 1880-1920. Thereafter, artworks tended to lack detail and following the Second World War aerial photography became more widely available.

Figure 2.6. 'The Harbour, Lowestoft, Suffolk' by Alfred Robert Quinton. Watercolour, c.1920. Image courtesy of J. Salmon Limited.

Summary of the Art Ranking System

1. Accuracy of Artistic Style (Maximum 5 Points)	
1.1 Caricaturist/Genre subjects	1
1.2 Picturesque landscapes	2
1.3 Marine/Shipping subjects	3
1.4 Topographical/beach and coastal scenery	4
1.5 Topographical/beach and coastal scenery with Pre-Raphaelite influence	5
2. Most advantageous medium for illustrating coastal change (Maximum 6 points)	
2.1 Copper plate engravings	1
2.2 Oil paintings	2
2.3 Oil paintings by Norwich School and Pre-Raphaelite Artists	3
2.4 Steel Plate Engravings and Aquatints	4
2.5 Lithographs, Fine Pencil and watercolour drawings	5
2.6 Watercolour Drawings by Pre-Raphaelites and Followers	6
3. Value of the subject matter in supporting understanding of long-term coastal change	
(weighting x2 and Maximum score of 6 points)	
3.1 General coastal views which assist overall appreciation of the coastal geomorphology and landscape character of the coastal zone	1
3.2 More detailed view of the beach, cliff, backshore and hinterland including some appreciation of beach profile, cliff geology and structure	2
3.3 Very detailed appreciation of shoreline position, beach profile, geology, geomorphology, coastal environment and coastal defences	3
4. Value of the time period (Maximum of 4 points)	
4.1 1770-1840 (early except Dutch ‘Golden Age’)	1
4.2 Dutch Golden Age (17th century paintings)	2
4.3 1840-1880 (Victorian coastal development period)	3
4.4 1880-1930 (Late Victorian, Edwardian and later coastal development period)	4
Compiling the scores for ranking artists and their works	
1. Accuracy of artistic style Maximum	5
2. Most advantageous medium Maximum	6
3. Value of subject matter Maximum	6
4. Value of the time period Maximum	4
Total maximum score	21

Table 2.12. Summary of the art ranking system

All scores were then normalised to a total score out of 100 in order to enable comparison.

2.2.4. Maps and Charts Ranking

In addition to a range of physical techniques of studying coastal evolution (such as coring and remote sensing), historical maps provide an important source of information. From the late Middle Ages onwards the detail and quality of maps rapidly increased. These maps can be used for coastal research, for instance by georeferencing the maps (comparing the historical map to the present day situation) and digitizing (drawing polygons, lines of points) elements like the evolution of the former shoreline in a GIS (Geographical Information System) like ArcGIS or Quantum GIS.

The quality and detail varies widely between different maps, and simply using them with the assumption that they depict an accurate image of the former (coastal) situation, is likely to induce large mistakes in the coastal reconstruction. Therefore it is important to analyse the quality of a map, before starting the actual interpretation.

When using the term 'accuracy' in relation to maps, this refers to the quality of data and the number of errors contained within the map. A high accuracy indicates a more useful map for coastal research, although this usefulness also depends on the specific goals of the research and the specific location of interest. The latter, of course, cannot be measured and defined in an evaluation system and should therefore be assessed by each researcher individually.

Evaluation of the accuracy of historical maps and charts can be achieved in very different ways. It is important to keep in mind the purpose of the study: maps used to study coastal research are subjected to other quality criteria than maps used for ancient road reconstructions. Furthermore it is important to define which elements are taken into account in the accuracy assessment. For this research project we chose a rather classical approach to the elements of map accurateness, freely interpreted after Blakemore and Harley (1982). This includes an evaluation of the topographic, geometric and chronometric accuracy of the maps.

2.2.4.1. Topographic Accuracy

Topographical accuracy refers to the types of depicted elements within a map or chart. What is the smallest depicted element? Which elements are depicted? Are towns simply symbolised by a church symbol or are separate houses drawn? In the Arch-Manche area three main types of coasts are present: estuaries (or tidal basins), cliff coasts, and sand (or dune) coasts. The types of coast represented within a map will define the types of features expected to be mapped. Therefore, separate sub-categories were made within the ranking system for the three above mentioned coastal types.

Figure 2.7. Examples of the depiction of the division of supra-, inter- and sub-tidal areas within estuaries and tidal basins: Left = Well Depicted (high and low marsh clearly defined (source: Algemeen Rijksarchief, Kaarten & Plans II, 8554)). Right = depicted (marsh is separated, but more subjectively (source: Koninklijke Bibliotheek Den Haag, 1049B11_094)).

Figure 2.8. Examples of the depiction of inlets within cliff coasts: left = well depicted, right = depicted (source: commons.wikimedia.org).

Figure 2.9. Examples of depiction of division of dunes and beaches on sandy coasts: left = well depicted (source: Koninklijke Bibliotheek Den Haag, 1049B11_094), right = depicted (source: commons.wikimedia.org).

Estuaries and Tidal Basins: Important estuaries within the Channel – Southern North Sea area include the Scheldt Estuary (Low Countries), the Somme Estuary (Northwest France), the Seine Estuary (heavily transformed under Le Havre´s influence) and the Solent Estuary (Southern England). Within these areas the following criteria for topographical accuracy were assessed to determine whether they were 'well depicted' or 'depicted':

- Divisions depicted between non-tidal, intertidal and subtidal areas
- Tidal channels and inlets depicted

Cliff Coasts: Cliff coasts cover most of the shoreline of Southern England and Northern France (Normandy). The following criteria for topographical accuracy were assessed:

- Division of cliffs and beaches depicted
- Division non-tidal, intertidal and subtidal area depicted
- Inlets (both tidal and river originated) depicted

Dune and Sand Coasts: Sandy coasts are found along the entire coast line of the Low Countries and in Northern France, only intersected by the Scheldt Estuary and some (smaller) river mouths. The following criteria for topographical accuracy were assessed:

- Divisions dunes and beaches depicted
- Division between non-tidal, intertidal and subtidal area
- Topography of dunes depicted

Detail in Non-Coastal Areas: Although there is particular interest in the coastal (intertidal) area, it was useful to note information about topographical detail in the non-coastal area when assessing the maps. The 'non-coastal area' includes everything landward from the water front formed by for instance sea dikes, dunes or cliffs. The ranking system is kept simple in comparison to the coastal areas. Three different categories were used (in addition to 'not depicted'):

- High quality
- Medium quality
- Low quality

2.2.4.2. Geometric Accuracy

Geometric accuracy encompasses both geodetic accuracy (referring to the positioning of a map in a global coordinate system) and planimetric accuracy (referring to distances as depicted by the map versus real distances). Difficulties are imposed by the original coordinate system of the old map as it is not the same as modern coordinate systems; this causes distortions which do not necessarily point to a lack of accuracy. Since these distortions are usually small, and many historical maps do not have information about their coordinate system, the planimetric accuracy assessment was concentrated on to examine the errors due to complexities in the different coordinate systems. The accuracy of the entire map was assessed rather than just the water front zone. Assessing only the latter might create difficulties in finding sufficient suitable Ground Control Points (GCP´s, see below for further info) for analysis.

There are computer programs available to investigate geometric accuracy. Bernhard Jenny describes, in various articles, the methodology used in the program *MapAnalyst* (freely available via http://mapanalyst.org/) in order to define the geometric accuracy of historical maps (Jenny, 2006; Jenny et al 2007; Jenny 2010; Jenny & Hurni 2011). Basically, a present day map (*open street map*) is re-projected and transformed in order to fit on the old map. The more the new map has to be re-projected, the less accurate the old map is. The geometric accuracy is visualised by displacement vectors and distortion grids. The displacement vectors connect the ground control points (GCP´s) in both the old and new map. The longer the line, the bigger the displacement. Alternatively circles can be used (the larger the circle, the greater the displacement). The main visualisation tool is the distortion grid, showing the local distortions in the old map. Where the distances on the old map are smaller than the new map, the grid size will decrease and vice versa. A scaled and rotated (but undistorted) reference grid can be shown for comparison.

Numerical values to compare the geometric accuracy in *MapAnalyst* can be found in the form of the Mean Positional Error (MPE) and the Standard Deviation (SD). Both refer to the average distance from a point in a repositioned historical map (using the GCP´s) and its 'true' position. In most cases the MPE and SD are calculated using a Helmert four-parameter transformation (translation in x and y, scaling and rotating). The MPE is calculated by $\sqrt{(\sum v^2)/(n-2)}$ *(v=distance between each pair of GCP´s, n is number of GCP´s)* and the SD by $\sqrt{(\sum v^2)/(2n-4)}$. Since we use these values as a comparison between different maps it basically does not matter which one is evaluated, as long as the choice is uniform. Since the MPE is calculated in the least complex way we have used this value for the project.

MapAnalyst: Program Interface

The *MapAnalyst* program interface is quite simple (Figure 2.). In the main window both the old and the new map can be shown. Tools are found at the upper end of the display and visualisation tools and output can be found at the bottom of the screen. Open Street Map is set as the default map which projects the world in a Mercator projection but has the disadvantage to exaggerate distances when approaching the poles. The calculations, however, do compensate for this effect and are correct. Alternatively it is possible to import any other map, as long as it has a *World File* (giving all information on the projection system).

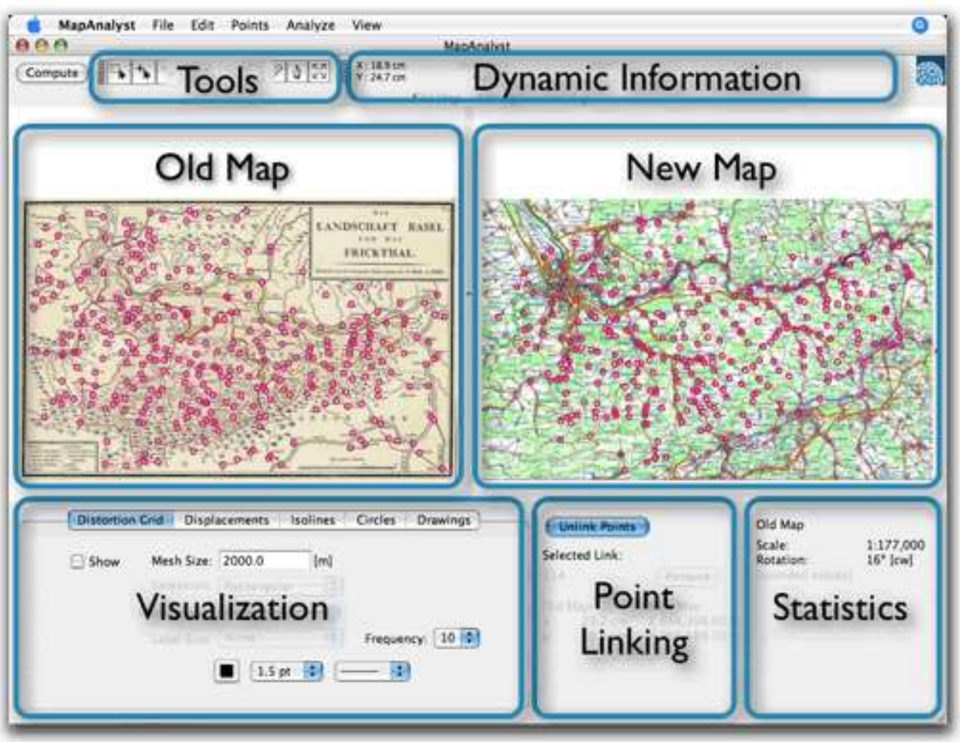

Figure 2.10. Program interface MapAnalyst

2.2.4.3. Chronometric Accuracy

Assessing chronological accuracy is, if it is to be assessed in the most accurate and detailed way, a very time consuming process. For all depicted features a *terminus ante quem* and a *terminus post quem* (giving the date range a certain feature was present in the actual landscape) should be known. These dates should then be compared to the date of manufacturing of the map. In case the map is a copy of an original map, the date depicted should be compared. In this way it is possible to find out if certain parts of the map are either ‘fantastic’ or simply copied from older maps.

Unfortunately, when analysing a large number of maps this process is likely to be too time consuming. Therefore the use of proxies is the only possible solution. The proxies chosen to assess the chronometric accuracy within the Arch-Manche project are:

1. Date of the map. Is the date of the map known? And, in the case of a copy, is the date of the original (and therefore the depicted situation) known? If it is not known, the potential for using the map for (chronological) evaluation of coastal change is limited. It also indicates that it may not be possible to do a full chronometric assessment as there is no date for comparison.

2. The use of terrain measurements. If the use of actual terrain measurements is noted on the map, or several distances are noted, this indicates that an actual land surveyor studied the area which automatically means an increased chance of having chronometrically correct items on the map.

3. Is the map an original or a copy? The chances of a high chronometric accuracy are increased when studying an original map. Certified, authentic copies (or *“Copie Authentique”*) are the next best examples as the quality of the copy is assured. Normal, not certified, copies induce the chance of left-out or added elements, not corresponding with the date depicted by the map. It should be noted that in the case of copies, the date depicted (mostly the date of the original) should be taken into account and not the date of the copy.

An evaluation of these three elements, results in the following ranking (high to low) of the (suspected) chronometric accuracy of historical maps:

Date known	Measurements	Original
Date known	Measurements	Authentic copy
Date known	Measurements	Copy
Date known	Measurements	Unknown
Date known	No measurements	Original
Date known	No measurements	Authentic copy
Date known	No measurements	Copy
Date known	No measurements	Unknown
Date unknown	Measurements	Original
Date unknown	Measurements	Authentic copy
Date unknown	Measurements	Copy
Date unknown	Measurements	Unknown
Date unknown	No measurements	Original
Date unknown	No measurements	Authentic copy
Date unknown	No measurements	Copy
Date unknown	No measurements	Unknown

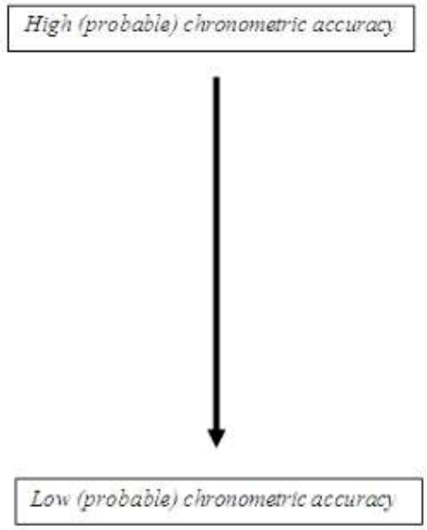

Figure 2.11. Ranking of maps based on chronometric accuracy

2.2.5. Historic Photographs Ranking

Unlike historic maps, charts and artworks it was not necessary to rank historic photographs for reliability and accuracy as they provide and objective view at a point in time. The methodology applied ranked them based on their usefulness in supporting understanding of long term coastal change. Four criteria were used:

1. Purpose of the Photo or Postcard

This was a non-ranking criteria and consisted of the following four options:

- Private.
- Touristic.
- Scientific (geology, geomorphology, archaeology).
- Unknown.

2. Coastal View

The next criteria applied depended on whether the image depicted cultural heritage features. If these were not shown (for example the image was a general landscape view) the following criteria were used:

- General view – no clear detail on the coastal geomorphology (2 points).
- Semi-general view – possible to identify coastal features such as the division between the cliff and beach (4 points).
- Detailed view – possible to clearly see the shoreline position, beach profile, geology etc (6 points).

3. Heritage View

If the image did contain cultural heritage features then the following criteria were used:

- The view provides a general insight on coastal evolution without chronological indications (2 points).
- The view provides an indication on the chronology – identifiable period (4 points).
- The view provides a detailed indication on the chronology – precise chronology (6 points).

4. Quality
The final criteria was based on the current physical condition of the image:

- Poor (1 point).
- Medium (2 points).
- Good (3 points).

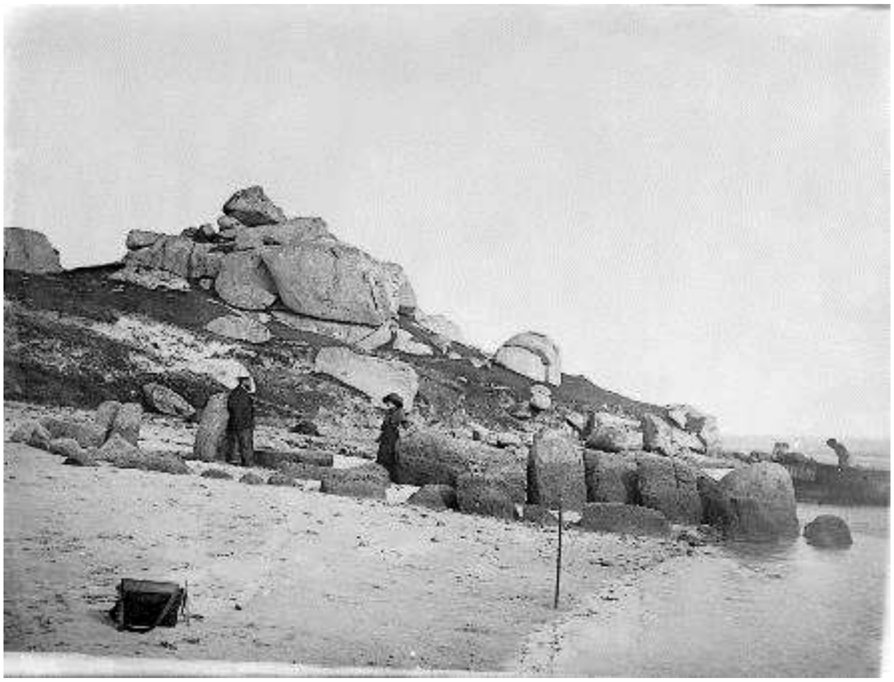

Figure 2.82. The Kernic beach and prehistoric passage grave, Plouescat (Finistère)', ancient photo - (around 1900), author Cdt. Devoir (?) © Labo Archéosciences UMR 6566 CReAAH.

Figure 2.8 is a photo of Kernic beach and a prehistoric passage grave in Plouescat, this image contains cultural heritage and scored 6 points under criteria 3 (Heritage View), the passage grave has been radiocarbon dated to 4300 Cal BP and is now located 3.2m under the current high water line. The current state of the image also scored highly (3 points) as the image has not degraded or been torn so it is still possible to view the detail.

2.3. Fieldwork Approaches

The project partners used a variety of fieldwork techniques to carry out detailed research on significant sites and areas of the coastline looking at the nature, scale and pace of coastal and climatic change as demonstrated through the archaeological, palaeoenvironmental and coastal heritage records as well as artworks. This involved in-depth, inter-disciplinary research including fieldwork with cross-partner staff involvement (two seasons in 2012 and 2013), data gathering, scientific dating and analysis. This section presents the various techniques and approaches used in the project, more detail on the results of the fieldwork can be found in the relevant case study reports (Section 3, the case study reports are numbered from 3A to 3N).

2.3.1. Diving

Diving fieldwork was carried out in the UK on case study area 3D, the Solent and Isle of Wight (Figure 2.). This involved the use of an archaeological dive team to survey known submerged landscapes and shipwreck sites which have the potential to provide information on coastal change.

The fieldwork comprised survey and sampling of submerged landscapes in the western Solent, evidence held within these sites and deposits provides high resolution data on the development of the Solent as a river, including coastal and climate change and human responses to this. Shipwreck sites across the Solent were also investigated, the sites that were chosen provide valuable information on changing sediment patterns in the area, the monitoring of wreck sites in relation to seabed movement gives us an insight into modern environmental change processes and impacts. The sites investigated have been subject to monitoring in previous years, this provided comparative data in order to understand the rate and level of sediment change in these areas.

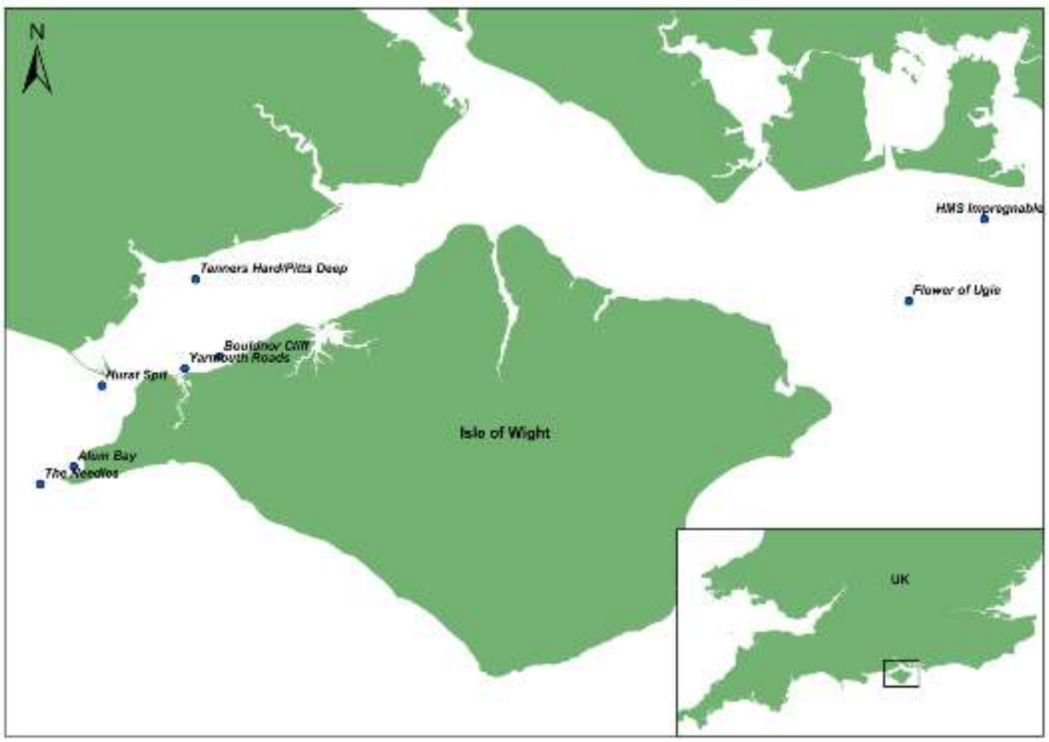

Figure 2.13. Location of dive sites in the Solent, UK

The methods used on the submerged landscape sites included:

Re-establishing previous grids – this allowed site plans to be overlaid in order to monitor changes over time on sites which have been subject to investigation in the past.

Recording and recovering surface finds when under direct threat – these were recorded on the site plans, photographed and recovered for further analysis.

Survey to record rates of erosion - baselines were set up across the sites and tied into previous survey grids, offset measurements were then taken to the edge of the peat drop off at Bouldnor Cliff, and to the foot of the cliff in the north-west Solent.

General site inspections – this involved a review of the seabed to determine whether there have been significant changes since previous diving, and creation of a photographic and video record of the site.

Drift dives – these were carried out in both easterly and westerly directions on both sides of the western Solent, the edge of the peat platforms were followed and inspected with areas of erosion noted. The sites were also inspected for any archaeological evidence which may have eroded from the submerged cliffs.

Sampling – landscape deposits which can provide information on past environments and change over time were recovered using a monolith tin. At the peat deposit west of Hurst Spit where no site plan exists the position was recorded from a fixed buoy on the surface and an accurate depth was taken using a dive computer and from the buoy, recording the exact time of the depth measurement. Samples were then sent for dating and environmental analysis.

The methods used on the shipwreck sites included:

Site inspection – initial diver inspection was carried out to review the area of seabed and determine whether there have been significant changes since previous diving.

Photographic and video record – the sites were photographed and video was taken where possible.

Monitoring – several sites have been subject to ongoing monitoring, established monitoring points were identified and measurements taken to the seabed.

All diving was carried out using a UK Health and Safety Executive (HSE) compliant professional dive team and a licenced dive boat. Volunteers were also able to take part where training and experience was appropriate. Diving activities conformed to the HSE Diving at Work Regulations 1997, and followed the best practice laid out in the Scientific and Archaeological Approved Code of Practice. All potential risks were mitigated through the use of risk assessments.

Figure 2.94. Diver at work on the site of Bouldnor Cliff. Image courtesy of Roland Brookes.

2.3.2. Intertidal Survey

Intertidal survey was carried out in the UK in Langstone Harbour within case study 3D, the Solent and Isle of Wight. Smaller surveys were also carried out on a number of sites around the Solent (Figure 2.10). Sites were chosen which can provide information on past coastal change, as well as more recent change where erosion or extreme weather has exposed archaeological sites and material, and where sites can be used as a proxy to determine the extent of change such as sediment levels.

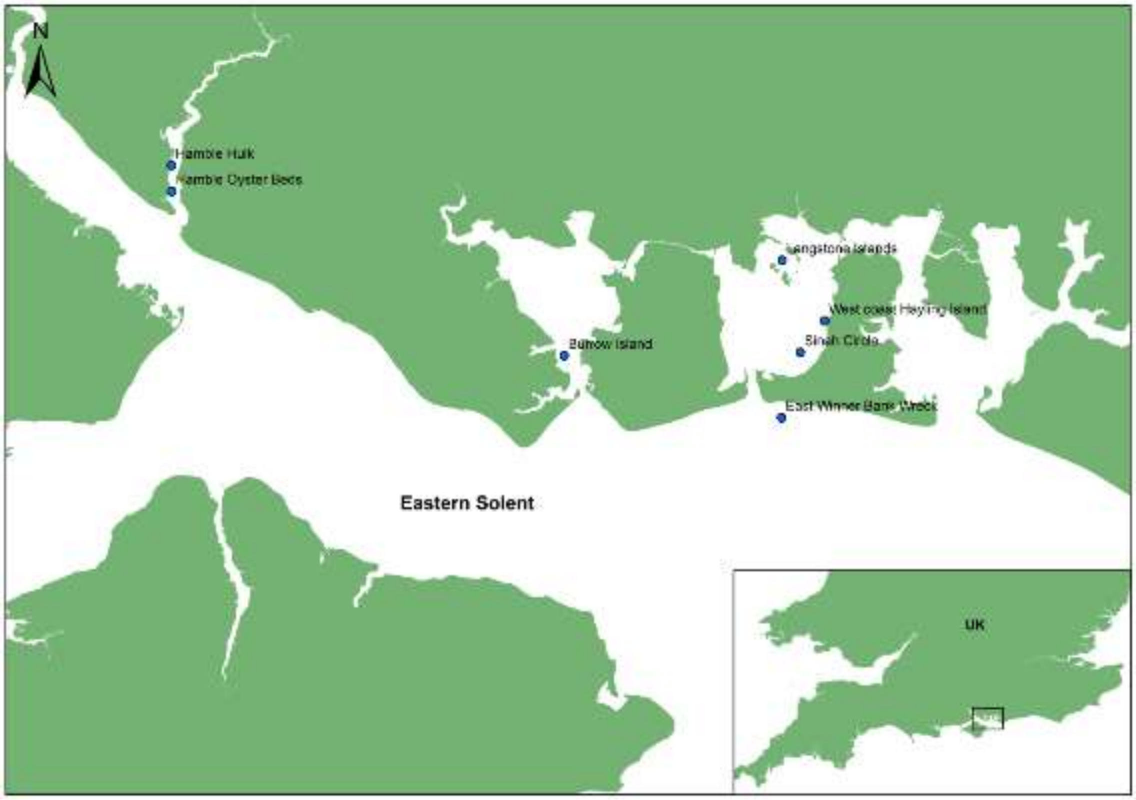

Figure 2.105. Location of intertidal sites in the UK

The following methods were used:

Walkover surveys – these were carried out in order to identify sites, features and finds which may have eroded or been exposed at the fieldwork sites. Positions were taken using a Real Time Kinematic (RTK) GPS along with a photograph, artefacts were recovered if at risk of loss and archaeologically significant.

Controlled Collection – the south east coast of North Binness Island appears to be the site of Roman activity, large amounts of pottery has been revealed on the foreshore. A controlled collection was carried out in this area and the pottery was sent for analysis to the University of Southampton.

Monitoring of previously recorded sites – sites recorded during the 1990's Langstone Harbour Project and survey work in 2002-2004 were revisited to determine whether they were still in-situ or had been eroded. Positions were recorded with the RTK GPS system and photographs taken.

Landscape survey – the RTK GPS system was also used to survey the current edge of two islands in Langstone Harbour, focussing on the base of the small cliff which marks the extent of erosion. The system was also used to survey the oyster beds on the Hamble River, the timber structures along the west coast of Hayling Island and the cliff, and the erosion on Burrow Island.

Photographic survey – this was carried out at all sites. For the East Winner Bank wreck site a camera was attached to a long pole in order to take aerial shots of the site, detailed measurements were also taken of the timbers and the extent of the site exposed by the sand bank.

Sampling – samples were recovered from the timber structures off Hayling Island and sent for Radiocarbon dating.

A Leica 1200 Real-Time Kinematic (RTK) GPS system was used to record the position of sites located during the landscape survey and to carry out a rapid survey of the timber remains found on the west coast of Hayling Island. The RTK system uses the UK Smartnet system to rectify the small basic error that is inherent in all GPS receivers and uses the OSGB36 datum. This allows the Leica 1200 system to operate in the field without a base station and can provide 3D accuracy within the British National Grid to with +/- 15mm. Data collected in the field is then processed through Leica GeoOffice and imported into ArcGIS for further processing, management and analysis. For archiving purposes, all basic data is retained in the form of a simple .txt file to ensure full future access to the original data collected during the survey.

Figure 2.116. The RTK GPS system in use on a timber structure off Hayling Island

2.3.3. Archaeological Excavation

Archaeological excavation was carried out in France at the site of Servel-Lannion (within case study 3I, Tregor and Northern Finistere) and at Quiberon (within case study 3K, Quiberon peninsula and Morbihan) see Figure 2.15. Due to their different environments, the methods used for the excavations were very different on both sites.

Lannion - in the Lannion-Servel area, the Petit Taureau fish-trap is located in the mouth of an estuary, in the intertidal area. Excavation was carried out at low tide using tools and methods applied in terrestrial archaeology, although the excavation was administratively considered as an "underwater excavation", authorized by the DRASSM.

Due to the nature of the site the fieldwork periods were selected to coincide with spring tides, the team generally had 2-4 hours on site per day at various times to fit with the changing tide levels and times. The team was composed of several specialists, students and volunteers, and comprised around 15 people. The surveys were hand drawn in the field but general views were taken along the excavation thanks to a drone. Wood samples were taken during each fieldwork campaign in order to carry out radiocarbon dating, dendrology and dendrochronology.

Quiberon - excavation at the Beg er Vil site in Quiberon involved classic terrestrial archaeological methods; initially a mechanical digger removed the topsoil which was followed by manual excavation. The sampling and sorting of sediments and faunal remains was carried out in parallel with the excavation on the adjacent beach (washing and sieving) and in the field laboratory there were several trainees able to manage the collections. The whole team comprised between 15 and 20 people. In parallel with the excavation and the archaeological data collection (mapping, photos, etc), geomorphological maps of the area were drawn by specialists.

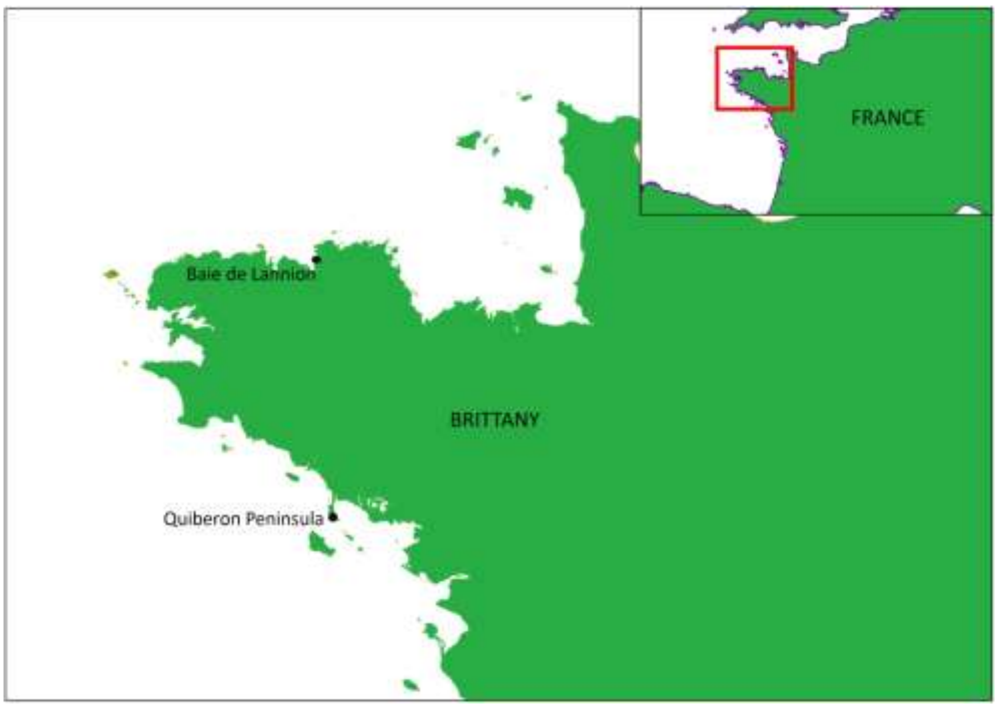

Figure 2.127. Location of Intertidal Excavations in France

2.3.4. Geophysical and Geotechnical

Geophysical and geotechnical fieldwork was carried out in the Belgian case study areas of Raversijde (case study 3L Ostend-Raversijde) and the Scheldt estuary (case study 3M Scheldt polders), as well as Langstone Harbour in the UK (case study 3D, Solent and the Isle of Wight) and off the coast of Quiberon (case study 3K) and St Malo in France (case study 3H, Cote d'emeraude). The various techniques used are described below, further details and results can be found in the relevant case study reports.

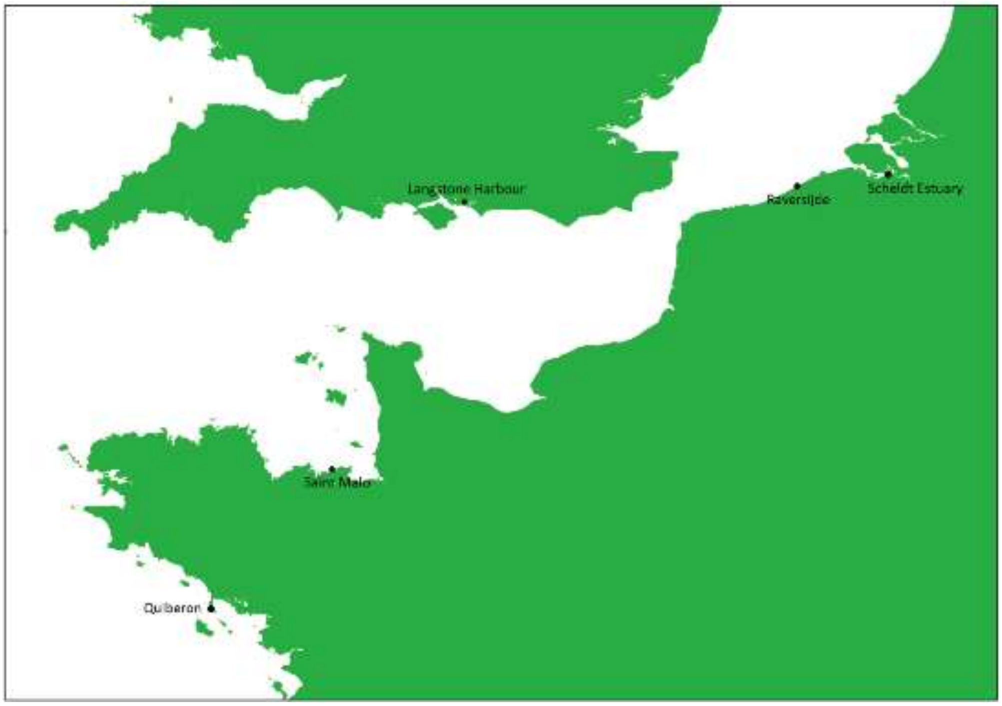

Figure 2.138. Location of geophysical and geotechnical investigations

Cone Penetration testing (CPT) – this method is used to sound the composition of the subsurface and allows for information regarding the geology and hydrology to be obtained as well as the physical and mechanical properties of the subsurface. The method is fast and allows for continuous profiling. The technique involves a cone which is pushed into the ground at a constant rate while continuous measurements are made of the cone resistance and the sleeve friction. The ration of sleeve friction divided by cone resistances, called the friction ratio, is used to classify the soil.

Land Sesimic Investigations - reflection seismic investigations on land involve the use of a controlled seismic source and an array of receivers (geophones). The generated seismic pulse travels through the sediments and will be partly reflected at the interface between two materials with different densities (part will be transmitted through the interface). The reflected waves are recorded at the surface and used to create an image of the subsurface. This image, or model, is not unique (more than one model adequately fits the data, typical for inverse problems) and therefore great care must be taken in data processing and interpretation.

Marine Seismic Investigations - as on land, reflection seismic measurements at sea involve the use of a sound source, towed behind a vessel or mounted to the hull, to generate acoustic waves that travel through the soil. Part of the acoustic signal is reflected from the seafloor but the remainder penetrates the seafloor and is reflected when it encounters boundaries between layers with different elastic properties (Figure 2.14). The recorded reflected acoustic waves result in a continuous record of the sub-seafloor stratigraphy.

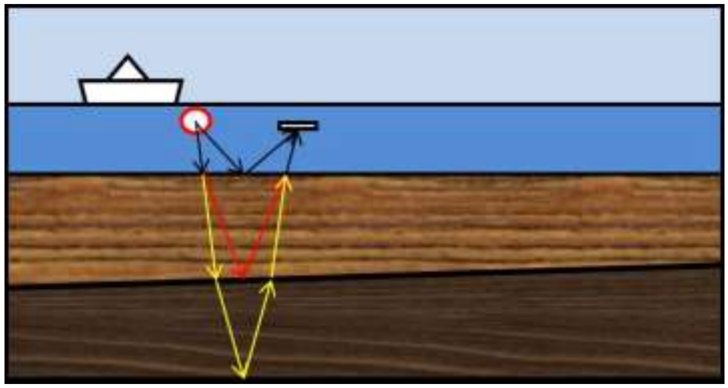

Figure 2.149. Marine seismic reflection principle

Several physical parameters (frequency, output power, pulse length) determine the capability of the chosen technique. High frequencies provide higher resolution, but are limited in amount of penetration below the seafloor whereas lower frequencies provide lower resolutions but better penetration. Increasing output power allows for greater penetration but in the case of a hard seabed or very shallow water this will yield strong multiple reflections (i.e. seafloor echo) and lower signal to noise ratio. Finally, long pulse lengths yield more energy and result in greater penetration but will decrease the resolution. Shorter pulses correspond to broader bandwidth frequency response, thus increasing the resolution.

At both the Belgian case study sites and in the UK case study site of Langstone Harbour a parametric echsounder was used. This source, which is mounted onto a pole attached to the side of the ship or boat emits two signals with a different frequency. The high-frequency signal (100 kHz) allows a very detailed image of the sea floor. The lower-frequency signal (between 6 and 14 kHz) penetrates deeper, resulting in an image of the underlying structure. The fast pulse rate (20-25 pulses per second) resulted in a high lateral coverage. During the measurements the echosounder was attached on a long iron pole fastened to the side of the ship. A motion sensor was used to filter out the wave movement. Positioning was done using a DGPS antenna with an accuracy of ±1 m. In France a sub-bottom profiler (Echoes 1000) was used.

Electromagnetic Survey (EMI) – this was carried out by the department of Soil Management at Ghent University on the site of Raversijde. EMI instruments produce an electromagnetic (EM) field, which varies over time. When electromagnetic fields are induced in the subsurface the resulting field, which depends on specific subsurface properties, can be measured and evaluated (Delefortrie et al., 2014). Zones with a high (measured) conductivity are of specific interest: this may be caused by different things, for instance the presence of metal objects, or shallow peat layers. However, also thick shallow clay layers are known to produce an increase in conductivity, making interpretation a complicated matter. An electromagnetic penetrating profiler was used in the French case study sites.

Auger survey – this was carried out off the west coast of Long Island in Langstone Harbour, with the aim of tracking the buried palaeochannel identified during previous excavations in the area. The survey was carried out using hand augers, both a gouge and dutch head were used. Samples were assessed on site and information logged on an auger log sheet which characterised the colour, consistency, type, size and percentage of inclusions, and soil type. The relative depths of the different soil types were noted when analysing the samples, so as to build a geological/stratigraphical sequence of the sediments. The samples that were taken created a cross formation, with cores AP51-58 and AP6 running south-west to north-east, and cores AP1-5 running north-west to south-east. Samples of peat were recovered for further analysis and dating. The results are detailed in case study report 3L (Ostend-Raversijde). Shallow test cores were also taken at the site of Raversijde, this was to provide ground-truthing for the seismic and electromagnetic data. These cores were taken by a hand-operating coring device called a 'van der Staay suction corer', designed for coring in water-logged sandy sediments.

Side-scan sonar – this was carried out at the French case study sites. The side-scan sonar transmits and receives sound waves. A towfish is towed through the water and transmits fan-shaped acoustic pulses, perpendicular to the direction of travel. The towfish is connected to the vessel by a coaxial electric cable which carries data to the topbox for processing in real time. The acoustic pulse transmitted by the towfish is reflected when it meets a surface, the seabed or any other element present in the ensonified area. Transducers situated on the towfish capture these reflected, or specular waves which travel along the same trajectory as the waves initially transmitted by the device. Travel time is recorded together with intensity. As sound travels at a known velocity through water, the echo, once processed, allows the system to produce an acoustic image of the seabed from which can be determined the lengths, breadths and heights of any objects scanned. An obstacle of sufficient size will intercept part of the transmitted signal and prevent it from being reflected by the seabed. This creates an acoustic shadow which the operator can use to estimate the height of the obstacle. The frequency of the transmitted pulse determines the penetration depth of the wave. Thus, the higher the frequency, the smaller the penetration and vice versa. However higher frequencies provide greater resolutions.

2.3.5. Art Fieldwork Approach

Fieldwork in relation to the assessment of artworks including paintings, watercolours, prints, photographs and old postcards was undertaken at case study sites in England and Brittany, France.

The fieldwork objective was to support the wider Arch-Manche ambitions of establishing:

- What information can the historical images provide to support understanding of long-term coastal change?
- How can the potential of this resource be used most effectively by stakeholders?

Identifying the Artworks for Field Study

The first stage was to identify potential images that might merit more detailed study; this work was undertaken through a review of art data sources in the respective countries. Information about the artworks and photographic images was then entered on the database in order to assess the rank that they achieved in terms of their value in informing us about long-term coastal change. For each image a ranking score was calculated automatically based on the approach described in Section 2.2.3.

Having established, through the art ranking system which of the images were likely to be true representations of the conditions that would have been observed at the time they were painted, and which works achieved the highest scores, it was then possible to consider the locations for field study in more detail. The project partners were anxious to try and ensure that the field study sites represented the full range of geomorphological conditions that exist around the Channel-Southern North Sea coastlines so that art could be used to support evaluation of coastal change across a wide range of environments. The case study sites selected achieved this through inclusion of hard rock clifflines, soft cliffs, coastal landslides, shingle and sandy beaches and spits and saltmarsh and mudflats.

Fieldwork Approach

The ranking system had confirmed that the artworks being studied were by artists who generally achieved a fair degree of accuracy in the images they produced. It was now necessary to test this in the field. Prior to the site visits the location from which the artist depicted the view was established as closely as possible in order that a direct visual comparison could be made in the field.

Each of the case study locations was visited and photographed in varying weather conditions. Inspections were timed, wherever possible, to coincide with Low Water and a walk-over survey was made along the beach and base of the cliff returning along the cliff top. This ensured that thorough comparison could be made between the geomorphological conditions depicted in the artwork and the present day situation. In terms of on-site assessment particular aspects of interest included the extent of coastal erosion since the artwork was produced, evidence of rock falls, landslides and other substantial changes to the coast, changes in the form and nature of the beach (eg: steepness, volume and composition) and changes in the extent of saltmarsh and mudflats as a result of sea level change or human intervention. Furthermore, the nature and extent of coastal defences and development patterns was noted as a number of the interesting geomorphological features had been obscured subsequently as a result of the expansion of coastal towns and villages or by tree and scrub growth.

The main focus for each case study has been the examination of one or two particular artworks, and then to make an assessment of what the image tells us about changes over time from field observation (Figure 2.18). However, for some of the study sites it has been found that several artists painted the view from the same or a similar spot. This helps us to establish a chronology of coastal change through the nineteenth and twentieth centuries. The results for each case study location are described below.

Art fieldwork was undertaken at the following case study locations:

England

- East Anglia
- East Kent Coast
- Hastings, East Sussex
- Solent and Isle of Wight
- West Dorset-East Devon
- West Cornwall

France

- Cote D’Emeraude, Brittany
- North Finistere and Tregor, Brittany
- Quiberon Peninsula and Morbihan
- Cornouailles, Brittany

Nearly two hundred and fifty artworks from across the Channel-Southern North Sea region were ranked. A substantial number of these (39%) were deemed to be of sufficient interest to require more detailed investigation through case studies (56 in England and 42 in Brittany, France).

Figure 2.20. Art field studies involved comparing the current situation to the original artwork, this is Bonchurch shore which was painted by E.W Cooke.

2.4. Data Management

In order to provide common working approaches a database and project GIS were developed, these used open source software to allow joint working and the analysis of project results. This section outlines the methodology for data management.

2.4.1. Context

The Arch-Manche project has placed a high priority and emphasis on effective, efficient and innovative data management that underpins many of the overarching project aims and objectives. As stated in the project proposal, "*Successful data integration and management will be key to the development and delivery of the project. Activity 1 and 2 will be developing datasets on which illustrative, modelling and presentation materials will be based. Presentation materials will be integrated into all levels of reporting, communication and dissemination.*"

A database was created to contain archaeological data, palaeoenvironmental data, maps, charts, photographs and artworks. All of these data sources were integrated into one database that was accessible by all partners and also linked to a project GIS in order to view and analyse the results spatially. This was then developed into a geoportal which could be accessed by the public in order to interrogate the data obtained through the project and to view the 2, 3 and 4 Dimensional models.

2.4.2. Software Rationale

The Arch-Manche project database was developed as the central repository for storing, rationalising and distributing the results of the work undertaken. The key parameters used for the selection of the appropriate system in order to deliver on the aims and objectives for data management and analysis were as follows:

- *Functionality*: the database was required to store various data types and deliver results rapidly enough that the end user need not be conscious of the transactions that were taking place once queries were submitted; the application had to be extensible, with optional features being available if required (for this project the spatial extension functionality was to be key).
- *Licensing and distribution*: the database might have been proprietary, but the output had to be cross-compatible with other non-proprietary systems so that data could be shared between audiences or potential partner projects not necessarily deploying the same proprietary system; open-source software offered the greatest data sharing potential; cost was a factor when comparing like-for-like functionality.
- *Cross-compatibility*: for the reasons cited above, the database was required to run on a variety of hardware and software solutions, not operating system dependent.
- *Accessibility*: a database using a front-end/back-end approach was deemed to enable the greatest flexibility in terms of access, enabling multiple concurrent users and the widest range of options in working with and extracting the project data, therefore a web-based front-end was desired, as opposed to a client running on a single machine.
- *Archiving suitability*: a database system that stores data in ASCII text format is easily archived and managed during and beyond the life of the project, database systems that produce proprietary formats are not appropriate for this reason, or require additional work to make data archive-ready.

Following detailed consideration and assessment PostgreSQL was chosen as the database software. PostgreSQL satisfied all of the criteria, being freely available, open-source, community developed, yet powerful and with the greatest range of spatial extensions currently available. PostgreSQL is described, by its developers, as “the worlds most advanced open-source database” and it is currently deployed in several high profile global organisations and social media platforms. This software is server based, running on all major platforms, including Android, and can be administered and queried from numerous client applications and web-based frontends to display and manipulate the data. SQL dumps are ready to be archived with minimal administration required.

As PostgreSQL satisfied all of the criteria for access, archiving and distribution it can easily interface with other available data sources that have been, are being, or will be developed in the near future. The database can be used to supply spatial data, records for online database portals, images and other content for integration with various other internet based resources.

Despite the rapidly changing technological environment, three years on from the initial selection of PostgreSQL as the Arch-Manche project database platform it remains the leading choice for this type of application.

2.4.3. Database Development

The Arch-Manche project database was developed according to the following principles that were established at the project out-set:

- *Geographic functions:* the database must be a spatially enabled geodatabase and records must be available to a project GIS;

- *Accessibility:* the database and interface should be as accessible as possible and should allow concurrent user working for international partnership development;
- *Ranking:* must contain a ranking system for individual records establishing relative ranking of information from various interrelated disciplines, including art, archaeological, palaeoenvironmental and coastal management data; and
- *Visualisation:* the resulting data should be suitable and accessible for the development of illustrative material, including 3D models, animations and schematic representations, web-GIS and the project website.

2.4.3.1. Geographic Functions

These criteria were used to design a database that provided spatial functionality through the integration of PostGIS, a PostgreSQL extension that enables storage of geographic data and associated geometry as well as suitable coordinate system functions. PostGIS integrates with other available software packages for viewing and analysing the project data, including Quantum GIS (QGIS) and Mapguide open-source. The WGS84 geographic coordinate system, using latitude/longitude and decimal degrees, was defined as the global database coordinate system due to being the most appropriate for marine data distributed across the coast of Western Europe.

2.4.3.2. Accessibility

Database accessibility was maximised through the development of a web-interface front-end that provided data entry functionality for project partners. Access was facilitated using an ordinary internet browser, requiring no special plugins but using a secure login system to ensure security of the data. Functionality to translate feature and boundary coordinates into geographic objects through this interface was built into the database at this time.

Multiple users were able to work on the database concurrently, regardless of geographic location. Occasionally this resulted in record insert or update functions failing, though the user was notified in this eventuality. The primary advantage was the immediate availability of user input to all partners, and the complete avoidance of versioning issues, with the fully updated database being the only copy available. The data store was backed up on a nightly basis to guard against data loss or user error for ‘point–in-time recovery’ (PITR).

2.4.3.3. Ranking

This functionality was implemented through the use of standard SQL ‘trigger’ actions on the database that ‘fire’ when a record is created, updated or deleted, as appropriate. The trigger for each data source was coded individually with sequential SQL statements to calculate a total score which was then normalised to a value with a maximum of 100, thus enabling comparison with other results. On the Arch-Manche database the triggers are set to fire when a record is inserted or updated.

For details of the weighting, normalisation and overall ranking method and rationale, please refer to Section 2.2.

2.4.3.4. Visualisation

The Arch-Manche database was created specifically for the purpose of reusing the resulting data with the minimum of effort. The data is stored on a web-server owned by the Maritime Archaeology Trust, and as such is accessible globally.

The initial visualisation requirement was for project partners to be able to view a spatial representation of records. In the first instance, the data was visualised by connecting to the database through the open-source Quantum GIS package (QGIS) or via ESRI ArcMap. While the records could be visualised and edited in this way, the method was not conducive to partnership work in remote locations due to speed and access conflicts.

Subsequently a web-GIS mapping application was developed to display these results. Mapguide open-source was selected for its extensive functionality, speed and ease of use. The geometry and associated meta-data are pulled directly from the database, meaning that changes to individual records are seen immediately on the map. Together, the database and the web-GIS application formed the basis of the data analysis toolbox for the project.

2.4.3.5. Database Structure

The Arch-Manche database is a relational database designed to provide the maximum potential for query building and ease of obtaining the required information and reports. It is composed of 84 tables of the broad types as shown in Table 2.13.

Table type	Count
Data store (main)	5
Data store (sub)	6
Link tables	5
Lookup tables	66
Spatial tables	2

Table 2.13. Summary of the Arch-Manche database table types

An overview of the schema relationships between these tables is provide in Figure 2.21

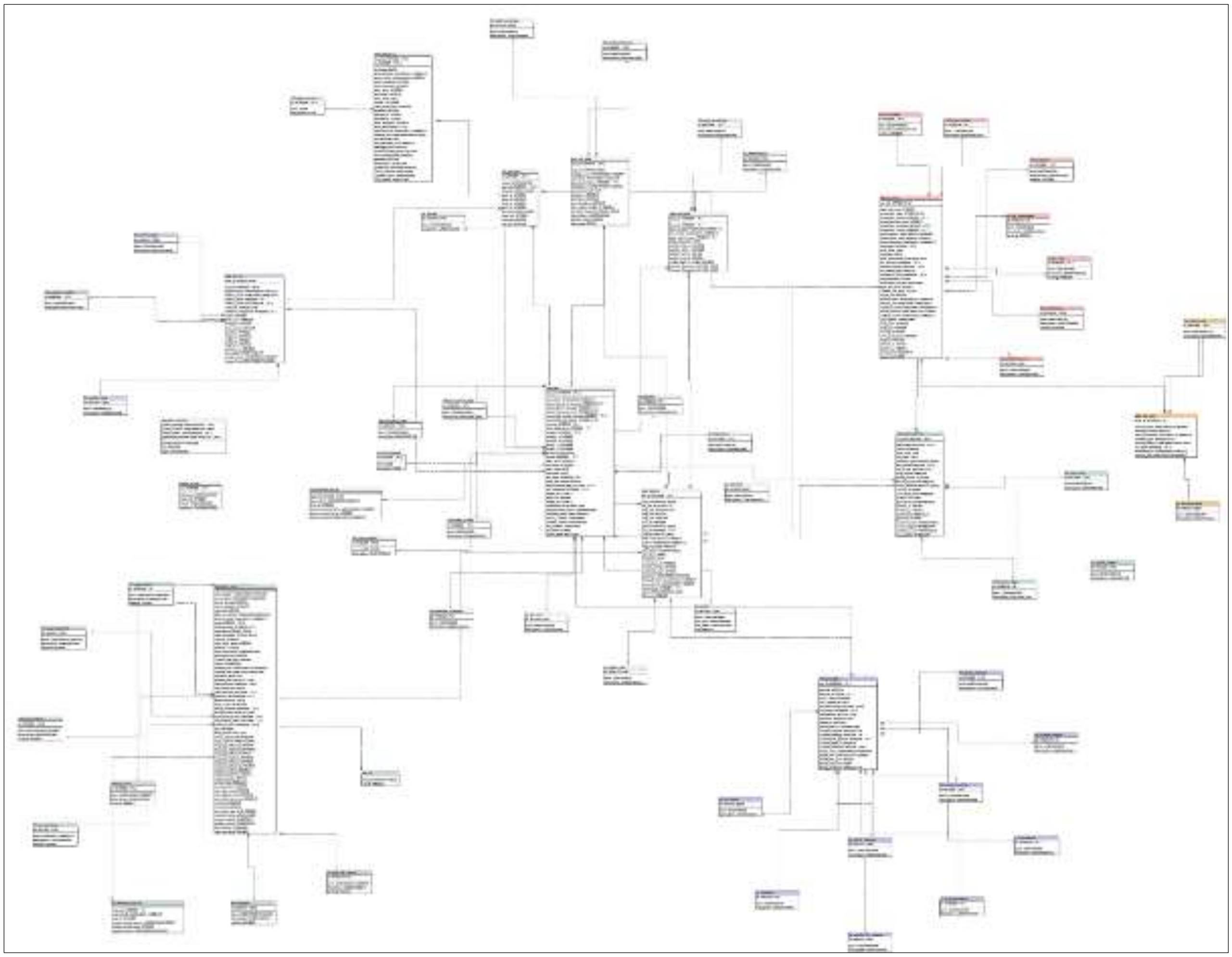

Figure 2.21. The Arch-Manche database schema, showing the five main data table clusters and a sixth group of link tables

Fields are controlled through the use of word-lists, wherever possible, ensuring record consistency. Queries are structured as 'views' on the data and have been developed to provide data for further visualisation.

Form views of each table were built in the web-interface to provide a user-friendly graphical user interface for data entry and individual record searches (Figure 2.15).

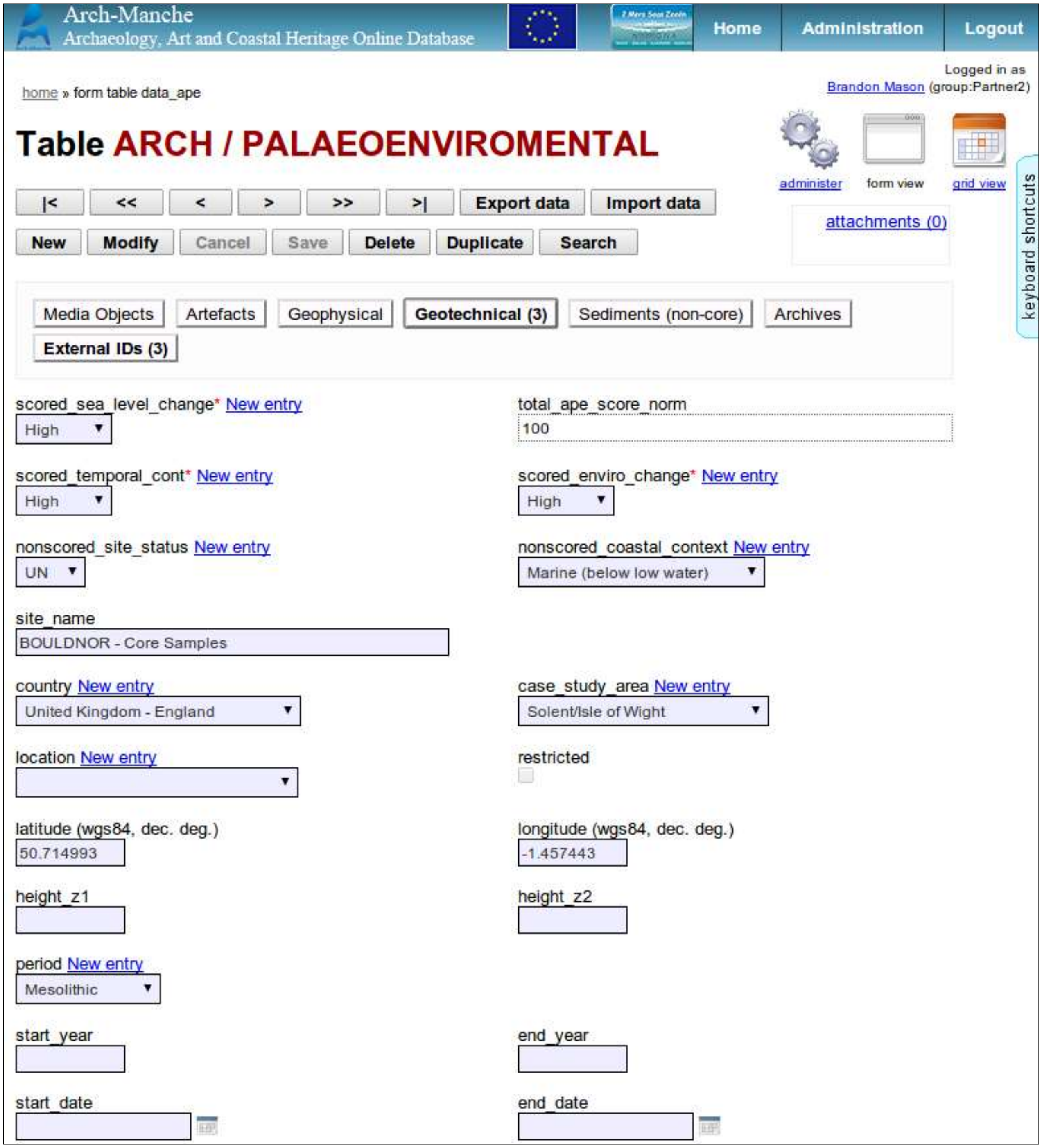

Figure 2.15. Form view of the Arch / Palaeoenvironmental table via the web-interface

2.5. Data Analysis

The Arch-Manche project has developed an online exploration platform for the visualisation and interpretation of the entire project study area (2-Dimensional) and specific partner case study areas (2 and 3-Dimensional). The platform is browser based, requiring no plugins or additional software. It offers the means to explore, understand and engage with the wealth of art, archaeology and heritage common to the partner states in a way not previously accessible to such a broad and diverse audience.

This approach has been achieved through the development of an online geo-portal which provides an easily recognisable Google Maps style plan view interactive map illustrating an immediate appreciation of the range and intense distribution of indicators of coastal change. Each of these points reveals additional information and imagery drawn directly from the underlying database when hovered over with a mouse pointer or touched (for touch enabled devices). The user can also find links and additional information signposting other projects, sites and archives.

Several of these sites are featured as detailed case studies which the explorer has the option to delve into further. Additional navigation controls are available to allow the user to zoom into selected sites and features, pan and tilt the view, revealing full three-dimensional representations of the case study areas.

In this way, the portal caters for basic users (2D interactive) while providing an easy to navigate and even more engaging experience with advanced controls (3D interactive). This is now feasible due to the recent, cutting edge, innovation in visualisation technology, itself not previously developed and deployed in marine archaeology, in tandem with the growing ubiquity of public internet access.

Figure 2.23. The Arch-Manche Geoportal

2.5.1. Case Study Models

Through the project 2, 3 and 4-Dimensional visualisations have been created in order to illustrate the changing landscape over time. These have been created for four case study areas; Langstone Harbour, the Baie de Lannion and two for the Scheldt Polders region.

2.5.1.1. Scheldt Polders

Two models were created for this region, the first was a series of palaeogeographical maps from 9,000 BC to 500 BC. The second was a series of maps from the post-medieval period based on evidence from historical maps.

Holocene Palaeogeographical Landscape Reconstruction

The data obtained from the field studies in this region only provided local information (restricted to Doelpolder-Noord), insufficient for a regional palaeogeographical study. Additional geological information was needed from existing data (sediment cores, archaeological augers, CPT). The vast majority of this data was obtained from the subsurface database of the Flemish Government (Databank Ondergrond Vlaanderen, DOV). The Department of Archaeology of Ghent University provided all the geological information from augers taken during archaeological site surveys in the area.

A major difficulty in the data integration proved to be the high diversity of the type and date of data (some being over 100 years old), the diversity in data resolution and also the diversity of the observers (i.e. geologists, engineers, archaeologists). Consequently the quality of the data varied greatly, as did the interpretation of the geological data. Where possible the raw data and the original descriptions or measurements were studied and reinterpreted taking into account the current geological knowledge of the area. The total data set contained 6423 data points, of which 5783 reach the Pleistocene/Holocene boundary.

The first step in the reconstruction was the creation of an isohypse map of the top-Pleistocene relief using both geostatistical software and geological interpretation. More details on how this was done can be found in the report “Holocene palaeogeographical evolution of the Waaslad Scheldepolders” by Heirman, Missiaen & Vos (2013). In order to allow correct integration with Dutch palaeogeographical maps the NAP level was used instead of TAW. The southwestern part of the Waasland Scheldepolders is located above 0 m NAP (= 2.33 m TAW), while the northeastern part is located below 0 m NAP. The topography of the Pleistocene/Holocene surface fits very well with the Pleistocene/Holocene surface of the southern Netherlands (Vos, 2002, Vos and van Heeringen, 1997).
Full details of the palaeogeographical maps are available in the Scheldt polders case study report (3M).

Post-Medieval Landscape Reconstruction

Based on historical maps, landscape reconstructions for certain time periods (depending on the availability of the maps) can be made. For the Waasland Scheldepolders test-case five time sections were selected (1570, 1625, 1700, 1790 and 1850) that represent major landscape changes. The maps were selected based on their ranking results and an inherent additional criterion: the date of manufacturing should be as close to the chosen time frame as possible, in case of analysis based on multiple maps per time section. This implies a crucial role of qualitative interpretation, as a trade off of the above factors should be made in order to acquire the best possible reconstruction. It also means it is not always possible to use the most accurate map available.

Each time section was based on multiple historical maps, making it necessary to conduct a number of interpolations, in order to “match” the different maps into one continuous reconstruction. For more details regarding the landscape evolution and the choice of maps see the Scheldt polders case study report (3M).

2.5.1.2. Langstone Harbour and the Baie de Lannion

A 4-Dimensional model of the topographical and environmental changes in Langstone Harbour has been created, and a model of the topographical changes in the Baie de Lannion has also been created as part of the project. The models are presented in an interactive format that allows the user to control time and place in 4 dimensions.

The software used is a Cesium WebGL cross-platform to demonstrate the environmental development of Langstone Harbour and the Baie de Lannion. A visual representation is aesthetically pleasing, and provides a very different understanding and appreciation of the information collected and contained therein.

Cesium Web GL is a JavaScript library that has made it possible to create visual representations of the study areas by using online web-maps. The maps interface is similar to Google-, Yahoo-, or Bing maps but does not limit the publication of the obtained data.

The benefits of using Cesium are;

- Availability without any additional software or plugins;
- Open-licensed topographic mapping;
- Simple and user friendly navigation controls;
- Simple layer and time control, giving the user a possibility to change time and place;
- Allows adapted raster imagery and surface models;
- Allows labels and highlights features of interest in a user friendly way; and
- Drastically increased audience reach as webGL technology, 3D computer generated imagery is available to any internet user with a modern web-browser.

Cesium is an open licensed cross-platform virtual globe that can be downloaded and used for free and without licencing issues. The software is developed and supported by an active open-source community, see http://cesiumjs.org/ for more details. The model developed with Cesium can be run on a variety of hardware and software solutions and is not operating system dependent.

Users of the model can view it with the help of any modern web-browser that is connected to the internet. If the user's computer or internet connection is outdated or exceptionally slow increased downloading time might occur. The system was tried on several types of computers, internet connections and phones without encountering any problems.

Model Development

The main objectives when creating the model was to create a:

- User friendly model that allows the user to navigate through space and time;
- Model that visualises the results obtained during Activity 1 and 2;
- Easily accessible model; and
- Model that includes information about areas of interest.

The objectives were achieved through a three stage process:

Stage 1 Summary of Known and New Archaeological Information

Stage one focussed on gathering and summarising the previously known historical and archaeological data as well as the archaeological data obtained during fieldwork. Maps, charts and images where environmental and topographical changes of Langstone Harbour are visible were identified. Based on this data it was decided that the model would focus on re-constructing the Mesolithic, Neolithic, Bronze Age Iron Age, Saxon, post medieval landscapes and compare them to the current environment of Langstone Harbour.

Stage 2 Reconstructing the Landscape
The environment and topography of the past landscapes was recreated by using evidence collected from core samples, pollen and plant analysis and radiocarbon dating together with deposit models previously created for Langstone Harbour.

For each of the of the time slots contour lines representing the topography were created. The contour lines were then exported as raster images with a 1 metre resolution, these files make up the local terrain at the various times in Langstone Harbour.

To accompany the terrain files, high resolution geotiff images for each landscape were created. The images were generated by using segments from current aerial photographs to mosaic a landscape that illustrates the changes that Langstone Harbour has undergone.

Stage 3 Software Development
As described Cesium was deemed to be the satisfactory software for presenting the data. To achieve the aims and objectives of the project Cesium was installed and styled. The software is provided with stylesheets and templates and to adapt the user-end of the model, to add points of interest a combination of html and JavaScript was used.

To be able to import the raster and geotiff into Cesium GDAL software library a software application was developed. The application uses GDAL to read the raster data and converts it to the format required by Cesium. The application was developed by Geodata Institute and is completely independent from the rest of the Langstone Harbour model, it must be run on a Linux server and has been made publicly available through github (https://github.com/). The converted files were imported into Cesium, which then allows the topographic raster data to be overlapped with the geotif to create a 3D model of the landscape. By adding a time element and giving users a way of controlling and choosing what they want to see the 4D model is complete.

Once this process was completed it was also applied to the Baie de Lannion case study area where topographical changes have been modelled.

2.6. Summary

The historical evolution of the coast provides valuable information on past trends which can help develop future coastal climate change scenarios. Present coastal landforms have developed since the last Ice Age, studies of their evolution based on archaeology, palaeoenvironmental and coastal heritage features provides a seamless timescale from the Ice Age to the mid-20th century. Early archaeological evidence demonstrates how people were impacted by coastal change in the past and how populations reacted to some large-scale landscape and climate changes. More recent human activity along the coast can show us how humans have had a direct impact on coastal stability. Some has been positive but much has been counterproductive.

Maps, charts and artistic representations of the coast can all be available for study. Combining information from these data sources within particular coastal frontages enables an in depth understanding of long-term change. An understanding of ongoing changes and the consequent environmental and physical impacts can help inform coastal managers when they are faced with long term strategic decisions.

Sources of data vary within each country with some nations or regions having particular specialist collections, while others do not hold directly comparable data sets. The research process identified key collections which have then been used in support of the Arch-Manche analysis, many of the data sources were ranked using the assessment criteria developed for the project outlined above.

The next section (section 3) of this report includes the individual case study reports from across the partner countries, these outline the results of the ranking and fieldwork, and the subsequent analysis of these results to inform our understanding of long-term coastal change. In order to ensure that a diverse range of coastal situations were assessed across the Channel-Southern North Sea region, fourteen case study areas were selected. These included a variety of coastal frontages which are faced with different challenges in terms of management, physical conditions and available data resources.