1. Project Introduction

The Arch-Manche project has demonstrated how archaeology, art and maritime coastal heritage can be used to show long-term patterns of coastal change and the impact on human settlement. Study of this data allows understanding and modelling of past reactions to climate change to help with planning for the future. The results are important for Integrated Coastal Zone Management (ICZM) and can help inform sustainable policies for adapting to coastal climate change. The results of the project are timely due to predicted increases in coastal erosion, flooding and coastal instability affecting the Channel and Southern North Sea coasts.

Funded by the European Regional Development Fund through the Interreg IVA 2 Seas Programme, the project was led by the Maritime Archaeology Trust (MAT) (formerly the Hampshire & Wight Trust for Maritime Archaeology (HWTMA)) in the UK, working in partnership with the Centre National de la Recherche Scientifique (CNRS) in France, Ghent University in Belgium, and the research institute Deltares in the Netherlands. The common geology, structure and physical coastal processes at work across the partner countries require common coastal reactions to climate change across the Channel and Southern North Sea. In prehistoric times the Channel did not exist and was a landscape used by early human peoples, the traces left in the prehistoric archaeological record are therefore comparable across the region. Later historical development includes common maritime coastal infrastructure and coastal industries based on a shared climate that have left traces in the archaeological and artistic record.

This record can provide high resolution data on coastal change spanning thousands of years, contributing to an understanding of the evolution of coastal areas where there is a need to gain an overall understanding of past, present and future impacts on coastal communities. The Arch-Manche project used this data to enhance sustainable approaches to ICZM to help meet the challenges of coastal climate change through informing mitigation and adaptation strategies appropriate for differing coastal frontages within the Channel region.

Past coastal planning regimes have suffered from a poor understanding of the ongoing processes and natural trends that are shaping our coastal zones. Consequently, many coastal settlements are becoming increasingly vulnerable as the relationship between the land and sea evolves. Using archaeological, palaeoenvironmental and artistic resources the Arch-Manche project has demonstrated the value of the ‘wisdom of hindsight’ and leads to a position where coastal management decisions can be based on knowledge drawn from the long-term behavioural trends in the shifting boundaries of the sea.

1.1. Summary of the Project Approach

The Arch-Manche project brought together partners and sub-contractors from a number of organisations with a range of specialist expertise. Drawing on these skills allowed a new integrated approach to the use of archaeological, historic and artistic data for understanding coastal change. It also brought together partners working on the coast around the Channel-Southern North Sea area, providing a coordinated approach across the study area.

Maritime Archaeology Trust (UK): Specialists in the investigation of maritime and marine archaeology and heritage, with particular experience in submerged past and prehistoric environments, and the use of maritime archaeological data for understanding coastal change. This experience was used to lead the project and deliver aspects of archaeological investigations, data gathering, ranking of various data sources and analysis. Experience of artistic representations of the coast and their ranking, in addition to marine archaeological techniques have been shared with the partnership. MAT has taken a lead with the management

of data across the project team and development of illustration and visualisation. This experience has been shared through partnership working.

Centre National Recherche Scientifique (France): the Arch-Manche team work within CReAAH, which is a department within the CNRS that specialises in archaeology and archaeosciences in north west France. The team has extensive experience in international and collaborative projects including coastal and island excavations and survey projects. Work has included a range of archaeological investigations, data gathering, scoring of various data sources and analysis. A focus on the scoring of historic photographs and the application of archaeological field techniques in the inter-tidal zone has enabled this experience to be shared through the partnership.

University of Ghent (Belgium): The Belgian team are from the Department of Geology and Soil Science, Ghent University, and are specialists in geology, geophysics, marine and coastal environments, data processing, and interpretation and visualisation. The team has a solid international reputation in the design and application of remote sensing techniques in offshore/nearshore/coastal environments. Work has included a range of geophysical and geotechnical survey techniques to investigate submerged and buried sites and landscapes and a focus on the scoring of historic maps and charts, this experience has been shared through partnership working.

Deltares (Netherlands): Deltares are a Dutch-based research institute that specialise in the reconstruction of palaeolandscapes, based on geology, geomorphology, archaeology and historical data. Work has included the use of the mapping of deposits through archaeology and geotechnical data for understanding change and how this is represented.

The partners have worked together to pool and share their specialist experience to deliver the project, which was based around three inter interlinked activities, (a detailed methodology is presented in Section 2 of this report). The activities were:

- Activity 1. Study of archaeology, palaeoenvironment and coastal heritage features to demonstrate coastal change;
- Activity 2. Study of artistic representations of coast, recording geology, geomorphology and coastal heritage; and
- Activity 3. Data integration and presentation, including use of GIS for cross-partner working and analysis on a Channel-wide scale.

The approach was applied across a number of case study areas which provided examples of differing coastal frontages across the Channel – Southern North Sea Region. Figure 1.1 shows the location of the project case study areas, Table 1.1 and Table 1.2 highlight the main geomorphological types and coastal change processes affecting the case study areas.

Figure 1.1. Arch-Manche case study areas and partners.

Case Study Area		Main Geomorphological Type/s						
		Tidal Basin	Estuary/Creek/ Low-lying land	Hard Rock	Soft Rock	Beach	Dunes	Landslides
UK	East Anglia		✓		✓	✓		✓
	Kent					✓		
	Hastings				✓	✓		
	Solent and IOW	✓	✓		✓	✓		✓
	West Dorset/East Devon			✓	✓	✓		✓
	West Cornwall			✓		✓		
	North Cornwall			✓		✓		
France	Cote d'Emeraude		✓	✓		✓	✓	
	Northern Finistere and Tregor		✓	✓		✓	✓	
	Cornouailles			✓		✓	✓	
	Quiberon			✓		✓	✓	
Belgium	Raversijde					✓		
	Scheldt Polder		✓					
	SW Netherlands	✓	✓					

Table 1.1. Main geomorphological types of the case study areas

Case Study Area		Main Coastal Change Processes				
		Natural Erosion	Natural instability	Natural Flooding	Breaching	Human Induced
UK	East Anglia	✓	✓		✓	✓
	Kent	✓		✓	✓	✓
	Hastings	✓	✓	✓		✓
	Solent and IOW	✓	✓	✓	✓	✓
	West Dorset/East Devon	✓	✓	✓		✓
	West Cornwall	✓				✓
	North Cornwall	✓		✓		✓
France	Cote d'Emeraude	✓	✓	✓		✓
	Northern Finistere and Tregor	✓				✓
	Cornouailles	✓				✓
	Quiberon	✓				✓
Belgium	Raversijde					✓
	Scheldt Polder		✓			
	SW Netherlands	✓	✓			

Table 1.2. Main coastal change processes affecting the case study areas.

1.1.1. Activity 1 – Archaeology, Palaeoenvironmental and Coastal Heritage Data

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. Archaeological evidence also demonstrates how people were impacted by coastal change in the past.

Evidence for Activity 1 was gathered through a desk based survey of maritime heritage and archaeological sites in case study areas within the partner countries, significant sites and areas were then selected for detailed research through in-depth inter-disciplinary research including fieldwork, scientific dating and analysis. A ranking system was also developed in order to allow archaeological, palaeoenvironmental and coastal heritage features to be assessed for their potential to demonstrate coastal change.

1.1.2. Activity 2 – Historic Paintings, Maps, Charts and Photographs

Oil paintings, watercolours and prints (1770-1940), historic photographs, maps and charts depicting the coastlines of the Channel region (Netherlands to Brittany on the Continental side and Norfolk to Cornwall on the English side) were systematically appraised to establish how they can contribute to understanding of long-term coastal change. Different ranking systems were developed or refined for each of the data sets (paintings, historic photos, historic maps and charts) allowing the partners to establish the reliability, accuracy and level of information that each of these artistic representations could provide.

Case study locations covering a range of coastal geomorphological types were identified across the partner countries and a survey was undertaken to identify artistic representations and compare various artistic styles, techniques and media within different ‘Schools’ of artistic work.

1.1.3. Activity 3 – Data Integration and Presentation

The large quantity and variety of data gathered through the activities was integrated and managed in order for the datasets to form the base for analysis and resulting illustrative, modelling and presentation materials. The database produced as a result of Activities 1 and 2 contains spatial information on the sites, features and artistic representations. This allowed a GIS platform to be developed in order to view and analyse the data. The data was also used to produce illustrative presentations in order to demonstrate coastal change visually, this includes Two Dimensional (2D) and Three/ Four Dimensional (3/4D) models showing progressive change across key case study areas. Additional work included reviewing the project results in relation to the use of the outputs with a range of target audiences such as museums, galleries, schools and educators, local residents and tourists.

1.2. Summary of the Geology, Geomorphology and Evolution of the Channel Region

Understanding the geology and geomorphology of the Channel Region has been essential in the development of project activities. These aspects have a direct relationship to the changing landscape used by human populations from prehistoric times through to modern day and are inextricably linked to coast processes and changes over time.

1.2.1. Geological Overview

The Channel-Manche and Southern North Sea Region of North-Western Europe can be divided into three quite distinct geographical zones, each with their own geological characteristics (Figure 1.2*)*. The western-most zone comprises the coastlines of Devon and Cornwall in England and the regions of Brittany and the western part of Lower Normandy in France. These zones are largely composed of ancient granite rocks that range in age from Lower Palaeozoic to Miocene (500 to 20 million yrs BP) and are characterised by rugged durable coastal clifflines that also contain outcrops of volcanic rocks (Smith *et al.,* 1975).

The central zone is dominated by younger rocks ranging in age from the Jurassic period to the Eocene (200 to 40 million yrs BP). It is marked by a line of faults extending across the Channel from west Dorset & Kent to the Cherbourg Peninsula. It includes the Hampshire-Dieppe Basin, the Paris Basin and part of the London Basin, all of which are comprised of Palaeogene sands and clays, as well as extensive outcrops of chalk. As a result the coastlines of England and France bear striking similarities in terms of the geology and resulting geomorphological features across this central zone (Mortimore & Duperret, 2004).

The eastern zone comprises the coastline of East Anglia and of Belgium and the Netherlands. The coastal zone of England is geologically dominated by the Wealden Anticline, which is comprised of Cretaceous rocks, and the London Basin. The coastal zone of Belgium comprises largely Palaeocene and Eocene sediments, which are overlain by more recent Pleistocene and Holocene age sediments, resulting from fluvio-glacial, eolian (dunes) and marine sedimentation. The Dutch coastal zone and hinterland was formed by the relationship of the main river systems (IJssel, Meuse, Rhine, Scheldt) and the North Sea. As a result the Netherlands is mostly composed of deltaic, coastal and eolian derived sediments deposited during the Pleistocene glacial and inter-glacial periods and the recent Holocene period.

The varied geological exposures outcropping around the Channel-Southern North Sea coasts have resulted in the formation of a wide range of geomorphological features and have created coastlines of considerable variety, scenic beauty and interest. The present day coastal scenery has been formed over geological time with the diverse rock formations being created or deposited, uplifted during mountain-building phases, compressed, folded and faulted, before

being affected by processes including glaciation, inundation, coastal erosion, and weathering by wind and rain.

The detailed mapping work undertaken by the Geological Surveys of the member states bordering the Channel have helped identify the inter-relationships between the terrestrial and sub-marine geology, resulting in an improved understanding of coastal evolution. For example, in the Channel-La Manche between England and France, terrestrial mapping has extended to include the continental shelf, allowing the British Isles and France to be set within the European geological framework illustrating many key structural features including major fault lines, sea basins and areas of shallower sea.

The geological history does, therefore, dictate the present day structure and scenery of the Channel and North Sea coasts. Along the coast the most marked differences are often created through contrasts between those more resistant rocks, which form headlands and uplands, such as those found in the west of England and along the Brittany coast, and the softer, usually sedimentary rocks, which form the lowlands and soft cliff line coastal frontages, such as those of the Hampshire and Paris Basins and along the coasts of Belgium and the Netherlands. Large parts of the Netherlands today are below sea level and have, in the past, been covered by the sea or flooded at regular intervals.

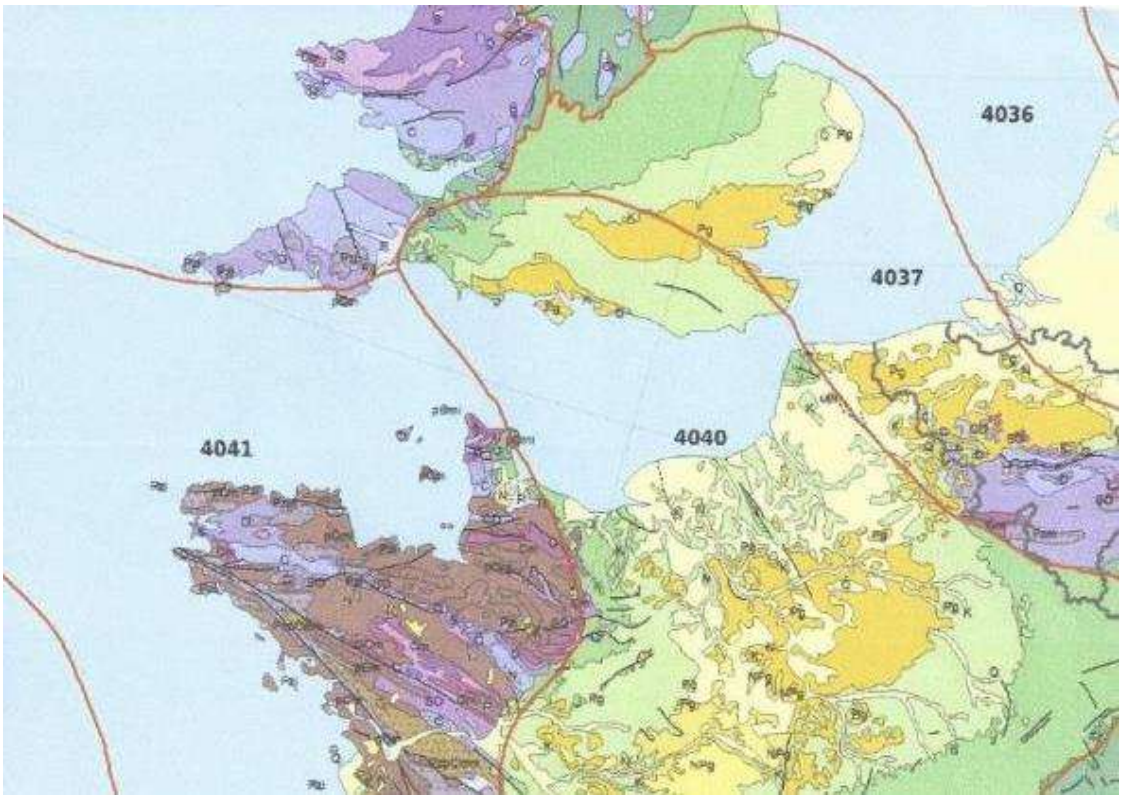


Figure 1.2. Summary geological map of the coastline of the Channel-Southern North Sea showing the relationships between the geology of the four partner countries. The oldest rocks are in the west of England and Brittany and western Lower Normandy, becoming younger. Image credit Commons Wikimedia.

1.2.2. The Evolution of the Channel-Southern North Sea Region

During the last ice ages the climate of NW Europe was extremely cold and ice sheets repeatedly covered the North Sea and large parts of the land. Sea levels fell considerably (up to 120 m during the last ice age, the Weichselian) because so much water was trapped in the growing ice sheets, and a wide 'land bridge' between England and the continent emerged. Whilst the landmasses of Northern Britain and Scandinavia (sometimes also Germany and the Netherlands) were covered by ice, a large glacial lake was formed behind the ice mass, fed by water from the mainland rivers (Rhine, Meuse, Thames, Elbe), and dammed to the south by the Weald-Artois ridge. At least during two periods in Quaternary history (Elsterian and Saalian ice age) this ice lake overspilled, resulting in a devastating flood causing dramatic deepening and widening of the Dover Strait and English Channel (Gibbard 2007).

Around 12,000 years ago the last ice sheet had largely melted, and rivers were again flowing out into the North Sea. Sea levels started to rise (but were still > 60m below present day levels), and sea water entered the southern North Sea again, through the Strait of Dover in the south and through channels along the Dogger Bank in the north. Still the land bridge between England and the continent was largely intact and early man and animals crossed over to England. Over the next three to four thousand years sea level continued to rise fast and the land bridge was gradually flooded. In the meantime the sea further invaded the English Channel. By 5000 yrs BP the present coastline was more or less reached in the Channel region.

1.2.3. Long-term Coastal Change

The Channel coastline is largely influenced by the overall geological structure and the geological periods that created major folds, escarpments, basins, valleys or other key topographical features. Elsewhere the influence of glaciation has sculptured the geology, whilst in other areas extensive deposits of more recent materials, including clays, gravel deposits, landslide debris and alluvium, form blankets masking the solid geology beneath. An examination of geological cross-sections illustrate the full extent of the folding, erosion and weathering that has taken place since the rocks were first deposited.

More recent factors that have led to the evolution and shaping of the Channel-Southern North Sea coastlines include wave size, wind speed, water depth, the strength of tides and the rates of relative sea level change, as well as rainfall and the frequency and intensity of storm events. In some locations changing rates in sea level have been dramatic over the last 30,000 years. This, in turn, has influenced the nature and severity of coastal erosion, a key factor in transforming the coastal landscapes. The influence of climate is also particularly important on the coast as rainfall and run-off carrying sediment from the hinterland down to the coast is very significant, whilst along the coast itself the rates of erosion and transport of materials by waves, tides and currents have led to the formation of beaches and sediment sinks resulting in accretion in some places and depletion in others.

The recognition of coastal change and practical experiences of the results of this over the last three centuries has clearly demonstrated that the Channel-Southern North Sea coastal zones are areas that are naturally dynamic and prone to significant changes over time and geographical extent. The factors that result in coastal change do not always operate at the same frequency, whilst some factors are more intense than others. Understanding the coastal response may be complex; particularly changes in the rates of erosion, landsliding or other factors may depend on certain thresholds being exceeded followed by periods of relative tranquillity until another threshold is exceeded. Some of the factors that lead to the more dramatic coastal changes may have, therefore, been influenced by activities in past decades, whilst others may have swift reactions. All this emphasises the need for particular care to be

taken when examining coastal processes and the need to draw evidence from longer-term experiences rather than making decisions based upon data derived from a short time frame (McInnes *et al.*, 2006).

All round the Channel-Southern North Sea coastlines the influence of the geology on the coastal landscape is clearly illustrated through dramatic examples. On the Isle of Wight in southern England the more resistant chalk headland at its western end, which terminates in the famous Needles rocks (Figure 1.3), forms a marked contrast against the softer sediments to the north and to the south. In northern France the processes of coastal erosion and weathering have created a unique coastal environment of textbook landforms including sea caves, stacks and arches along the chalk cliff coastline of the Côte d'Albâtre in Upper Normandy (Figure 1.4).

Figure 1.3. Chalk cliffs at The Needles, Isle of Wight, UK. Image courtesy Wight Light Gallery.

Figure 1.4. The spectacular chalk cliff landforms of the Côte d'Albâtre, Etretat, Upper Normandy, France. Image courtesy Wight Light Gallery.

In southern England the dramatic rise in sea level during the Holocene by as much as 100m, resulted in aggressive coastal erosion, leaving many parts of the coastline in a vulnerable, over-steepened state. The effect of the erosion process has been to destabilise some coastal

frontages, resulting in a legacy of landsliding and instability problems. The largest urban landslide complex in north-western Europe is the Isle of Wight Undercliff, which extends for 12km along the south coast of the Isle of Wight. A combination of coastal erosion and the effects of high ground water levels have promoted a series of landslide events within the complex, which continue to this day.

Apart from the processes of marine erosion and weathering, coastal change is taking place continuously through the natural transport of sediment around the coastline. The movement of sediments follow sediment transport pathways. These transport systems may be interrupted by major coastal headlands and estuaries or may be influenced by human activity, for example, by the construction of harbour walls or coast protection works such as groynes. Some famous examples of sedimentary features include Hurst Spit in Hampshire, which provides protection for the Western Solent (the sea separating the Isle of Wight from mainland England) and Chesil Beach on the Dorset coast in South-west England (Figure 1.5). Where rivers enter the sea estuaries, creeks and harbours exist. River systems carry sedimentary materials (usually finer silts) to the river mouth, where they may be deposited to form mudflats. Natural coastal processes may be complex in these areas with a wide range of interactions between the fluvial and coastal environments (Figure 1.6) (McInnes, 2008).

Figure 1.5. The famous Chesil Beach shingle spit in Dorset, UK, links the Isle of Portland to the adjacent coast. Image courtesy: Shutterstock.

Figure 1.6. Low lying coastal communities along the Channel –Southern North Sea coasts are vulnerable to flooding aggravated by sea level rise & post-glacial land settlement. This view shows the historic town of Yarmouth on the south west coast of the Isle of Wight. Image courtesy Andrew Butler.

Whilst the western part of the French Channel coast comprises rocks of great age including granite and volcanic rocks (Figure 1.7), which bear a striking resemblance to those found in Cornwall, the coastline to the east extending northwards through Normandy, Picardy and Nord-Pas-De-Calais as far as the Belgian border, are composed of softer rocks including the chalk, sands and clays which form part of the Hampshire-Dieppe and Paris Basins. The present French-Belgian North Sea coastal zone was shaped after the last Ice Age, when, especially between 10,000-5,000 BP, sea levels underwent a rapid rise and the gently sloping northern part of the Flemish coastal plain and the incised river mouth were flooded (Houthuys *et al*., 1993).

Figure 1.7. The hard rock coastline of Brittany in north-west France. Image courtesy: Shutterstock

Figure 1.8. Photo of Fairlight near Hastings on the coast of East Sussex, UK, Fairlight was developed close to the edge of an unstable coastline. Properties and assets have been lost as a result of both coastal erosion and landsliding. Photo courtesy of Wight Light Gallery.

East of Calais the shoreline consists of gently sloping sandy beaches backed by coastal dunes. These sandy beaches were built up over thousands of years by the action of wind, waves and tides on the supply of loose sand grains at the seaward side of the complex coastal barrier, perhaps an island barrier, whose location changed with time. At the same time, in the more sheltered areas landward of the coastal barrier, an intertidal flat developed by deposition of finely grained material and by intermittent peat formation (Houthuys, *et al*., 1993). The French-Belgian coastal plain extends for up to 20km inland from the beach barrier. Most of the plain's present day elevation is between Mean and High Tide sea level. As such, the sea would inundate the plain twice a day, should it not be protected by a continuous system of beaches, dunes and dikes.

Figure 1.9. Dunes and beach – the Zeeland coast. Image courtesy: Shutterstock.

Figure 1.10. The beach at Knokke, Belgium. Image courtesy: Shutterstock

The Dutch coastline along the south-east part of the North Sea extends for approximately 350km and consists largely of straight sandy beaches (Figure 1.9) and various large-scale tidal inlets. Large stretches of the coastline have dunes that prevent the low-lying hinterland, which is in many places below sea level, from being regularly flooded. Where dunes are absent, sea defences have been constructed as a flood protection measure (Marchand *et al.,* 2012).

1.2.4. Conclusion

It is clear, therefore, that the geological structure of the study region provides the foundation for understanding the geomorphology and coastal scenery, but it is the natural processes of erosion and weathering that adapt the geological outcrops on the coast to form the continually evolving coastal landscape and shoreline. A consideration of coastal change issues does, therefore, require, first, an appreciation of the geology and geomorphology, an understanding of the natural conditions (forcing factors) such as the wave climate (its direction and energy), rainfall, wind and temperature. In addition, there is clear evidence of long term coastal change including rising sea levels.

The erosion and weathering processes are acting upon the coastal geology creating weathered material that is being transported around the coastline by longshore drift. An understanding of these sediment transport 'pathways' is also, therefore, fundamental to development of sustainable solutions for managing the shoreline. This approach has been developed in England through the mapping of coastal littoral cells on which coastal risk management and planning can be based.

This description of the geology, geomorphology and physical processes at work within the Channel-Southern North Sea region illustrates the wide variety of conditions that exist on its coasts. The geomorphology and the dynamic coastal environment have resulted in a range of hazards, risks and management problems arising from marine erosion, coastal cliff instability, landsliding, and flooding by the sea. Approaches to the management of these coastal zones are described in Section 1.5.

1.3. Summary of the Archaeology and History of the Channel and Southern North Sea

Human populations have been utilising the Channel – Southern North Sea area for hundreds of thousands of years. During this time there have been large-scale landscape changes which

have impacted territories available and the resources within them. Over time the coastal zone has been favoured for human occupation and movement, resulting in traces of activity in this area. In historic periods settlement around the coast continues to be dense due to economic and environmental factors. Understanding the broader archaeological and historic developments across the region provides the context for the in-depth work within the Arch-Manche case study areas.

1.3.1. Palaeolithic

The presence of Palaeolithic technologies in the North Sea and Channel runs from approximately 900,000BP to 10,000BP, a period that witnessed huge cyclical changes transforming the climate, landscape, varying sea-levels and creating a continuous landscape linking Britain to the continent for the majority of the period. Britain was essentially a peninsula of north-west Europe, only cut off during brief interglacial highstands (Westley & Bailey, 2013:10). The earliest evidence of human occupation in Britain is from the site of Happisburgh dating to around 814,000 – 970,000 BP (Parfitt et al. 2010). From 500,000BP onwards north west Europe was occupied by the western European species Homo Heidelbergensis, associated with distinctive Acheulean handaxes. By the middle Palaeolithic the species evolved to Neanderthals, marked by Levallois and Mousterian technology. Anatomically modern humans ultimately replaced Neanderthals by the upper Palaeolithic and the use of lithic blades and bone implements are seen in the archaeological record. Brief interglacial highstands meant that occupation of Britain was not continuous and saw periods of inward migration and depopulation. Throughout this period the position of the coast would have varied dramatically, with purely terrestrial landscapes now found in modern maritime contexts (Westley & Bailey, 2013:12).

Figure 1.11. Lithics from the Palaeolithic site of Fermanville, France. MAT.

Few sites reflecting coastal or maritime adaptations are known as many sites on our current coastline, such as Happisburgh and Hengistbury Head would have been inland sites during the Palaeolithic. Fewer submerged Palaeolithic sites are currently known, with Fermanville on the French Channel coast being the only site which has been archaeologically investigated. The site contains over 2000 knapped flints, typically Levallois, thought to be evidence of Neanderthal occupation on the continental shelf during the last interglacial (Cliquet *et al* 2011). Another important collection of associated middle Palaeolithic flint artefacts has been isolated to aggregate extraction 'Area 240' situated approximately 11km off the Norfolk/Suffolk coastline. The tools were recovered during commercial dredging which was followed by targeted grab sampling (Tizzard *et al* 2011). The remainder of finds from this period are chance finds and collections dredged or trawled from the Channel and North Sea. Such finds are predominantly

known from the Dutch coast, the Zeeland ridges containing a considerable faunal collection, as well as a Neanderthal skull fragment and Levallois lithics (Hublin et al 2009). Oyster dredging in the Solent region has also recovered many Palaeolithic handaxes, blades and Pleistocene fauna.

Sites like Happisburgh in Britain and Fermanville in France contain evidence of a dramatically different climate and environment, Happisburgh, now eroding from the modern cliffs, and Fermanville, now submerged under water, have the potential to provide information on long term coastal change and the environments occupied by early hominins in the Palaeolithic period.

1.3.2. Mesolithic

The change from the upper Palaeolithic to the Mesolithic corresponds with the transition from the last glacial to the current interglacial around 10,000 BP and is mainly identified through changes in lithic artefacts, ending with the appearance of the Neolithic in north-west coastal France around 4,500 BC and across the Channel to Britain by around 4,000 BC. The Mesolithic is marked by rapid sea level rise as warmer climates released large volumes of water from extensive ice sheets back into the oceans. Britain was first cut off from the French coast then mainland Europe as water flooded the continental shelf from the west and north (Bell & Warren, 2013:35). The changing landscape was not a simple inundation but witnessed complex isostatic and eustatic changes, as well as the effects of tectonics and varying localised uplift and subsidence, this report will not go in to detail on this as much work has been carried out in recent years (such as Gaffney et al 2009, Lambeck 1995, Shennan et al 2000).

Mesolithic occupation was based on hunting, fishing and gathering lifestyles, the main archaeological remains of these mobile peoples are scatters of lithic artefacts. Sequences providing evidence of sea level rise, such as submerged forests and peats have been found around the Channel and southern North Sea coasts, often preserved in submarine contexts and in the intertidal zone (Bell & Warren, 2013:37).

Mesolithic sites have been found on the coast and underwater in the Channel and southern North Sea regions. Bouldnor Cliff in the western Solent contains evidence of Mesolithic occupation now submerged in 11m of water. This unique site provides information on the palaeoenvironment, the process of inundation and subsequent erosion, excavation has also revealed worked wood, burnt flints, charcoal, string and hazelnuts (Momber et al 2011). The site of Beg-er-Vil in north west France is a large drowned landscape, now consisting of several small islands and a rocky peninsula, evidence here from the Mesolithic period includes a large shell midden and lithics, and the nearby Teviec island contains evidence of Mesolithic burial practices (Marchand & Dupont, 2013).

Figure 1.12. Left: worked and channelled timber recovered from Bouldnor Cliff. Right: Collection of flint flakes recovered from Bouldnor Cliff. MAT.

Recent research has shown that coastal resources were regularly exploited in this period, living on the coast would have had several advantages including transportation, communication, and access to resources, including a variety of marine foodstuffs (Bailey, 2004; Momber 2014). Although there is evidence on islands and peninsulas such as Beg-er-Vil in France, and the site of Culverwell on Portland, England (Palmer 1997), large areas of the Mesolithic landscape are now submerged in the Channel and southern North Sea (Momber 2013). Such areas are largely inaccessible and challenging to explore although recent work has started to identify and target these deposits (Gaffney et al 2009, Fitch 2011). This would have been a resource rich landscape in the Mesolithic and has the potential to provide a much more detailed picture on Mesolithic communities and their responses to large scale changes in the shoreline position (Bell & Warren, 2013:43; Peeters & Momber 2014).

1.3.3. Neolithic

By the Neolithic the rate of sea-level change had slowed considerably, although small and localised relative sea-level, erosion and sediment accumulation means that the Neolithic coastline may now be submerged in some areas or further inland in others. Many of the present day islands in Brittany are the last visible remnants of Neolithic landscapes which would have consisted of large coastal plains, sites like the Er-Lannic stone circle in Morbihan demonstrates this as half of the monument now lies some 1.5 metres under water. A set of Neolithic trackways off the north coast of the Isle of Wight are also now submerged with some sections visible at low water (Tomalin 2012).

The Neolithic period is marked by more sedentary communities involved in farming which spread across north west Europe by around 4500 BC through cultural diffusion and migration; it should be emphasised that this was not a simple and sudden change to farming, there may have been several centuries when hunter-gatherer-fishers lived alongside farming communities, particularly along the coastlines in our study area (Sheridan 2010:101).

By the Neolithic, Britain was cut off from mainland Europe, however, evidence from domesticated animals and cereals, as well as the concepts of early Neolithic monuments in Britain, provide evidence of long distance maritime networks and links to the continent from this period (Sturt & Van de Noort 2013:72). Along the Atlantic façade small megalithic closed chambers and passage tombs are seen in coastal areas of western Britain, and have a clear

affinity with closed chambers and passage tombs from the Morbihan region of Brittany (Sheridan 2010:92). In eastern Britain dense concentrations of Carinated Bowl pottery have been found which is thought to originate from the Nord-Pas de Clais region of France in the early Neolithic (Sheridan 2010: 99).

The Channel and Southern North Sea played an important role in this period, the sea is often perceived as a barrier, however, archaeological evidence clearly indicates that is was 'a medium through which people, ideas and material flowed freely' (Sturt & Van de Noort 2013:74).

Figure 1.13. Excavation of the Neolithic Groh-Colle site on the coast of Brittany, France. Le Pessec 2013.

1.3.4. Bronze Age

The transition from the Neolithic to the Bronze Age is broadly thought to be around 2200-2000 BC (although this does vary across north west Europe, see Roberts et al 2013 for a detailed discussion on the complex chronology). This period witnesses large social, economic and technological changes and the archaeological record demonstrates long and complex exchange networks across the Channel and Southern North Sea. Most of this evidence is indirect, in the form of objects which have travelled large distances, direct evidence of links across these waters is much harder to find. Sewn plank boats like the Dover boat and Ferriby boats may provide evidence of maritime activities, although it is unclear whether these were used along the coasts and rivers, or to cross the Channel/North Sea, or both (Hill and Willis 2013:75).

The Bronze Age of western Europe has generally focussed on the Atlantic façade with evidence of networks represented by the appearance of Bell Beaker material culture, with primary subsistence strategies relying on arable and pastoral farming and living in relatively small settlements. However, despite these general trends the Bronze Age evidence also suggests huge regional variation in settlement architecture, craft-working, burial practices etc. As well as this, the definitive material of the period – Bronze, an alloy of copper and tin, demonstrates regular communication and interaction across the Channel and Southern North Sea as tin is only available in central Europe and south-west England (Roberts et al 2013:38).

By the middle Bronze Age more settlement sites and field systems become visible in the archaeological record, and in the Mid to Late Bronze Age many deposition sites containing large amounts of bronze objects have been found both on land and under water. There was clearly regular contact throughout the Bronze Age across the Channel and Southern North Sea, this was not just about trade, and there may have been a common social identity across these waters as communities were in regular contact. Evidence of clear regional identities does not necessarily suggest a lack of links between communities but may have been a reflection of the need to maintain regional identities as a response to regular contact (Hills and Willis, 2013:89).

The Channel and Southern North Sea coasts were still subject to localised relative sea-level changes in this period, Wootton Quarr (mentioned earlier due to Neolithic remains) also contains early Bronze Age structures only accessible at equinoxal spring tides (Sturt & Van de Noort 2013:64), and the site of Seahenge originally thought to have been built in a saltmarsh environment was recently exposed on Holme beach.

1.3.5. Iron Age

The Iron Age began around 800 BC, the middle of the period witnesses the start of a rise in the population, seen archaeologically through an increase in settled communities and mixed farming, as well as an intensification in salt extraction, with evidence found along the coast and in estuarine environments often associated with saltmarsh grazing (Hill & Willis 2013:75).

There is little evidence for the consumption of fish in southern Britain, some later Iron Age sites contain evidence of oysters, perhaps reflecting pre-conquest contact with the Romans, such as Silchester and Owlesbury in Hampshire and Alington Avenue in Dorset (Hills & Willis, 2013:83). There is also very little evidence of seagoing boats and ships from this period, logboat finds such as the Hasholme logboat, from this period are thought to have been used in calmer waters (McGrail 1990).

Metal objects were moving across the seas in large quantities in the Bronze Age, but evidence of trade from the early-mid Iron Age is scarce, it is not until the late Iron Age that trade becomes more visible. The lack of European objects in the Iron Age does not necessarily indicate reduced contact with the continent, similarities in artefacts and 'fashions' implies contact throughout this period. By the 2nd century BC there is a marked increase in contact across the Channel with a large range of materials including coins, pottery and foodstuffs from France and Belgium being transported (Hills & Willis 2013:88). This period also sees marked similarities in burial forms and material culture between southern England, northern France and Belgium, including the adoption in all countries of the same coinage indicating a common social identity (Hills & Willis 2013:89).

1.3.6. Roman

The effects of the Roman conquest on the Channel-Southern North Sea coasts is visible through the construction and development of coastal settlements, the building of Roman villas, ports of trade and maritime industries (including fishing, shipbuilding, salt production and maritime defences) as well as a much deeper change in the territory and political organisation of coastal communities with more formalised coastal and cross-Channel maritime networks. Although the Roman conquest of Britain was later than that of France, Belgium and the Netherlands, a huge amount of evidence of pre-conquest maritime connections and contact exist.

Maritime activity generally shifted focus eastwards along the Channel with London becoming a major port in this period as well as Dover, being the closest point to continental Europe. Ports on both sides of the Channel contain evidence of cross-Channel trade with lighthouses and similar navigational aids existing at the entrance to harbours such as Dover and Boulogne (Walsh, 2013: 97). Evidence of coastal industrial activity includes the remains of salt extraction sites, which existed in large numbers on both sides of the Channel.

Although general rates of sea level change had reduced by the Roman period, the coastline was still changing, particularly through local geological responses, human intervention and land reclamation (Walsh, 2013: 95), although in both the UK and mainland Europe there is evidence of the abandonment of coastal marshes possibly as the result of marine transgression. In the south west Netherlands tidal channels were used to drain high peat areas further inland with ditches and channels created to drain the land for habitation and to use the peat as fuel. Large scale peat extractions in this period had disastrous consequences as this lowered the ground level resulting in flooding and increased tide storage areas. In turn the tidal channels increased in strength and size, further eroding the peat, resulting in increased tidal storage capacity. By 350 AD the Roman peat areas became completely submerged.

1.3.7. Medieval

The Medieval period of north west Europe began around the 5th Century AD with the collapse of the Western Roman Empire. The movement of people continued in this period, with Anglo-Saxons in Britain and evidence of external invasions from Vikings along much of the Channel-Southern North Sea region. In the early Medieval period we see the development of coastal and estuarine ports, these include Southampton in the UK, Wijk-bij-Duurstede in Holland and Quentovic in France.

By the 11th Century AD the period is marked by a rapid increase in population, this may be down to the 'Medieval Warm Period' as well as technological and agricultural innovations. The warm period was followed by the 'Little Ice Age' causing significant climatic and environmental change, in particular a series of North Sea storm surges from the 13th-15th centuries. These changes altered settlement patterns, coastal industries, fortifications and infrastructure (Adams & Flatman, 2013:138). By the later Medieval period much of the population was diminished by famine, plague and war, most notably 'The Black Death' in the mid-14th century which led to changes in settlement patterns and increased specialisation in many industries.

Land reclamation and peat extraction continued across the region, the drowning of peat areas in the Netherlands after the extensive Roman peat extraction continued and by 800 AD the whole of Zeeland was flooded. Although later silting resulted in the expansion of salt marshes, coastal communities were still affected by large and frequent storm surges. Many of the salt marshes were later diked-in primarily for the grazing of sheep as the textile industry grew, however this process then in turn increased the severity of storm surges as it reduced the water storing capacity of the salt marsh area.

1.3.8. Post-Medieval

By this period the volatile society of the Medieval period was transformed with the emergence of larger nation states, this process was largely a maritime process as the emerging nation states competed and fought largely at sea (Adams & Flatman, 2013:140). This change is also clearly reflected in the 15th-16th Century changes in ship building across north west Europe from the late Medieval to Post-Medieval period.

There was increasingly sophisticated and far-reaching trade and communication links, with major roads and river networks facilitating the movement of people, goods and ideas (Adams & Flatman, 2013: 138), particularly the trade of wool, cloth and wine across the Channel-Southern North Sea region. The wine trade was particularly extensive from the late Medieval to Post-Medieval period, with a vast amount of evidence from the under crofts and cellars in the ports for the storage of wine to documentary sources detailing the scale and geography of the trade. Most notable was the trade between Bordeaux and England.

Although the coastlines of the Channel-Southern North Sea were not witnessing dramatic changes from sea-level and climate change in this period, the biggest changes to the coasts were through anthropogenic change. Land reclamation continued in this period, with the reclamation of coastal fens and marshes for agriculture common place as well as a complex embankment process in Belgium and the Netherlands closely linked to large scale peat extraction. Embankments in these areas were also used as flood defences, although later the dykes of Saeftinghe were breached and the whole area was intentionally inundated during the Eighty Years' War.

From 1650 AD the region experienced large changes with the maritime world expanding, particularly through the English maritime Empire and navy by the 18th Century and steamships dominating long-distance trade in the late 1800's (Dellino-Musgrave & Ransley, 2013: 164).

1.3.9. Modern

The Channel-Southern North Sea region witnessed two world wars in this period, the British empire fragmented and marine industries such as fisheries began to decline. Evidence of the two world wars can be seen all along the coastlines of the region with the remains of gun emplacements, pill boxes, anti-tank defences and military installations, many of which are now threatened by coastal erosion.

The impacts of sea-level and climate change were minimal in this period, with the majority of changes associated with localised events including the silting of rivers, storm events shifting and destroying spits, and coastal erosion. Again as with the preceding periods the major changes affecting the Channel-Southern North Sea coasts have been anthropogenic, most notably; port development, small-scale land reclamation and defences (both military and against the sea).

By the 1960's the increase in coastal management programmes, coastal conservancies and nature reserves meant that fewer reclamation projects were carried out (Parham & Maddocks, 2013:187).

1.4. Imaging the Channel-Southern North Sea Region

The development of artistic representations of the coast including maps and charts extends back over 500 years. Over time the style, diversity of media and accuracy of mapping techniques has developed. While some depictions are stylistic and subjective interpretations, others have been created from a more objective basis. Through art, maps and charts it is possible to view the earliest representations of the coast in different periods. This evidence provides early sources of information prior to the development of photography, which then shows a more empirical record or 'snap-shot'. Developing an understanding of these various media has been essential in the delivery of the Arch-Manche project and has provided background for the ranking schemes which have been developed and applied.

1.4.1. Art of the Region

1.4.1.1. The Origins of Coastal Landscape Art in the Channel-Southern North Sea Region

Landscape is a term that describes the scenery and environment of the countryside and coastline. Landscape paintings depict the natural beauty of the landscape and of coastal environments, often encompassing a broad view of the coastline, the sea and the sky, together with elements such as the weather and human activities. The word *landscape* started to be used in the English language from the early seventeenth century and is derived from the Dutch word '*landschap'*, which means 'an area of cultivated land'. Those landscape paintings which depict specific subjects such as parts of the coastline, buildings and structures, are called topographical views and are commonly seen in various types of prints (engravings, aquatints and lithographs) as well as in pencil drawings, watercolour drawings and oil paintings.

The origins of landscape painting date back to the fifteenth century where landscape scenery was incorporated in the paintings of artists such as Leonardo da Vinci (1452-1515) and Albrecht Dürer (1471-1528). In the Netherlands Pieter Brueghel the Elder (1525/30-1569) also developed stylised panoramas depicting life through the seasons, as well as the daily activities of residents of the countryside and coast. During the sixteenth and seventeenth centuries there was a great emphasis on portrait painting where English artists had learnt painting techniques from the Flemish artists Anthony Van Dyck (1599-1641) and Peter Paul Rubens (1577-1640).

The interest in art was accentuated by the desire of royalty, such as King Charles I (1600-1649) in England, and the nobility across Europe to become important collectors of works of art. During the late seventeenth century and eighteenth centuries wealthy young gentlemen were starting to travel more widely and they took the Grand Tour, gaining education and aesthetic inspiration from the classical remains and Renaissance art and architecture of Italy and Greece. Art patrons were particularly impressed by the works of artists such as Claude Lorrain (1604-1682), Nicholas Poussin (1594-1665) and Salvator Rosa (1615-1673), whose paintings evoked the classical landscapes of the Italian countryside and the grandeur of ancient Rome with its fine classical architecture.

In north west Europe the *Dutch Golden Age* of the seventeenth century saw a significant increase in the popularity of landscape painting, with many artists developing skills in the representation of the landscape. Dutch artists were also influenced by the Italianate landscapes but they developed their own particular skills, for example in the field of marine art. A decline in the popularity of religious paintings started in the eighteenth century; this led to the increased popularity of landscapes, for example in the Netherlands, resulting in this genre becoming the most popular for the next hundred years. The Dutch have a long tradition of marine painting with Willem van Velde the Elder (1611-1693) and his son, Willem (1633-1707) being leading exponents. Salomon van Ruisdael (1600-1670), Aelbert Cuyp (1620-1691) and Johannes Hermanus Koekkoek (1778-1851) and other members of his family painted both fine landscapes and coastal and estuary scenes with shipping. During the fifteenth to seventeenth centuries Flanders produced some of Europe's leading artists although their importance declined after the death of Rubens and the Eighty Years War in 1648. During the early nineteenth century there was a revival in Flemish art that is generally referred to as Belgian art thereafter.

In Europe landscape painting was influenced, first, by collectors and artists returning from the Grand Tour, resulting in an Italianate style being regarded as the height of fashion, whilst also works by artists such as Thomas Gainsborough (1727-1788) started, for the first time, to comprise portraits of landowners in the settings of their country estates. This approach was popularised by Van Dyck and other Flemish artists who were working in England and in this respect they influenced Gainsborough.

The French Revolution and the Napoleonic Wars prevented travel across large parts of Europe from 1793 until after the Battle of Waterloo in 1815. This led to an increased interest and discovery of the landscapes of countries such as Great Britain. In fact, from the middle of the eighteenth century, a number of British writers and travellers such as William Gilpin (1729-1797), sought to define and categorise human responses to natural phenomena. Edmund Burke (1724-1804) described the exploration of the 'sublime' and the 'beautiful' in the context of the landscape (Burke, 1757), whilst William Gilpin travelled across Great Britain in 1782 exploring the sites of wild landscapes such as the Scottish Highlands, Snowdonia, South Wales and the River Wye, the New Forest in Hampshire and the Isle of Wight, and set out his theory of the 'picturesque' landscape in a number of publications (Gilpin, 1786).

Figure 1.14. Coastal scene at St Helens, Isle of Wight, UK. Hand coloured copper plate engraving, 1813. Robin McInnes.

What we regard today as landscape painting developed particularly in the eighteenth century and was therefore strongly influenced by Dutch and Flemish artists from the seventeenth century onwards. As populations grew across Europe and with increased industrialisation in some areas, there was a new-found appreciation of the wild and open landscapes to be found outside the cities. Later in the eighteenth century, watercolour drawing started to become a popular medium and a speciality of English artists, who were encouraged by their patrons who sometimes took artists with them to record the scenes on their Grand Tour. Artists such as Francis Towne (1739-1816), Thomas Girtin (1775-1802) and Alexander Cozens (1717-1786) were leaders in the field of watercolour drawing, shortly to be joined by others including J. M. W. Turner (1775-1851), who continued the English tradition of taking tours around parts of the country and abroad, producing numerous drawings, some of which were subsequently worked up into major landscape paintings. The romance of the English landscape was now being interpreted in a new and more precise way by artists such as John Constable (1776-1837), Samuel Palmer (1805-1881) and J. M. W. Turner. At first, watercolour drawings were not accepted by the art establishment, such as the Royal Academy (founded in 1768) but, eventually, following the formation of the Society of Painters in Watercolours in England in 1804, they were increasingly accepted as a fine addition to the world of landscape art.

In France there is a long-standing tradition for capturing the landscape through art dating back to the Middle Ages. In Fact, French artists such as Claude Lorrain played a highly influential role in the development of landscape art across Europe through paintings of the classical landscapes and pastoral scenes of Italy. A friend of Claude Lorrain, Nicholas Poussin, was also a leading figure in the promotion of eighteenth century European landscape art. Some of the first French landscapes were those by Jacques Callot (1592-1635), who was influenced by the Dutch and Flemish masters. The founding of the Paris Academy of Painting and Sculpture in 1648 also gave strong support for artists of the period. The paintings of Jean-Honore Fragonard (1732-1806), Hubert Robert (1733-1808) and Claude-Joseph Vernet (1714-1789) continued to promote the concept of the classical landscape in France through the eighteenth century.

It was in the early nineteenth century that landscape painting developed more expressively in France. Artists such as Eugène Delacroix (1798-1863) and Gustave Doré (1832-1883) encouraged by the establishment of the '*Prix de Rome du Paysage Historique'* (Rome Prize for Historical Landscape) in 1817. As the Norwich School of Artists developed in East Anglia, in England, in the early nineteenth century another group of artists gathered in the village of Barbizon near Fountainbleau south of Paris for the purpose of drawing and painting in the open air. Key figures in this group of artists included Jean-Baptiste-Camille Corot (1796-1825), Jean-François Millet (1814-1875), Paul Huet (1803-1869), Charles-François Daubigny (1817-1878) and Théodore Rousseau (1812-1867). The Barbizon School established a tradition of fine French landscape paintings that would prove to become perhaps the most influential in Europe for over a hundred years, leading to the Impressionist and post-Impressionist schools exemplified by the artists Camille Pissarro (1830-1903), Edgar Degas (1834-1917), Claude Monet (1840-1926), Pierre-Auguste Renoir (1841-1919) and Alfred Sisley (1839-1899).

On the coast, artistic communities flourished in Normandy and Brittany. Jules Noël (1810-1881) painted extensively on the Normandy coastline. At Honfleur Eugène Boudin (1824-1898) taught Claude Monet to paint and Boudin produced numerous beach and coastal scenes whilst Alexandre Dubourg (1821-1891) painted the coastal scenery on the banks of the River Seine. In Brittany, Alfred Guillou (1844-1926), Emma Herland (1856-1947), and Henry Moret (1856-1913) painted genre scenes and the landscape whilst along the whole of the Channel coast English artists including J.M.W. Turner, Clarkson Stanfield (1793-1867), Richard Parkes Bonington (1802-1828) and many others travelled across the Channel to paint coastal scenes in watercolour and oils. English artists learnt the '*En plein-air'* technique of painting from the artists of Brittany and established colonies in England in Cornwall and on the Suffolk coast at Walberswick producing works often painted out of doors.

John Ruskin (1819-1900), the English art critic, believed that landscape painting was the most important artistic creation of the nineteenth century, leading to an increased appreciation of the natural beauty of the countryside and coastline. In his book '*Modern Painters*' (Ruskin, 1843) he argued that the principal role of an artist was to achieve "*truth to nature*" and to "*observe the reality of nature and not to invent it in the studio*". Ruskin also encouraged the development of a number of artists who became influential in the mid-nineteenth century and were known as the Pre-Raphaelite Brotherhood. These artists wished to capture nature in its precise detail and beauty, often through painting out-of-doors. The works of the Pre-Raphaelites and their followers coincided with an increased interest and understanding of both natural and earth sciences following the publication '*The Origin of Species'* by Charles Darwin (Darwin, 1859) and the development of the science of geology. Many of the best geological exposures were to be found around the coastline, and this was one of a number of factors that started to attract some

of the leading artists and their patrons to the shorelines of the Channel to record the varied geology and scenery.

In England in the eighteenth century there was an increasing interest in the coast particularly after sea bathing was encouraged by King George III, who bathed at Weymouth on the south coast and, later, by King George IV, who built a summer palace, his Royal Pavilion, at Brighton (1787-1823). At the same time early travellers were starting to explore the picturesque coastal landscapes of Netherlands, Belgium, France and England, and were following the aristocracy to the coast, where they had built '*Cottages Ornées'* or seaside villas in attractive locations for both health and relaxation. As 'spas' or 'watering places' started to develop and increasing numbers of visitors travelled to the seaside, taking the advice of physicians on the benefits of the coastal climate for health, artists met the demands of their patrons and started to produce views of the coastal scenery.

Improved communications and the development of coastal fishing villages into popular seaside resorts and spas, together with the expansion of the road and railway network from the cities to the coast, led to an ever increasing demand for paintings of coastal scenery. Artistic 'Schools' developed all around the European coastline, often centred on particularly attractive, aesthetic locations where artists enjoyed working together and collaborating and developing individual styles drawing on the beauties of the coastal scenery, and the impact of the meteorological conditions, such as the sunlight on the water.

The nineteenth century was the great period of English coastal landscape painting with the cliffs, shores and dunes as well as the developing ports and seaside resorts being depicted. In addition to individual works of art numerous topographical books were written, often finely illustrated with a range of media including copper and steel plate engravings, aquatints and lithographs. Alongside original works of art, these provide a rich source of information on the changing and developing coastline over a period of some 200 years. Topographical books such as William Daniell's 'Voyage Round Great Britain' containing 308 fine aquatints (Daniell & Ayton, 1814); Clarkson Stanfield's 'Coastal Scenery' (1847); Finden's 'Ports, Harbours and Watering Places of Great Britain' illustrated with steel engravings (Finden, 1838) and in France 'La Normandie Illustraée' that included views of the coast (Benoist, 1852). Other English artists including John Wilson Carmichael (1800-1868), Alfred De Breanski (1852-1928), Edward William Cooke (1811-1880) and John Brett (1830-1902) produced accurate coastal paintings. Scenes along the shoreline, often showing fishing scenes or shipwrecks, were painted in watercolour by Thomas Miles Richardson Junior (1813-1890) and Edward Duncan (1803-1882). Whilst Myles Birket Foster (1825-1899) and Charles Robertson (1844-1891) captured the same scenes in finely detailed watercolours. It is this legacy of historical art works that provide the basis for informing this study on art and its contribution to understanding long-term coastal change.

Figure 1.15. Lulworth Cove, Dorset' by William Daniell RA, 1825. Aquatint. Robin McInnes.

Figure 1.16. 'Mevagissey, Cornwall' by William Daniell RA, 1825. Aquatint. Robin McInnes.

1.4.1.2. Art of the Channel-Southern North Sea Coastlines – Literature Review

The landscape art of the coastline and countryside bordering the Channel-Southern North Sea coasts has been described by a number of authors over the last 200 years. However, the Arch-Manche project is believed to provide, for the first time, a comprehensive description of the coastal art, its history and development, and the inter-connections between the coastal paintings of these four countries. Literature accounts that include descriptions of coastal art have, historically, considered the artistic output from the whole territory of each of the four countries rather than just their coasts except where artistic colonies have developed and thrived; such locations have merited more detailed descriptions.

The literature on coastal art comprises a hierarchy of publications ranging from European art overviews, which usually describe the range of artistic styles practised across the continent (e.g. Hook & Poltimore, 1986) through dictionaries or Catalogues Raisonneés of the names of artists and their works by country (e.g. Hardie, 1966; Mallalieu, 1976; Graves, 1984; Wood, 1995; Smith, 2000; Bénézit, 2006) to national art overviews including the development of art over time (e.g. Gilpin, 1782; Burke, 1757; Clark, 1949; Pevsner, 1956; Stechow, 1966; Haak, 1984;

Sutton, 1987; Wood, 1988; Silve, 1998; Turner (Ed.), 2000; Auricchio, 2004; Ellis, from 2004; Kopp, 2009; Roger, 2009; McInnes & Stubbings, 2011).

Other publications describe artistic colonies or 'Schools' (e.g. Hemingway, 1979; Marlais et al., 2004; Marsh, 2005; Newton (Ed.), 2005; Munn, 2006; Hardie (Ed.), 2009; Kerlo & Durac, 2006; Brettell, undated; Delarre et al., 2009; Dudley Barrett, 2010; Bergeret-Gourbin, 2010; Tapie, 2010; Cariou, 2005) and finally monographs on the works of individual artists including Duffy, 2011; Reynolds, 1984; Munday, 1996; Rodrigue and Cariou, 2005; Payne, 2011; Kirby Welch & Morton Lee, 2011.

Descriptions of coastal art that relate to the selected case study locations for Activity Two 'Art and coastal change' include for Cornwall – Newton (Ed.), 2005 and Hardie, 2009; for Dorset - The Public Catalogue Foundation, Ellis 2009; Johnson, 2011; for The Solent and the Isle of Wight key reference works include Drummond & McInnes, 2001; McInnes, 2008; for Hastings in East Sussex - the Public Catalogue Foundation, Ellis 2005; for the Kent coast - the Public Catalogue Foundation, Ellis 2004; for the East Anglia study area the key reference works include Munn, 2006; Walpole, 1987; Walpole, 2009 and McInnes & Stubbings, 2010.

1.4.1.3. The Influence of Dutch and Flemish Painters on the Development of European Coastal Art

Artists from the Netherlands, Flanders and Belgium have played a significant role in the development of European landscape art, particularly in relation to the coastal and marine environments. As a result, this overview of coastal art in the Channel-Southern North Sea region commences with consideration of the Dutch, Flemish and Belgian influences.

Flemish painting thrived from the early fifteenth century until the seventeenth century. Pieter Brugel the Elder (1525-1569) produced some early landscape paintings featuring village life through the seasons. During this time Flanders also produced some of the leading artists of the period, for example, Sir Peter Paul Rubens (1577-1640), Sir Anthony van Dyck (1599-1641) and Jacob Jordeans (1593-1678). Rubens had a powerful influence on visual art and Anthony van Dyck had a deep influence on English portraiture art rather than landscape painting. This, in turn, led to other European artists being attracted to work in this artistic centre of activity. Flemish Baroque painting (i.e. the artistic style that embraced exuberance and grandeur in Europe from the early 1600s onwards) flourished, particularly in the Antwerp School. It was not just Antwerp, however, that provided the setting for creativity, and both Brussels and Ghent were also notable centres of artistic production during this period.

However, the Siege of Antwerp (1584-1585) led to Flanders becoming separated and, therefore, independent from the Dutch Republic and this caused many artists to then flee to the Dutch Republic and led to the development of landscape painting. Flanders' influence declined partly as a result of the Eighty Years War (1568- 1648) and following the deaths of leading artists, such as Rubens in 1640.

The Dutch 'Golden Age' of painting refers to a period spanning roughly the seventeenth century. An independent Dutch Republic emerged after the Eighty Years War and this new nation became the most prosperous in Europe at that time. The Dutch Republic led the field in the subjects of art, science and aspects of trade. Haarlem and Amsterdam were strong centres for painting at this time. The 'Golden Age' of paintings can be said to fall into the general period of European Baroque art, but with less emphasis on idealisation of love and more emphasis on

detailed realism. This provided an excellent backdrop for the development of naturalistic landscape paintings.

It was during the seventeenth century that landscape painting began to develop into a major genre in its own right. Flemish landscapes, particularly from the Antwerp School, provided some of the first examples of this growing genre. Artists such as Rubens, van Dyck and Jordeans were pioneers in this field. However, these early landscapes were often painted primarily in the studio of the artist and were, therefore, less accurate than the styles that later developed, such as, painting '*en plein air'* (out of doors) and the Pre-Raphaelite style of endeavouring to capture nature in its most realistic form.

Drawings began to be made out of doors and these would form the basis of the paintings that would, therefore, more accurately depict the landscape in its true form. Important figures in the move towards realism were Esias van de Velde (1587-1630), who painted landscape, genre and shipping subjects and Hendrick Avercamp (1585-1634) who painted some of the first Dutch landscape paintings. The Dutch seacoast provided popular subject areas and this, in turn, formed part of the catalyst towards seascapes developing as a more popular movement within the 'Golden Age'. Hendrik Vroom (1566-1640) can be, arguably, considered as the "*first 'Dutch' seascape painter*" (Royal Museums, Greenwich, 2012) and the father of Dutch marine painting, although he was "*brought up to a Flemish palette, which he maintained all his life*" (Archibald, 1982). Jan Porcellis (1583-1632) further contributed to the genre of marine painting through his development of tonal painting - a softening and blurring of outlines and a more atmospheric effect being achieved as a result, and it can be argued that it was "*only through this development that marine painting pure and simple could come into its own"* (Stechow, 1966).

Figure 1.17. 'The Beach at Scheveningen' by Adriaen van de Velde. Oil on canvas, 1658. Image courtesy: Commons Wikimedia, 2014.

The new Dutch Republic's strong economy was based heavily on sea trade and seascapes were seen as celebrating the vibrant activity off the coast. The "*economically successful Dutch Republic prompted increased specialisation*" in this new genre (Royal Museums, Greenwich, 2012). Naval conflict and also the natural dangers of the sea provided plenty of material for the artists of the time and as a result "*Dutch painters of seascapes were thorough connoisseurs of ships as well as of the water*" (Stechow, 1966), indeed, Jan van Goyen's (1596-1656) early

sketch books produced a surprisingly mature themes during the earlier period of the seascape genre. Later artists of the period included Jacob van Ruisdael (1628-1682) "*primarily a landscape painter but also did some marines*" (Archibald, 1982), Albert Cuyp (1620-1691) and Phillips Koninck (1619-1688). Although sea trade provided a plethora of material for artists, many paintings also included detail of land, beaches, harbour viewpoints and views stretching across estuaries.

The strong trade links between the new Dutch Republic and the rest of Europe encouraged the export of artistic works; many Dutch, and Flemish painters also worked abroad. The most famous artists who exemplified this trend were Willem van de Velde (c.1611-1693) and his son, also Willem (1633-1707), who moved to London in 1672. Van de Velde the Elder had a love of the sea and ships and "*perfected his technique to a level never attained by anyone else*" and as a result the "*studio of van de Velde and his son Willem, dominated marine painting in England and their style and approach to their subjects were the models and inspiration for the first generation of English marine painters"* (Archibald, 1982).

The relationship between the Old Masters of the 'Golden Age' and the beginnings of English landscape painting began to develop as artists such as John Constable (1776-1837) and Richard Parkes Bonington (1802-1828) looked to the narrative realism of the Dutch Old Masters. In particular, Constable denounced the then fashionable Italianate artists for their lack of realism and instead took inspiration from the Dutch and Flemish artists of an earlier time. In 1824 "*a sensation was caused by the naturalistic landscape paintings of the English, although they in turn owed a debt to the Old Dutch Masters*" (Dudley Barrett, 2010). A new generation of landscape painting was developing as the English drew inspiration from the Dutch. Dutch art can be noted as being particularly influential on the Norwich Society of Artists (1803-1833) or 'Norwich School', due to the history of strong trade links between Norwich and the Netherlands. The Medieval wool trade "*resulted in large numbers of classic maritime and landscape paintings in merchants' manors*" (Dudley Barrett, 2010) and it was not unusual for local gentry to have impressive collections of Old Masters such as Jakob van Ruisdael and Jan van Goyen hanging on their walls. The Norwich School "*carried on the landscape tradition*, *directly and indirectly, from the Flemish and Dutch Masters*" (Dudley Barrett, 2010). In 1821, Joseph Stannard (1797-1830), of the Norwich School, visited Holland to study paintings and indeed, his "*work tended to be highly finished like that of the Dutch masters*" (Hemingway, 1987).

The influential role of Dutch, Flemish and Belgian artists on the development of land and seascape paintings cannot be underestimated. In particular, the prosperity of the Dutch Republic created an opportunity for strong trade links with the rest of Europe and this in turn enabled works of art, and therefore artistic styles, to permeate into other countries.

1.4.1.4. The Influence of The Grand Tour

Taking the Grand Tour of Europe formed a key part of the education for wealthy young aristocrats in the eighteenth century. They travelled across Europe for several months or up to two years, accompanied by a tutor, who would oversee their studies and safeguard their morals, as well as looking after the practicalities of travel arrangements and accommodation. These gentlemen would have received, through schooling, education in languages such as Latin and Greek, and they were familiar with some of the historical literature from those countries. The purpose of the tour was to appreciate and understand the meaning of the classical landscapes of Italy and Greece in particular. However, *en route* they travelled through the picturesque mountain scenery of the Alps, as well as some of the major European cities. "*Those on the Grand Tour did not travel straight to Italy, for at that time France was regarded universally as*

the repository of all that was refined in manners and style, with a Court and attached luxury trade that all other countries sought to copy" (Hudson, 1993).

On arrival in Italy, the well-to-do young gentry were able to purchase examples of engravings and paintings after the masters or coastal and landscape scenes that had been painted by local artists for this 'tourist trade'. Often some of the most celebrated Grand Tour travellers were accompanied by their own artists and, later, photographers, who were able to capture the great sights on the tour. For example, the English aristocrat, Lord Palmerston, took the artist William Pars (1742-1782), whilst William Beckford was accompanied by the artist J. R. Cozens (1752-1797), (Hudson, 1993). During the middle of the eighteenth century, the War of the Austrian Succession was restricting travellers across parts of Europe, and it wasn't until the 1760s that the Grand Tour reached its height of popularity. The continuing discovery of important sights such as Herculaneum outside Naples in 1738, and Pompeii in 1748 continued to excite the imagination of travellers from north west Europe. Many of the gentry returning from the Grand Tour brought back treasures from their travels including works of art in the classical Italianate styles, as well as ideas of a perfect landscape inspired by artists such as Claude Lorrain, Nicholas Poussin and Salvator Rosa.

The taste for classical Italian landscapes had been inspired by some of the earlier Grand Tour travellers such as Joseph Addison (1672-1719), who made his tour in 1699 and recorded his experiences in his publication '*Remarks on several parts of Italy, etc'* (Addison, 1799). In crossing the Alps he said that "*the Alps fill the mind with an agreeable kind of horror*", and he commented on the concept of the 'sublime', which comprised the three pleasures of the imagination – greatness, uncommonness and beauty arising from visible objects. Addison's notion of greatness was integral to the concept of the sublime. These ideas were expanded further by the Statesman and writer, Edmund Burke in his 'Philosophical Enquiry into the Origin of Ideas of the Sublime and the Beautiful', written in 1757 (Burke, 1757). Burke argued that both beauty and the awe-inspiring experience of the sublime were perceived emotionally. Burke conditioned the thinking of a wide range of artists in terms of the way they treated the landscape and the development of the concept of 'picturesque' scenery across Europe.

In Great Britain in the nineteenth century travellers still perceived the wilder landscapes as sinister and dreadful. William Daniell and his colleague, Richard Ayton toured the coast painting and describing its scenery. Ayton wrote "...*here was the ocean in all its grandeur, ploughed up by a storm, and bursting with a continued and sullen roar against precipices of rock, awful for their vastness, black and dreadful, and exposing on their battered sides a combination of* all *rugged and horrid forms"* (Daniell & Ayton, 1814). The Grand Tour was hugely influential in the development of the aristocracy's interest in art and therefore, the movement of artistic works and styles across and around Europe. The development of landscape painting owes a huge debt to the movement around Europe of the gentry during their undertaking of the Grand Tour.

1.4.1.5. The Discovery of the Coast

The British aristocracy collected the works of leading artists such as Lorrain, Rosa and Poussin enthusiastically, and collectors were soon commissioning artists to paint views of their own landscapes but finished in the 'Picturesque' style. However, the Grand Tour and travel across Europe was effectively halted between 1793 on the outbreak of the French Revolution, until the Battle of Waterloo in 1815. This situation led to a search for picturesque landscapes in locations such as the British Isles, where travelling artists and writers were encouraging a renewed interest in the landscape. Wealthy gentry, with time on their hands, who previously might have been exploring the great sights of Europe now took a renewed interest in the landscape and coastline of Great Britain, encouraged after reading William Gilpin's descriptions of his first

picturesque tour to South Wales in the summer of 1770. Gilpin (1724-1804) was less concerned about the topographical accuracy of the scene than with capturing the atmosphere of a '*picturesque landscape'* (Gilpin, 1809). An enlightened educationist, Gilpin defined picturesque as "*that kind of beauty which is agreeable in a picture"* and began to expand his principles of picturesque beauty through travels across the British Isles, to locations including the Scottish Highlands, the Lake District of North West England, South Wales and the New Forest in Hampshire and the Isle of Wight.

Figure 1.18. 'On the South Devon Coast' by Samuel Edward Kelly, c.1910. Watercolour. Robin McInnes.

Where the aristocracy travelled around the coastlines of the Channel-La Manche artists and engravers followed, recording images at the request of their masters, or producing their own publications, which were often lavishly illustrated. As early as the mid-eighteenth century visitors were being drawn to the coastline. These were principally those visitors in search of health, leisure and pleasure. In 1736, for example, the Reverend William Clarke and his wife stayed for a month in Brighthelmstone, a small town on the south coast of England. Clarke wrote to his friend, a Mr Bowyer, stating "*we are now sunning ourselves upon the beach at Brighthelmstone... the place is really pleasant. My morning business is bathing in the sea and then buying fish*" (Gray, 2006). King George III bathed on the beach at Weymouth in Dorset and, later, King George IV enjoyed sea bathing at Brighton, and established his summer palace, the Brighton Pavilion, in the town.

At the same time the early travellers were starting to explore the picturesque landscapes of the French and English channel coasts a fashion for sea bathing, particularly for the benefit of health, was in its infancy. However, by the end of the eighteenth century a number of small coastal towns were starting to provide rudimentary facilities for bathers. In locations such as the Isle of Wight off the south coast of England bathing places were provided on gentle beaches where people could enter the water easily on foot, or the beach would allow bathing machines to be towed down into the sea and later drawn up above high water mark. As the demand for access to the beach increased, sea walls were constructed to provide the necessary support for sea front pavements or carriage roads that formed the first 'esplanades'.

Initially known as '*spas*' or '*watering places*' rather than seaside resorts, their future was assured as an increasing number of scientists and physicians started to proclaim the benefits of the seaside for improving the health of invalids. Sir James Clark wrote in his '*Influence of climate on the prevention and cure of chronic diseases'* of the benefits of the climate of the south coast of the Isle of Wight for one's health (Clark, 1830). '*Watering places*' often developed where natural mineral waters were found emerging as springs from the coastal cliff lines. Local physicians, with claims that they could cure a range of ailments and diseases, often highlighted the benefits of taking these waters for health'. Elsewhere the use of seawater to cure a range of diseases was also promoted.

Around the Channel coastlines of north west Europe the rapid expansion of the railway network and improved road communications linked industrial centres and cities to the coast. Main railway lines extended out towards the rapidly developing seaside towns, where fashionable seafront promenades, piers, hotels and marine villas were being built to cater for the increasing demand. The rapidly increasing popularity of both sea bathing and yacht racing, combined with better communications both on land and across the Channel were all important factors in the development of the Channel coastline.

Figure 1.19. 'Vue de la Plage de Dieppe' by Edouard Hostein (1804-1889). Oil on canvas. This magnificent oil painting shows the seafront before extensive nineteenth century took place. Image courtesy of Château Musée Dieppe.

By the early 1900s there were approximately 100 well-established seaside resorts around the Channel coasts. Visitors, wished to have a record of the views of the coastline to take back with them as a souvenir of their vacation. Before the days of photography large numbers of artists painting in watercolour and oils captured the scenery of the coast and found a ready market with these often relatively wealthy tourists. Before the days of photography purchasers were seeking images that provided an exact reproduction of the coastal views they had enjoyed so much. As a result, many fine and accurate topographical paintings were produced of the coast during the nineteenth century in particular. Even after the introduction of photography in the late 1850s

works of art were still required because it was to be many decades before the innovation of colour photography became widely used, and therefore, landscape paintings in full colour continued to fulfil an important role.

The relatively expensive guide books illustrated with engravings in the mid-nineteenth century could not be printed in sufficient numbers to meet the demands of increasing numbers of visitors to the Channel coasts. The invention of chromolithography in Germany and colour plate production of paintings to illustrate books allowed much larger print runs to be achieved. Publishers such as A. & C. Black in London commissioned authors and artists to write and illustrate books covering all parts of the European coast to meet the needs of the travelling public.

In 1894 British publishers were granted permission by the Royal Mail to manufacture and distribute postcards, which could be sent through the post. Postcards produced between the 1890s and the 1920s often provided views of coastal scenery and the seaside resorts; specially commissioned watercolour artists had printed them from works. These postcards form a rich resource available to those wishing to understand coastal change on account of the accuracy of many of the portrayals.

1.4.1.6. Pre-Raphaelite Coastal Landscapes

The Pre-Raphaelite movement "*fundamentally altered English approaches to landscape painting*" (Tate Britain, 2004) in the mid-Victorian period through the introduction of uncompromising attention to detail. Up until the seemingly radical Pre-Raphaelite movement, Victorian artists had opposed change and modernisation in the countryside and wished to make their pictures as "*sentimental and pretty as possible*" (Wood, 1997). The central pillar of Pre-Raphaelite landscape painting was, therefore, a new method of painting, "*looking carefully at nature, without recourse to conventional modes of composition and expression*" (Payne & Brett, 2010). The critics of the time were said to find the work of Pre-Raphaelite landscapes as reminiscent of the "*effects which could be achieved with optical instruments, particularly microscopes and the new science of photography*" (Payne & Brett, 2010).

In 1848 the Pre-Raphaelite Brotherhood (PRB) was formed by a group of young artists, poets and critics in London. The three founding members were Dante Gabriel Rossetti (1828-1882), John Everett Millais (1829-1896) and William Holman Hunt (1827-1919). The PRB was greatly influenced by nature and the artists tried to depict nature in its truest form through the laborious study of even the smallest detail. They were unrelenting in their quest for detailed realism and would spend the majority of their time working outside and not within the confines of a studio. A leading art critic during the Victorian era, John Ruskin (1819-1900), a geologist and botanist by training, said during his Edinburgh Lectures of 1853, that *"Pre-Raphaelitism has but one principle, that of absolute, uncompromising truth in all that it does, obtained by working everything down to the most minute details, from nature and from nature alone"* (Halsby, 1986). Indeed, one of the founding members William Holman Hunt is quoted *as* saying: *"I purpose…to paint an out-of-door picture…with every detail I can see, and with the sunlight brightness of the day itself"* (Payne & Brett, 2010).

John Ruskin played a prominent role in the development of Pre-Raphaelite landscape paintings, including coastal scenes, through his encouragement of the artists to "*go to Nature in all singleness of heart…rejecting nothing, selecting nothing and scoring nothing*" (Payne & Brett, 2010). John Everett Millais and William Holman Hunt were among the first of the PRB to endeavour landscape paintings based on the influence of Ruskin's principles; they were striving for "*total fidelity to nature*" (Wood, 1997). It was within this canon that the landscape paintings of

John Brett (1831-1902) developed, who soon became recognised as the "*head of the Pre-Raphaelite school of landscape painting*" (Payne & Brett, 2010). However, it is worth noting that although Brett was not actually a member of the PRB, he was strongly influenced by their works. Ruskin also heavily influenced Brett and upon reading Ruskin's essay *'Mountain Beauty'*, in Switzerland in 1856 Brett decided "*in a reasonable way to paint all I could see*" (Marsh, 2005).

Many of the wider circle of the Pre-Raphaelites also devoted their attention to "*pure landscape*" (Wood, 1997), i.e. detailed realism, particularly William Dyce (1806-1864) and John William Inchbold (1830-1888). William Dyce only painted occasional landscapes throughout his career, but did so with such detail and precision that it was enough to class Dyce's work "*among the leading examples of Pre-Raphaelite detail and finish*" (Staley, 2001). His detailed study of the geology, a developing science at that time, of the coastline in '*Pegwell Bay, Kent – a recollection of October 5th 1858'* is a true example of meticulous realism in landscape painting. Dyce's oil painting of Pegwell Bay was in fact considered to be so accurate that at the time it was suggested that Dyce had used a photograph to paint from and not from sketches, as was the traditional method. Staley (2001) argues that, "*if we compare Pegwell Bay with a contemporary photograph of the same locality, we can see that in this instance Dyce not only equalled, but outdid the camera in clarity and thoroughness"*

Figure 1.20. 'Pegwell Bay, Kent – a recollection of October 5th 1858' by William Dyce (1806-1864). Oil on canvas. This very detailed oil was painted at a time when the science of geology was developing. Dyce, an artist of the Pre-Raphaelite Brotherhood, wished to depict nature in precise detail. Photograph courtesy of Tate Images, 2014.

Along with Dyce, John William Inchbold is also considered to be one of the most prominent Pre-Raphaelite painters of landscapes and was much praised by Ruskin for his detailed landscape paintings. Inchbold's '*Anstey Cove, Devon*' 1853-4 provides an example of Pre-Raphaelite detail of the coastline: "…*the colours are bright throughout, and the foliate detail in the foreground is beautifully and delicately drawn*" (Staley, 2001).

The ripples of the influence of the Pre-Raphaelites were felt throughout the art world, and many artists were inspired by their methodical approach to depicting the natural world. From Ruskin's annual reviews of art, he declared that year on year more artists were beginning to emulate the detail used by the PRB. Ruskin and William Michael Rossetti (1829-1919), the longest surviving member of the PRB, even went on to claim, in 1862, that, "*landscape came almost entirely into the domain of Pre-Raphaelitism*" (Staley, 2001). Charles Napier Hemy (1841-1917) was a follower of the PRB and his work '*Among the Shingle at Clovelly',* dated 1864, clearly shows a very detailed study of the topography and geology of the coastline.

Edward William Cooke (1811-1880) also took a keen interest in depicting the geology of the coastline with great accuracy and precision. The paintings he produced of the English, French and Dutch coastline produced "*detailed images as intense and totally realised as any from the brushes of the Pre-Raphaelite brethren*" (Munday, 1996). Furthermore, E.W Cooke's paintings are now considered to be so accurate that in the twentieth century, his work took on an "*archaeological importance. If Cooke painted or drew it, it is reliably correct*" (Munday, 1996). Charles Robertson (1844-91) is a further example of a Victorian landscape and genre artist influenced by the PRB who painted coastal views with meticulous detail.

Figure 1.21. 'Yarmouth', 1891. Watercolour. Charles Robertson (1844-1891). Robertson was a follower of the Pre-Raphaelites and portrays the extent of the saltmarsh and mudflats on the north-west coast of the Isle of Wight in precise detail. Private Collection

The Pre-Raphaelite movement and its followers' deep fascination with the natural world and capturing every detail as precisely as possible were, arguably, as revolutionary in the art world as the achievements of the Impressionists of the same period (Tate Britain, 2004). Indeed, Staley (2001) argues that "*Pre-Raphaelitism as a movement marked an almost complete break in the continuity of the English landscape tradition*". The artists were revolutionising the art world by taking their canvases out of doors and working directly from nature; the natural world was not being romanticised and the artists were unrelenting in their pursuit of detail. By looking carefully at nature and trying to portray it as truthfully as possible, the Pre-Raphaelite landscape movement provides an accurate representation of the natural world as it was seen at that time.

It is for this reason that Pre-Raphaelite works can be of particular use for those studying the chronology of coastal change.

1.4.1.7. Artist Colonies on the Channel-Southern North Sea Coasts

Coastal art colonies began to emerge in Europe in the nineteenth century and thrived until the early years of the twentieth century. In the post Napoleonic War years and after the European-wide revolutions of the early 1800s there began a gradual movement of artists towards the coastal towns of Europe. The demise of this trend continued until the outbreak of the First World War and thereafter the move towards the acceptance of the harsh realities of modernity. Art colonies emerged as village movements and gradually grew in size throughout the 1800s. Between 1830 and 1914 approximately 3,000 professional artists participated in this movement from the densely populated urban areas (due to the population explosion caused by the Industrial Revolution) into countryside and coastal locations.

There were over eighty communities around the Channel-Southern North Sea coasts and these communities can be divided into three main types: First, villages with transient and fluctuating artist populations, for example Honfleur on the French coast and Katwijk on the Dutch coast; second, villages with semi-permanent visiting and residing artists, for example, Concarneau in France and St Ives on the Cornish coast; and third, villages with mainly stable groups of artists in residence, for example, Egmond on the Dutch coast and Newlyn in Cornwall and Walberswick in Suffolk, East Anglia.

Although colonies appeared right across Europe many were clustered in France and the Netherlands. Over thirty nationalities were represented and this provided a unique international flavour. Some artists settled in one location, for example, Eugene Boudin (1824-1898) at Honfleur in Normandy, France. As a result they usually became well respected and revered within these communities. However, many artists flowed between the colonies and sought inspiration from the varied destinations at which they worked, for example Stanhope Alexander Forbes (1857-1947), John Singer Sargent (1856-1925), and Henry Scott Tuke (1858-1929).

Figure 1.22. 'Katwijk Church, Netherlands' . Image courtesy Cdr J Morton Lee.

A strong driving force that provided cohesion amongst the many varied artists of this time was that they were, by and large, informed by the narrative realism of the Flemish and Dutch. A move towards depicting the often harsh realities of life and the scenery in small coastal towns was a common objective of these colonial artists. There were some artists who wished to capture the social realities and others who wished to capture a "*literal reality now revealed by photographic images*" (Gates, 2012) of the scenery.

Painting by the coast was seen as a way to revert to a simpler way of life away from the industrialisation of many European cities. For many, however, it was simply the feeling of being drawn towards water that provided inspiration for their work (Gates, 2012). Typically, the colonies were situated at the edge of the country they inhabited, providing the artists with a "*sense of relief and release just getting there*" and, furthermore, the extreme position "*adding to a sense of…other-worldliness*" (Dudley Barrett, 2010); the remote peninsulas and coasts of Cornwall, Normandy and Brittany are examples of this. Stanhope Forbes described the "*beauty of this fair district* [Newlyn, Cornwall], *which charmed us from the first, has not lost its power and holds us still*" (Hardie, 2009). The remote coastal areas had a "*distinct topography, and ethnic particularities*" which made it almost seem like a "*world apart from the rest of Britain*" (Messum's, 2012).

The artists of the colonies shared a further common aspiration and that was to paint *en plein-air* (i.e. out of doors). The artists were keen to embrace descriptive realism and the naturalist principles that inevitably followed on from this. They were eager to paint out of doors in front of the subject and capture the subject in its natural setting. The French painter Jules Bastien-Lepage (1848-1884) was the "*major influence for this approach*" (Wallace, 2007), as he created his figures in landscapes mostly outdoors. The School of Newlyners were particularly influenced by the continental approach to painting out of doors. Indeed, Stanhope A. Forbes is quoted as saying, "*Yes, those were the days of unflinching realism, of the cult of Bastien-Lepage*" (Hardie, 2009). Many members of the Newlyn School studied in the studios or ateliers of Paris, Antwerp and Munich prior to migrating to the English coast. As a result of studying together, many artists became friends whilst on the Continent and later enjoyed not only painting together in Newlyn, but socialising together too. Forbes was a successful artist in Brittany after completing his studies there, and when he returned to England, he searched for an equivalent to the French coast and this led him to Newlyn in 1884. As a result of his success, many artists chose to follow him to Newlyn and thus the School grew in size and reputation.

Newlyners painted mainly out of doors and they particularly liked to paint local people and places and the people going about their day-to-day business. They were keen to capture the daily hardships endured by the inhabitants of the local area, "*truth and accuracy were their bedrock goals*" (Messum's, 2012) and as result of the industrial and commercial revolutions in previous years, workers' lives were at the forefront of the consciousness of the artists. Narrative realism derived from the Dutch and Flemish art schools was a strong influence and, in time, the artists looked to the Pre-Raphaelite artists' "*naturalist traditions*" of using local locations and non-professional models and usually providing a strong moral overtone to their work. Notable artists of the Newlyn School include: Frank Bramley (1857-1915); Stanhope Alexander Forbes (1857-1947); Walter Langley (1852-1922); Samuel John 'Lamorna' Birch (1869-1955); Laura Knight (1877-1970) and Harold Knight (1874-1961).

The rocky coasts of Brittany and the harbours, estuaries and chalk cliffs of Normandy pre-empted the schools of Newlyn and St. Ives in Cornwall. Open air sketching had been a common occurrence on the Northern coastline since the 1820s, pioneered by painters such as Jean-Baptiste-Camille Carot (1796-1875), Paul Huet (1804-1869) and the Englishman Richard

Parkes Bonington (1802-1828). The growing rail infrastructure in France in the nineteenth century enabled many artists to move freely around the French countryside and the industrialisation of the cities of the North in the mid-century fuelled the desire of artists to 'escape' to the unspoilt coastline. Colonies in France grew in size and number particularly during the 1870s and were often based around particular hotels and also language groups.

The art colony in Etaples on the Channel coast of Northern France was most widely inhabited by artists during the period from 1880-1914. Many artists chose to stay in the area for many years, whilst others moved freely along the coastline of Normandy and Brittany. The first French artists to paint in Etaples were widely in favour of painting *en plein-air,* for example Charles-Francois Daubigny (1817-1878) and Eugene Boudin (1824-1898). Boudin was inspired greatly by the Dutch artist Johan Jongkind (1819-1891), who encouraged Boudin to paint outdoors. Indeed, in 1862, Jongkind, Boudin and a young Claude Monet (1840-1926) travelled to Honfleur, Normandy together to work on painting the coastline entirely out of doors. The influence of Jules Bastien-Lepage was also apparent during this earlier period of the colonisation of the French Coastline and artists tended to choose humble subjects for their work in order to capture the reality of 'everyday life' of the local residents.

The coastal towns of Honfleur, Dieppe, Deauville and Trouville were popular resorts for the growing numbers of holidaymakers looking to escape from the industrialised towns. However, they still provided artists with humble subjects, such as the fishermen and women. Traditional themes of capturing nature's elements and its impact on the local residents provided a source of inspiration throughout the nineteenth century.

The latter part of the nineteenth century was an important time for the development of art colonies in the Netherlands. The Netherlands had an old culture that could provide a solid pedigree of Old Masters traditional settings and a wealth of non-literary, genre subjects. French Pleinairism had provided many of Dutch artists with inspiration at this time and as a result, Dutch art colonies flourished. The French School of Barbizon were particularly influential in the Netherlands and the Schools of Hague and Laren were even called the Dutch Barbizon. However, the Netherlands had a rich history of landscape art to draw upon too and artists' colonies had been developing in the Netherlands from as early as the seventeenth century.

There were a number of key coastal art colonies in the Netherlands: Domburg, Veere and Katwijk were particularly influential. Even from as early as the fifteenth century, Veere was a notable and wealthy city, rich in art and culture. Art loving tourists and artists flocked there particularly during the 1890s.

The town of Katwijk on the coast of the North Sea in southern Holland was attracting landscape artists from that time and throughout the next two centuries. Between 1885 and 1914, Katwijk was host to at least 879 named artists from a total of eighteen different countries and was, at this time, experiencing its peak in popularity with artists. The hard and intensive life of local fishermen was a source of great inspiration and most artists at this time were drawn to narrative realism in their style of work. A number of painters from The Hague School resided in Katwijk, such as Bernard Blommers (1845-1914), Jan Zoetelief Tromp (1872-1947) and Max Liebermann (1847-1935) (www.euroartcities.eu). Blommer generally painted genre works depicting fishermen and their wives. He portrayed them in a literal fashion, showing the impoverished and robust way of life (www.macconnal-mason.com). Maritime subjects were also of interest to him. Zoetelief Tromp was a painter of genre, landscapes and coastal scenes and spent over ten years working in Katwijk. Liebermann also painted rural workers and scenes of everyday life and believed that *"painting should be the exploration of art as the honest study of*

nature" (www.getty.edu). The results of working in artists' colonies confirmed the trend towards objective realism, a heightened sensitivity to light and fresh colour values.

The development of artist's colonies and their largely common goal of narrative realism, in effect an accurate portrayal of the harsh realities of life for coastal workers, enabled the development of a body of work that can be drawn upon as a relatively reliable resource when studying the ever changing coastline of La Manche region.

Conclusion

This overview of the art resources of the Channel coastlines illustrates a rich art history that can be interrogated to support understanding of long-term coastal change. The case study areas lie within a region that was painted more than any other part of Europe's coastline and which illustrates how landscape art developed since the sixteenth century. Most of the major European Schools of landscape and coastal art are also represented in the region. Section 2 explains how this rich art heritage can be evaluated in order to identify which artists and their works can be relied upon in terms of providing accurate depictions of coastal conditions at the time.

1.4.2. Maps and Charts of the Region

Historic maps provide an important source of information on studying coastal evolution. From the late Middle Ages onwards, maps rapidly increased in detail and quality. These maps can be used for coastal research, for instance by *georeferencing* the maps (fitting the historical map on the present day situation) and *digitizing* (drawing polygons, lines or points) elements like the evolution of the former shoreline in a GIS (Geographical Information System).

Although cartography is often regarded as a quite recent phenomenon since most remaining maps hail from the post-medieval period, the origins of cartography are to be found far earlier. Petroglyphs from the Stone Age show land use maps and places where herds were gathered. On Egyptian monuments depictions of land surveyors and their activities have been found. Land surveying techniques became more refined during the Greek and Roman periods. After the Roman Empire collapsed these techniques diminished in western Europe. The typical worldview of the Middle Ages was visualized in so called T-O-maps (Figure 1.23) containing three continents (Asia, Europe and Africa) surrounded by water and Jerusalem at the centre. More pragmatic were the "itineraria" (depicting how to travel from one to another place), the "portolans" (nautical navigation maps) and "isolaria" (maps depicting islands) that appeared at the end of the Middle Ages (De Maeyer et al 2004).

From the end of the 15th and in the 16th century major cartographical innovations took place. The main factors responsible for reviving land surveying and cartography were the rediscovery of ancient texts on land surveying, the great explorations, the development of book printing techniques, the development of the instruments used and the development of trigonometry. At the same time, the Low Countries, Germany and Italy became a centre of cartographical production (De Maeyer et al 2004:28-9). In Flanders, the Louvain University was an important centre of cartographical studies (Bossu, 1982:19). However, the still remaining maps of this era mainly focus on the regional or supraregional level. The maps of Pieter Pourbus (Brugse Vrije, 1561-1571) is one of the finest examples (Figure 1.24).

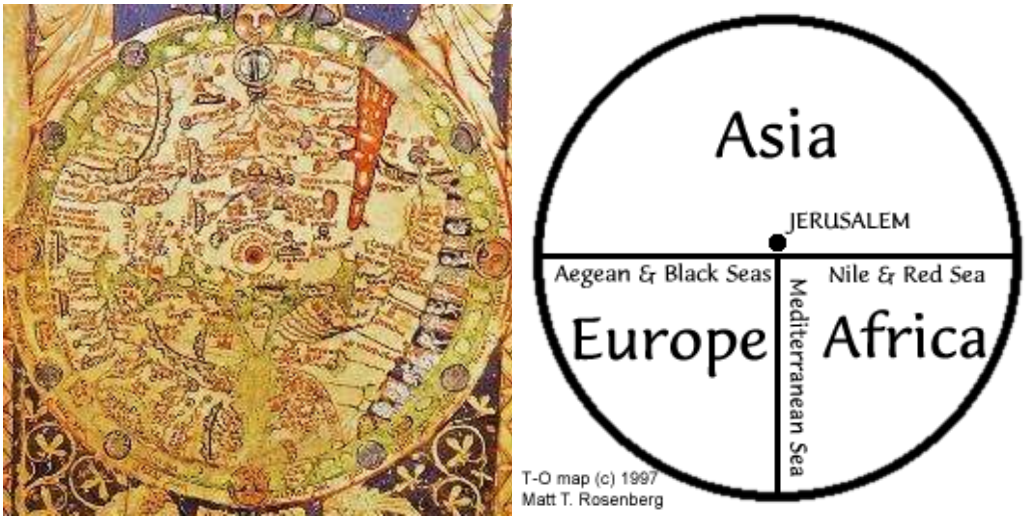


Figure 1.23. Typical T-O maps as found during the Middle Ages. Left an original example and right a reconstruction of the typical shape and contents of these maps. Left: http://kellyhayner.blogspot.be; Right: http://geography.about.com (05/04/2013)

Figure 1.24. Territorial map of the district of Bruges (Franc de Bruges) by Pieter Pourbus, 1561-71 (Groeningemuseum Brugge, I0220.I).

In terms of north west Europe the Flemish Cartographer Gerardus Mercator (1512-1594) sought to correct previous maps with his Mercator Projection. The first atlas containing maps was prepared by the Antwerp cartographer Abraham Ortelius in 1570, and a succession of eminent cartographers followed including Hertman Moll and Nicholas de Fer in the seventeenth and early eighteenth centuries. In fact the Low Countries led the world in the production of maps from the sixteenth century including Blaeu, de Wit, Hendrick Doncker and Pieter Goos.

Important cartographical innovators were at work at Louvain University: Gemma Frisius, who refined the trigonometry; Jacob van Deventer, who produced the famous maps of the Low Countries' provinces and very detailed city plans; and Gerard Mercator, famous for his projection system (Koeman, 1983). In the 17th century the centre of cartography shifted from Flanders (Louvain and Antwerp) to the northern Netherlands (Leiden University and publishers from Amsterdam (Bossu, 1982)), after which there is a large growth in the production of (more and more large scale and detailed) maps.

The first English attempt to compete with the Dutch was by John Seller with his publications *The English Pilot Books I and II* (Seller, 1671-72). During the seventeenth century maps were produced of the British coastline in order to try and reduce the number of shipwrecks in vulnerable locations, these being funded by insurance companies such as the East India Company.

In England, Blaeu and John Speed started to produce maps of each county from the early seventeenth century. Although these maps contained some topographical detail they were not generally accurate. On the coast the Warden of the Cinque Ports had been responsible for producing surveys and charts since the reign of King Henry VIII. However, it was Samuel Pepys, First Secretary to the Admiralty in 1673, who encouraged King Charles II to carry out the first complete survey of Britain's harbours and coastline. In England the preparation of accurate maps was encouraged further by a competition launched by the Royal Academy of Arts (RA) in 1759, which offered an annual prize for the most accurate survey of any county.

John Cary published an atlas of smaller English county maps in 1787, which became in great demand as people started to explore the coastline. In 1801 such private cartographers started to receive competition from the Ordnance Survey (OS) but the OS spent some fifty years on triangulation of the whole of England before their first One Inch OS Map was published in 1853. Maps were almost always included in topographical books from the late eighteenth century, and authors such as Sir Henry Englefield, an antiquarian and geologist, prepared one of the first geological maps and cross-sections of the Isle of Wight, Hampshire and Dorset coastlines with the assistance of his geologist friend, George Webster (Englefield, 1816). During the late eighteenth and nineteenth century maps became increasingly detailed and informative; John Roque, Bowen and Kitchen, John Cary, Thomas Moule and William Hughes being the best known.

However, 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, would probably induce large and unknown mistakes in the coastal reconstruction. Therefore it is important to analyse the quality of a map, before starting the actual interpretation, the methodology for this is outlined in Section 2.

1.4.3. Photography of the Region

The concept of 'photography' based upon the principle that exposure to light can alter some substances to create images, was developed in the early nineteenth century. After several early attempts at development of the process Louis Daguerre produced the first 'Daguerreotype' image in the 1830s and this eventually became available commercially. However, the exposure time took several minutes and this meant that there were limitations on the choice of subject matter.

Photographic processes were refined by William Henry Fox Talbot who managed to create photographic negatives on paper in 1835. Over the next five years, through experimenting with various chemicals, the method was much improved enabling the processing time to be further reduced. Early photography involved the use of large glass plates and although heavy and cumbersome some of the early images were extremely good particularly after the development of collodian emulsions. Early photographs were mainly portraits where the sitter could remain still. The quality was improved through the development of the bellows camera in Paris in 1847 allowing views to be focused for the first time. The development of photography coincided with the period of Victorian travel particularly to the seaside. From the late 1850s beach photographers were present in many resorts and spas and became extremely popular.

Those interested in coastal scenery, geology and heritage started to use this new medium to record their travels and finds; these now form a rich resource for research into long-term coastal change. However, photography continued to be a black and white process until the early 1900s when the autochrome plate was introduced in 1907. Up until the end of the Edwardian era art remained the only medium for depicting landscapes and coastal scenery in full colour.

Postcards originated in Vienna from 1869; this was followed in Great Britain the following year and soon they became widely available across Europe. Photographic images started to appear on postcards from the late 1870s and later included also reproductions of watercolour scenes of the coast.

During the 19th century the development of photography was gathering pace with experimentation using a range of equipment and chemical processes to capture images. One of the social processes driving development was the demand for portraiture from the emerging middle classes on the back of the industrial revolution. Although a number of photographs exist from the 1830s onwards it is not until the 1850s when a broader range of images are available including some wider viewscapes.

The real expansion in photography occurred in the 1880s when the modern photograph process became established with the use of paper or film rather than photographic plates. The first widely available Kodac camera went on the market in 1888, meaning photography became available to the mass market (http://www.all-art.org/history658_photography3.html).

1.5. The Challenges of Coastal Management in the Channel – Southern North Sea Region

The Channel – Southern North Sea coastlines are subjected to the natural processes of weathering, coastal erosion, landsliding and flooding. The impacts of these processes vary from one part of the coastline to another depending on the geological structure, the durability of the rocks outcropping along the coastline as well as the relative exposure to the effects of waves and tides. Waves and currents transport natural materials around the coastline, eroding some places, transporting material by the process of longshore drift and depositing it elsewhere. Human activity has taken place on parts of this continuously changing and evolving coastline over thousands of years.

In those locations where anthropomorphic development has taken place efforts have often been made to protect people, property and infrastructure from the impacts of natural hazards such as coastal erosion and sea flooding. This has often been achieved through the construction of sea walls, which continue to provide vital protection for many historic coastal towns and seaside resorts as well as for assets such as power stations, oil refineries, port installations and coastal roads and railways. However, in some locations the construction of coastal defences has had a detrimental impact on natural coastal systems. This has sometimes impacted beaches and salt marshes through increased erosion or instability problems through downdrift.

Significant lengths of the coastlines bordering the Channel-La Manche and the Southern North Sea are densely developed. The most rapid urban development can often be traced back to the nineteenth century or before when, for both health-giving reasons and on account of the popularity of sea bathing, the coastline became popular for recuperation, relaxation and recreation. Development pressures have highlighted the need to reconcile the needs of a diverse range of coastal users without increasing damage or pressure on the natural environment.

The last twenty years have witnessed a marked change in the philosophy adopted by those with an interest in the coast. In particular there has been the recognition that there is a need for those involved in coastal management to work more closely together. An appreciation has developed of the fact that the natural processes taking place around the coastline are not restricted to administrative boundaries but operate over much longer sections of coast (called 'sediment cells') and that decisions on coastal issues can often be made most effectively by examining these longer stretches of coastline as an entity.

Figure 1.25. Victorian seaside developments at Hastings, East Sussex, UK, c.1890. Robin McInnes.

Figure 1.26. Bathing machines line the beach at Ventnor, Isle of Wight, UK, c.1900. Robin McInnes.

Coastal research promoted by the European Commission (European Commission, 1999, 2002, 2007, 2011, 2012) has demonstrated the need for the wide-ranging groups with an interest in the coast to work together in order to achieve what has become known as *Integrated Coastal Zone Management* (ICZM). Coastal risk management is just one part of this, but taking account of the assets worth billions of Euros that are protected by coastal defence structures it forms a very significant component of to this management process.

In recent years there has been an increasing recognition that, wherever possible, the natural physical processes of erosion, sediment transport and deposition should be allowed to prevail

and that coastal defence can be achieved most effectively by trying to 'work with nature', for example by encouraging the build-up of beaches as a very effective form of natural coastal defence. Clearly the situation will vary from one part of the coastline to another and the most appropriate solution to any coastal defence problem must be considered taking account of all relevant factors. However, if we are to prevent further deterioration of the natural quality of our coastline much more thought must be given to achieving a better balance between the human, socio-economic and natural factors along the coast.

All the partner countries have appraised those assets that are at risk from natural hazards such as coastal erosion and flooding (McInnes *et al*., 2000, 2006; European Commission, 2004).The extent of coastal development has led to increasing demands for the implementation of sustainable strategies for the management of coastal risks. The cost of providing coastal defences form a significant item of public expenditure. It is very important; therefore, that local government and other organisations that plan and construct coastal defence schemes should ensure that the proposed solutions are effective in the long-term without detriment to the coastal environment.

Many professionals involved in coastal risk management around the Channel-Southern North Sea coastlines believe that meeting the challenges of climate change is the most important issue to be faced by decision-makers and the communities they represent. An enormous amount of research and investigation work is taking place in order that appropriate decision-making can be implemented through the planning and political processes. Steadily improving forecasting now being achieved at the regional and sub-regional scales will be of particular value alongside strategic coastal monitoring programmes (Parry, 2000; Foresight, 2004; McInnes *et al*., 2006, Channel Coast Observatory, 2014).

The climatic changes, predicted over the next century are expected to increase risks from coastal erosion in two ways. First, sea level is likely to rise by approximately 1m over the next 100 years, resulting in increased frequency of wave attack at the cliff base and more efficient debris removal from the foreshore as well as beach steepening. By the year 2050, the rise in mean sea level is predicted to increase the frequency of extreme High Water levels from once a century to, typically, once a decade.

Flood risk is determined not by the mean tide level but by the level of extreme tides that are caused by a combination of astronomical and meteorological events. Research is continuing to determine the rate of rise of these extreme tides, which identify the defence levels required. Since its establishment in England following the 1953 floods, the Storm Tide Warning Service has been developed to allow improved flood warnings and thereby reduce the risks to life from tidal floods. The key impacts of climate change are, therefore, rising sea levels, possible changes in wave direction and intensity and increases in rainfall with a predicted concentration in the winter, as well as a tendency for more unsettled weather patterns. It is necessary for those involved in coastal risk management to try and influence their own future ability to manage risks on the coast.

Clearly, the next 50-100 years are going to be challenging for those involved with managing the Channel – North Sea coasts. Considerable progress has been made at European, national and local levels but the response by politicians and practitioners varies. The implementation of sustainable policies for coastal risk reduction must involve solutions that are appropriate from a technical point of view as well as being justifiable economically and without detriment to the environment. An enormous amount of research is being undertaken by the European Commission, academic institutions, research centres, NGOs and those involved in central and

local government. The exchange of information and dissemination of results is a fundamental requirement to achieving successful management of the Channel-Southern North Sea coasts. This is being achieved at the European level through networking as part of the Interreg, LIFE Environment and VIIth Framework Programme projects as well as by the various administrative tiers in member states. All organisations that are receiving funding for coastal research have a responsibility to ensure that results of their studies are properly disseminated; this philosophy is a cornerstone for European Union funding programmes.

Figure 1.27.Storm surges create huge waves in Freshwater Bay on the Isle of Wight during storms in January 2014. Image courtesy Anna Mustchin.

1.5.1. Assessing the coastal hazards and risks

The natural hazards of erosion, landsliding, breaching and flooding have significant impacts along the Channel – Southern North Sea coastlines. The costs of emergency action, remediation and prevention can often represent a significant burden to the communities affected, often local authorities with limited resources as well as for the government. It is now accepted that the impacts of climate change on the coast are real and that sea level rise, in particular, poses serious risks to coastal communities in terms of increased rates of coastal erosion, an increased frequency of landsliding as a result of a wetter climate, accelerated toe erosion and increased sea flooding.

When these hazards interact with society, coastal risks arise. Risk-based decision-making is seen to provide the means of addressing the challenges put forward by climate change and sea level rise. Risk-based approaches allow an appreciation of the degree of risk reduction and the residual risk that must be borne by society or individuals after mitigation measures have been implemented. In order to identify the risks to assets, it is necessary, first, to establish the current level of risk, and then to gain an understanding of the potential increase in frequency and magnitude of hazardous events as a result of coastal climate change.

The varied geophysical and climatic characteristics of the four partner Member States make them susceptible to a range of extreme natural events. Natural hazards such as coastal erosion, flooding and instability are common features of their coastlines and have the potential to pose significant threats to the coastal communities. Operating on different timescales they present a varying degree of risk, coastal erosion being a relatively gradual process whilst flooding and

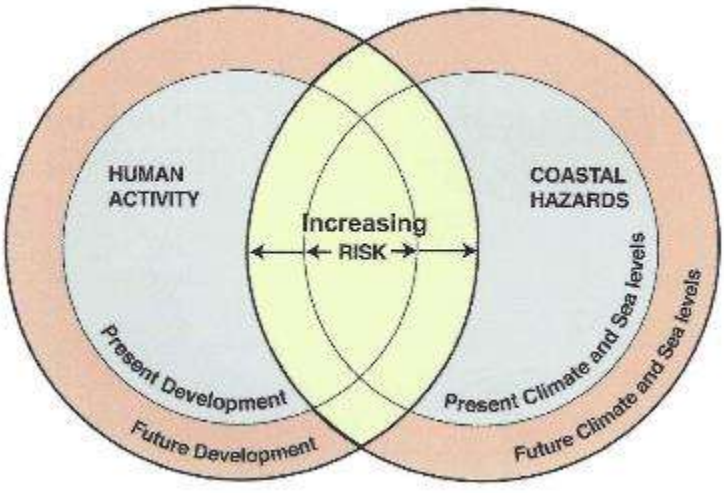
landsliding are more spontaneous, episodic events that may be relatively more difficult to predict and are potentially more costly to address as a result.

KEY TERMINOLOGY	
HAZARD	A threatening event, or the probability of occurrence of a potentially damaging phenomenon within a given time period or area.
MITIGATION	Actions that reduce the potential cause of an event e.g. reducing greenhouse gas emissions to help reduce the extent of climate change.
RESIDUAL RISK	The remaining risk after coastal management has taken place, i.e. unexpected events and highly severe flooding.
RISK	Expected loss (of lives, persons injured, property damaged and economic activity disrupted) due to a particular hazard for a given area and preference period. Based on mathematical calculations, risk is the product of hazard and vulnerability.
	Risk = Hazard x Potential Worth of Loss

Table 1.3. Key Terminology for Hazard and Risk.

1.5.1.1. Coastal Erosion Risk

Coastal erosion is a natural process that has helped to create the different landforms we see along the coast. The erosion process leads to change over long periods of time but may also promote more major landslide events or cliff failures through wave-induced undercutting and beach lowering. Sea level rise, as well as a predicted increase of frequency of extreme weather events, will have a significant impact on cliffs, slopes and beaches. The maintenance of beaches relies on the balance between the supply and removal of sediment. A rise in sea level, pushing the high water mark further up the beach, whilst more aggressive stronger waves and unpredictable weather events will increase the risks arising from beach change.



The concept of risk as the interaction of the human environment with the physical environment is illustrated. Only when the two systems are in conflict do hazards such as coastal erosion, landsliding and flooding become a threat to the community. Of particular importance is the fact that as urban development increases, intensifies or spreads into vulnerable areas so the potential impact of hazards also increases.

Figure 1.28. Coastal Hazards, Human Activity and Risk

Thus the hazard of coastal erosion will increase for coastal communities leading to:

- Risks to life, property, infrastructure and natural resources; and
- Destruction of natural or humanly formed-made defences, which, in turn, may result in retrogressive landsliding or flooding of the hinterland.

This highlights the importance of understanding the risks; identifying potential 'hotspots' and developing strategies that will inform land-use planning by ensuring decisions are compatible with specific local coastal conditions in the context of climate change (McInnes *et al.,* 2011).

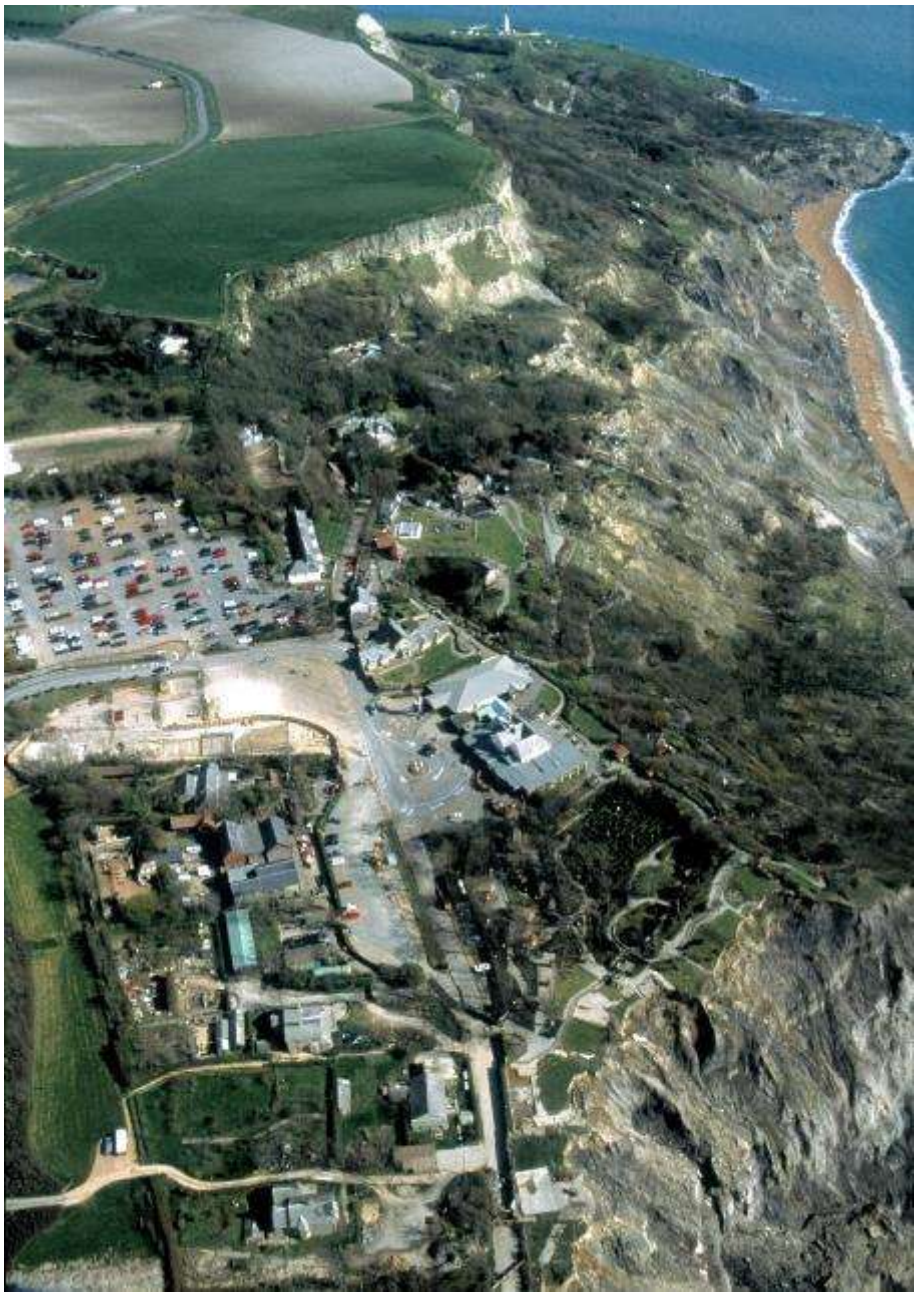


Figure 1.29. The village of Blackgang on the south west coast of the Isle of Wight, UK is attacked by south westerly storm waves. Erosion and instability problems have resulted in the loss of much of the village with the sea cliff retreating by over 300 metres in the last century. Image courtesy Andrew Butler

1.5.1.2. Landslide Risk

Over the last thirty years there has been a significant increase in landslide activity along the English and French Channel coasts, comprising both first-time failures as well as the reactivation of dormant landslides. These events have been promoted as a result of increased landslide toe erosion on the coast coinciding with increasing amounts of winter rainfall. In these locations ground instability poses significant risks to land use and anthropomorphic development. Landslide events have caused substantial damage and loss of property and assets, and problems have often arisen in the past because of the lack of co-ordination between land use planning and decisions over coastal defence and other strategies. Parts of the study area coasts have suffered from an inheritance of unplanned communities and developments built on eroding cliff tops and in other unsustainable locations – often, but not always, a result of nineteenth century development, or mass speculative development in the early twentieth century.

Whilst major landslide events inevitably lead to significant losses and damage to property in developed areas, minor, longer term failures can also have costly implications through disturbance of structures and damage. This again accentuates the importance of integrating natural hazard management into land-use development and planning policies, particularly as there are few mitigation measures that can be implemented to combat more major ground movement events that occur with little or no warning.

1.5.1.3. Saltmarshes

Coastal saltmarshes form the upper vegetated parts of intertidal mudflats, creating a 'living' buffer between land and sea and providing a valuable habitat for birds and invertebrate species. Saltmarshes are located in sheltered areas, regularly inundated by the sea between high water neap and high water spring tides. Saltmarsh systems are characterised by vegetation that shows distinct landward zonation from mudflat through to low or pioneer marsh, middle marsh, high or mature marsh and terrestrial vegetation. This succession is according to frequency of tidal inundation and species competition (Cope, S. in McInnes *et al*., 2011).

Figure 1.30. Newtown National Nature Reserve on the Isle of Wight, UK is at risk from inundation by the sea. This could lead to a loss of important inter-tidal saltmarsh and mudflat habitats. Image courtesy Andrew Butler

1.5.1.4. Erosion of Dune Coastlines

When dry intertidal sand is blown on or along with frequent, strong winds sand dunes develop. Sand becomes trapped around small objects such as strandline material, which eventually becomes vegetated, forming embryo dunes. As the embryo dunes increase in size they are less frequently covered by the tides, allowing more vegetation to colonise and in turn secure the system further. The survival of sand dune systems is very much dependent on a steady supply of sand and the ability of the vegetation to maintain ground cover whilst migrating inland with sea level rise. The extent of frontal dune erosion may increase over this century as a result of increased storminess and sea level rise, and this may have negative impacts on the extent of some dune habitats and the effectiveness of dune systems as flood defences (Pye *et al*., 2007).

Figure 1.31. Dune coast near Ijmuiden, Netherlands. Image courtesy: Shutterstock.

1.5.1.5. Barrier Beaches, Spits and Fringing Barrier Beaches

Barrier beaches are linear shingle features, attached to the coastline and backed by lowland or lagoons. Conversely, spit features are comprised of either shingle or sand, are attached to the coastline at their proximal end and are free standing at their distal end. Both systems offer a dissipative barrier against wave attack and often provide shelter to intertidal habitats. Barrier beaches and spits are dynamic features undergoing landward rollover through processes such as overtopping, overwashing and breaching. Where sediment input keeps pace with sea level rise the barriers will migrate onshore through landward rollover and spits will continue accumulating sediment at their distal ends. A continuous barrier beach, starved of sediment, will eventually be completely overwashed during a high storm or swell wave event or will breach to form two spits. Where sediment supply increases in time, these spits may re-seal to form a continuous barrier beach once again (Cope, S. in McInnes *et al*. 2011).

Figure 1.32. Hurst Spit, Hampshire, UK The Spit protects properties and rare saltmarsh habitats in the Solent between Hampshire and the Isle of Wight on the central south coast of England. Image courtesy Andrew Butler

1.5.1.6. Coastal Flooding

Coastal flooding, affecting villages, towns and cities along the Channel – Southern North Sea coastlines, can result from a combination of tide and surge levels that exceed the levels of sea walls but are more usually due to wave action in combination with high water levels. Near to the shore the maximum wave height is closely related to the water depth and the amount of wave run-up and overtopping is a function of the nature and configuration of the shoreline. Coastal defence infrastructure including sea walls, tidal barriers and related measures influence pathways and aim to control the impact that water flowing over defences or through breaches can have on the coastal floodplain. Sea walls often operate in combination with beach and foreshore management techniques such as beach recharge, groynes and breakwaters to control wave energy and improve the resilience of the coastal structures and limit wave overtopping.

Without suitable action it is expected that flood risk will increase to unacceptable levels affecting not just people and property but also businesses, hospitals and emergency services. The integration of flood risk into the planning and development process is one way of helping to reduce future costs for coastal communities in terms of economic, social and environmental losses.

Figure 1.33. The city of Portsmouth, Hampshire, one of Britain's great maritime ports, was developed on several low-lying islands. The city is densely populated and vulnerable to the impacts of climate change and sea level rise. Image courtesy Wight Light Gallery

1.5.2. Quantifying and Mitigating Risks

The risks resulting from natural hazards along the Channel – Southern North sea coastlines fall broadly into three categories: economic, social and environmental. The direct economic costs can be divided into two main categories:

- The costs of emergency provision and remediation in the occurrence of a hazardous event (most applicable to landsliding and flooding); and
- The financial costs of mitigation against the risks associated with natural hazards.

Economic costs are the greatest in financial terms and are perhaps the most important from the perspective of local authorities and other organisations responsible for managing coastal risks. However, there are also other 'indirect costs' such as insurance costs, depreciation of property or land values and legal actions.

The cost of an emergency response may include emergency coast protection works, evacuation, provision of temporary accommodation, and mobilisation of emergency and relief services, cost of investigations, transport delays and other interruptions. Mitigation is also very costly and involves research into coastal evolution, hazards and risks and the preparation of high-level plans and strategies to support the formulation of planning policies; the cost of coast protection schemes including design and construction, as well as the cost of coastal monitoring.

The **social** costs of natural hazards are largely intangible. Fatalities can be measured in real terms whilst health-related factors such as stress and depression, which may be related to risk, cannot be measured in the same way. Other factors that may impact upon the individual or society are largely related to inconvenience and are also difficult to measure.

Environmental costs are difficult to quantify because natural hazards promote natural coastal change. There is a wealth of ecologically important sites in coastal zones of the partner Member States and legislation requires the protection of these sites from erosion or flooding in order that they are maintained in a favourable condition. Environmental mitigation and, where possible, enhancement often results in significant additional costs for construction projects (McInnes *et al.,* 2011).

1.5.3. Coastal Research, Demonstration and Networking Projects

The important role played by the European Commission in encouraging the implementation of integrated coastal zone management has been highlighted earlier. Research, studies and investigations have been undertaken through projects receiving financial support from the Framework Programmes, the LIFE Environment Programme and the Interreg projects relevant to the Channel-Southern North Sea coasts include: 'Coastal change, Climate and Instability' (LIFE Environment, 1997-2000); 'Response – Responding to the Risks from Climate Change on the Coast' (LIFE Environment Programme 2003-2006); 'EMDI – Espace Manche Development' (Interreg, 2004-2007); 'DEDUCE – Développment Durable des Côtes Europeénnes' (Interreg, 2004-2007); 'CONSCIENCE – Concepts and Science for Coastal Management' (FP6, 2007-1020); 'C-SCOPE – Combining Sea and Coastal Planning in Europe' (Interreg, 2008-2014); 'CAMIS – Channel Arc-Manche Strategy' (Interreg, 2009-2013) and 'CC2150 – Coastal Communities 2150 and Beyond' (Interreg, 2010-2013).

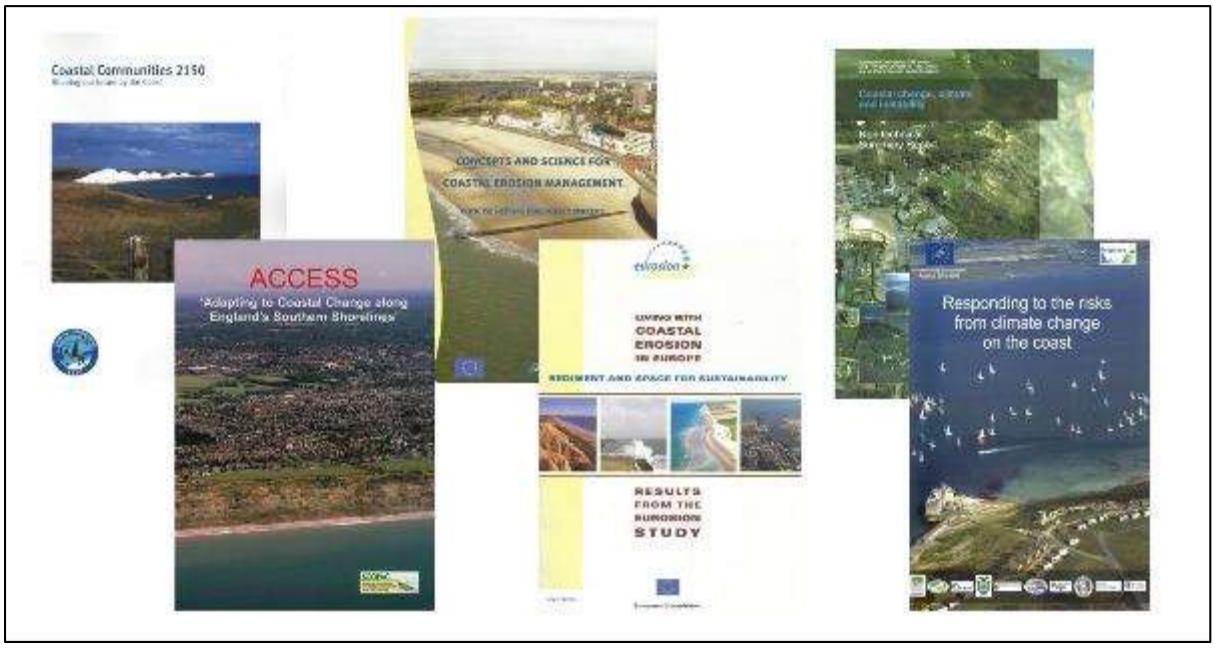


Figure 1.34. Some important studies that have provided valuable data and information on coastal hazards and risks.

Many of these projects have taken forward recommendations contained in the EU 'Recommendation on ICZM' (European Commission, 2002) and from the EUrosion project (DG Environment, 2004) and the more recent 'OURCOAST' project (DG Environment, 2009-2012). Coastal zone management has been developed actively in the four partner Member States bordering the Channel – Southern North Sea (England, France, Belgium and the Netherlands) in response to risks from coastal erosion, sea flooding and landsliding. Policies, management arrangements and research initiatives in the partner Member States are outlined briefly below.

1.5.4. Coastal Management: England

1.5.4.1. Coastal Risk Management

In response to the EU 'Recommendation on ICZM' the government published its 'Strategy for Promoting an Integrated Approach to the Management of Coastal Areas in England' in 2009 (Defra, 2009). This strategy has been implemented by Coastal Fora such as the Solent Forum

and the Dorset and Devon Coast Forums along the south coast of England. This ICZM framework policy document included within it the concept of 'coastal risk management'.

Policies concerning coastal risk management, instability and land-use planning developed at a national level are principally implemented at the level of local government or by the Environment Agency in England. Planning systems are designed to regulate the development and the use of land in the public interest. Such legislation usually aims to provide:

- Guidance, which will assist in planning the use of land in a sensible way and enable planning authorities to interpret the public interest wisely and consistently;
- An incentive, with local authorities stimulating development by the allocation of land in statutory plans; and
- Development control to ensure that development does not take place against the public interest and to allow people affected by development to have their views considered.

Since the mid-1980s, however, there has been a notable change in perception about the way in which coastal risk managements' problems are managed. These changes reflect a growing appreciation that the past approach was not in the public interest, namely that:

- Approval of developments in vulnerable areas can lead to demands for expensive publicly funded coastal defence works;
- There are possible adverse effects of development on the level of erosion or flood risk on adjacent coastal frontages;
- Coastal defence works can have a significant adverse effect on the interests of other users in the coastal zone; and
- Coastal defence works can encourage further development to take place in vulnerable areas, increasing the potential for greater losses when extreme events occur.

In addition to coastal erosion large parts of the coastline are vulnerable to the effects of coastal flooding. Flood defence policies usually aim to reduce the risk of flooding to people and the developed and natural environments by encouraging the provision of technically, environmentally and economically sound and sustainable measures. This objective can be achieved by:

- Encouraging the provision of an adequate and cost-effective flooding warning service;
- Encouraging the provision of adequate flood and coastal defence measures, which are economically, technically and environmentally sound and sustainable; and
- Discouraging inappropriate development in areas at risk from flooding.

In 2008 the Environment Agency was given by the government a *Strategic Overview* responsibility for the management of both flood and coastal erosion risks. The Agency works in close partnership with local authorities through the Coastal Groups to achieve sustainable coastal risk management involving:

- The preparation of 'Shoreline Management (coastal defence) Plans' to agree policies for management arrangements;
- Preparation of more detailed coastal defence strategy studies, particularly relating to sediment transport along the open coast, linked to estuarine studies, which identify the most appropriate and economically justifiable coastal defence option for each frontage taking account of all factors; and

- The undertaking of more specific local studies relating to the construction of a particular coastal defence scheme.

In England funding is made available by Defra to coastal protection authorities (who, together with the Environment Agency and Internal Drainage Boards, are known as Operating Authorities), through the Environment Agency, for schemes that are technically sound, environmentally acceptable, economically justifiable and cost-effective. A key feature of the powers is that they are permissive rather than mandatory; the coast protection authorities are not obliged to carry out the works. This clearly limits the role of the State to providing only defences that are deemed to be in the national interest. However, this subtle distinction can cause considerable public misunderstanding and frustration.

Through its Regional Flood and Coastal Committees (RFCCs) the Environment Agency implements flood and coastal defence policy. More recently, as part of the restructuring of coastal risk management nationally, the RFCCs now also assist delivery of the Environment Agency 'Strategic Overview' which includes coastal erosion as well as flood risk management. Local Authorities also have permissive powers to carry out flood risk management works and decisions are made through Coastal Defence Strategies as to who is best placed to manage any particular scheme.

1.5.4.2. Coastal Cells and Coastal Groups

Research commissioned by the government approximately 20 years ago suggested that the English coastline could be divided into major sediment cells; a sediment cell being defined as a length of coastline which is relatively self-contained as far as the movement of sand or shingle is concerned and where interruptions to such movements should not have a significant effect on adjacent sediment cells. The boundaries of the sediment cells generally coincide with the mouths of large estuaries or prominent headlands. These sediment cells form discrete units which broadly coincide with the establishment of seven strategic 'Coastal Groups' comprising local authorities, the Environment Agency and other interested organisations who have key roles in coastal risk management.

One of the first coastal groups to be established in England and perhaps the most influential is the 'Standing Conference on Problems Associated with the Coastline' (SCOPAC www.scopac.org.uk), which was founded in 1986. This group has played an important role in strategic coastal risk management in central southern England as an intermediary between the Environment Agency, central and local government as well as delivering a valuable sub-Regional research programme.

1.5.4.3. Shoreline Management

Shoreline Management Plans (SMPs) provide a large-scale assessment of the risks associated with coastal processes and allow the development of a policy framework to reduce these risks to people and the developed, historic and natural environments in a sustainable manner. In doing so, these 'high level' documents form an important contribution to the national strategy for flood and coastal erosion risk management. A key role for Coastal Groups has been encouraging the successful development and implementation of Shoreline Management Plans (SMPs) and the implementation of coastal risk management in practice.

Shoreline Management Plans – Aims and Objectives
AIM: A shoreline management plan should provide the basis for policies for a length of coast and set the framework for managing risks along the coastline in the future. OBJECTIVES: The objectives of an SMP need to be in line with the government's Strategy for managing risks from floods and coastal erosion (www.defra.gov.uk/environ/fcd/policy/strategy.htm) and should: • Set out the risks from flooding and erosion to people and the developed, historic and natural environment within the SMP area; • Identify opportunities to maintain and improve the environment by managing the risks from floods and coastal erosion; • Identify the preferred policies for managing risks from floods and erosion over the next century; • Identify the consequences of putting the preferred policies into practice; • Set out procedures for monitoring how effective these policies are; • Inform others so that future land use, planning and development of the shoreline takes account of the risks and the preferred policies; • Discourage inappropriate development in areas where the flood and erosion risks are high; and • Meet international and national nature conservation legislation and aim to achieve the biodiversity objectives.

Table 1.4. The aims and objectives of Shoreline Management Plans.

1.5.4.4. Monitoring Coastal Change

In England a 'Strategic Regional Coastal Monitoring Programme' commenced in 2002; an initiative involving thirty one Local Authority and Environment Agency partners in south east England. The programme, which is funded by the government, has now extended across England with the aim of providing a consistent, repeatable and cost-effective method of monitoring the coast to inform coastal risk management.

Large-scale coastal monitoring programmes such as this provide a systematic approach to collection, management and analysis of data for strategic and operational management of coastal erosion and flood risk. The programmes are risk-based and integrate the requirements of coastal local authorities with coastal defence responsibilities at both strategic and operational levels.

The need for better prediction of large-scale coastal evolution relates particularly to impending problems arising from sea level, rainfall and wave climate changes. Broad scale studies can provide information about mean shoreline trends and identify fluctuations from these trends but the ability to predict large-scale coastal evolution has been limited by the lack of long-term strategic coastal monitoring data. The inability to carry out robust assessments at broad scales has been criticised and has highlighted the need for a strategic approach to regional monitoring (Bradbury *et al*., 2007).

This strategic approach to coastal monitoring provides a basis for capturing the data required to make reliable assessments of processes and to predict future changes. The accuracy of predictions improves dramatically with an extended length of records and hence long-term data sets (ideally 20-30 years duration) are required, with data collected at a variety of spatial and temporal scales, to provide optimal decision-making. This aim lies behind the risk-based design of a national monitoring programme, providing a tiered framework of data collection and analysis that enables detailed information to be filtered and cascaded to a range of potential applications.

Figure 1.35. Coastal monitoring programmes provide valuable data to inform coastal risk management. Image courtesy Channel Coastal Observatory

1.5.4.5. Key English Coastal Research Projects 2000-2014

• **'The Investigation and Management of Soft Rock Cliffs'**: Prediction of recession rates and erosion control techniques (Ministry of Agriculture, Fisheries and Food (MAFF) Research and Development Programme, 1994-2001). The objectives of the research programme included the development of analytical methods of predicting cliff erosion rates for the wide variety of differing situations around the coast (Lee & Clark, 2002).

• **'FutureCoast'** (Defra R&D, 2000-2002): This was a regional-scale study of the whole coast of England and Wales designed to inform the approach used in the second round of Shoreline Management Plans (SMPs). FutureCoast provided a robust geomorphological framework for conceptualising coastal evolution. It included a 'cliff erosion database', which defined 'cliff behaviour units' and provided projections of potential erosion rates with or without coast protection measures in place (Halcrow, 2002).

• **European Union (EU) LIFE Environment Project 'RESPONSE'**: 'Responding to the risks from climate change on the coast' (Isle of Wight Centre for the Coastal Environment and partners, 2003-2006): The objective of this project was to develop sustainable strategies for local authorities and other stakeholders across the European Union to manage natural hazards in the coastal zone through demonstration of an innovative regional-scale methodology for coastal evolution studies and risk mapping, taking account of the impacts of climate change. Sustainable strategies for managing coastal and natural hazards inform land use development and planning by ensuring decisions are compatible with specific local coastal conditions and also future challenges (McInnes *et al*., 2006).

• **'Risk Assessment of Coastal Erosion – RACE'** (Defra Research & Development Programme, 2005-2008): The aim of the RACE project was to develop, test and disseminate a robust and consistent probabilistic method for assessing the hazard and risk of coastal erosion. The approach was supported by data and information from the FutureCoast cliff erosion database, monitoring programmes and risk-based inspections. The outputs represent hazard

and risk in a manner comparable with the RASP (Risk Assessment of flood and coastal defence for Strategic Planning) method used for flood risk assessment (Halcrow, 2006).

• **'National Coastal Erosion Risk Mapping - NCERM'** (Halcrow, 2010): NCERM maps erosion/instability around the coastline of England and Wales, taking account of the influence of current coastal defences and management policies. A key aspect of the work is capturing local knowledge and expert opinion using web-based mapping techniques to allow local operating authorities to verify, interrogate and amend input data and provide a live visualisation of the outputs generated. When it is completed, the project will complement NaFRA to provide a complete representation of flood and erosion risks along the coastlines of England and Wales.

• **ACCESS –** Adapting to Coastal Change Along England's Southern Shorelines (Coastal & Geotechnical Services, Halcrow & Channel Coast Observatory). This study commissioned by SCOPAC assessed the consequences of increasing coastal risks at study sites drawn from forty *Coastal Hotspots* along the coastline of central southern England. The report made recommendations on coastal data collection and management, asset valuations and dissemination procedures (McInnes et al. 2011).

1.5.5. Coastal Management: France

The French coastal zones bordering La Manche exhibit similar physical characteristics to those of the south coast of England, sharing also the similar challenges imposed by risks arising from coastal erosion and cliff retreat, landsliding and flooding, all of which are being exacerbated by the impacts of climate change and sea level rise. Over the last 20 years France has adopted a pro-active approach to the management of risks, taking on board the European Commission's 'Recommendations on Integrated Coastal Zone Management', as well as encouraging national research and 'bottom-up' initiatives at the local level.

The coastal zones bordering La Manche have seen progressive development since the eighteenth century in a similar way to the south coast of England, and the colonisation of the coast has been described in detail (Corbin, 1988). The development of the French Channel coast continued steadily and more recent studies (Debouldt, 2010) describe the rapid growth, which has increased considerably over the last 30 years. This issue of coastal development and its resulting impacts compared with that other EU Member States were investigated as part of the EUrosion project (European Commission, 2004).

Coastal communities on the French Channel coast face three particular natural hazards - retreat of the shoreline and coastal cliffs through erosion by the sea, coastal flooding, and changes in the patterns and extent of dune systems. Natural processes have been aggravated by human intervention; in particular public works projects on rivers have reduced the sedimentary contributions on the coast, whilst sand extraction from beaches and dunes has further depleted the supply of sediments. Port and harbour developments have, in some cases, interrupted the sedimentary transport processes along the coast, whilst further development, including seafronts, promenades and sea walls, have also had the effect of cutting off sediment supply in some locations. Although the EUrosion study (European Commission, 2004) found that a significant proportion of the French coastline remained in a state of equilibrium, erosion was occurring along 25% of the coastline, whilst only 10% was experiencing accretion.

1.5.5.1. Coastal Management

France embraced the concept of integrated coastal zone management (ICZM) during its meeting of the Inter-Ministerial Committee on the Sea in April 2003, where it announced its compliance with the Recommendation voted by the Council of Europe and the European

Parliament of May 2002 (European Commission, 2002). As part of the associated Demonstration Programme on ICZM a number of pilot sites experimented with ICZM including locations along the French coast of La Manche (the Côte d'Opale and the Rade de Brest). Over the next five years a process of implementation of coastal management initiatives at the regional and sub-regional levels continued. Later, in 2007, following a call for projects, French government grants were provided to assist coastal management projects at the Côte d'Opale, the Baie De Somme, the Seine Estuary and Le Havre, Havres De Coutances, the Baie of Mont St Michel, the Pays de Brest and the Rade de Brest. Altogether across France twenty-five ICZM projects were selected, most of which were initiated by groups of Communes or by a single Commune (Deboult *et al*., 2008).

1.5.5.2. Coastal Risk Management

In parallel with the wider policy work on ICZM more detailed consideration of the management of natural hazards had commenced in the early 1980s. In 1981 the position of Secretary of State for the Prevention of Natural Risks was created for the first time, and dialogue increased between the government and insurance companies particularly in relation to coastal territories. Natural disaster insurance (often known as 'Cat Nat') requires that such insurance is included as an obligatory extension of insurance for property damage, as well as loss of profits. This additional contribution, set at 6% on motor vehicle insurance and 12% for other properties, provided financial resources available to address insurance claims in the event of natural disasters.

The requirement for such an insurance system was demonstrated when disastrous coastal storms affected northern and western France on a number of occasions between 1982 and 2009. In particular, the storm event of December 1999 and the associated coastal flooding, affecting provinces including Pas-de-Calais and elsewhere, resulted in losses and damages amounting to 230 million Euros (Debouldt, 2010). The early 1980s saw the increased recognition of the need for policies for natural disaster prevention to be integrated with land use planning in coastal zones. Restrictions in urbanisation imposed through legislation such as the Law Littoral in 1986, following the establishment of the Conservatoire du Littoral (1975), with its aim of acquiring coastal land for environmental preservation and control urbanisation, represented further important steps.

As in England, the philosophy of aiming to control and physically stop coastal erosion through construction of sea walls, breakwaters and other forms of hard defence was gradually being replaced in France from the mid-1990s with the development of coastal risk management strategies. Risk strategies were developed based on an improved understanding of natural coastal processes and natural hazards. 'Natural Risk Exposure Plans' (PERs) created alongside the 'Cat Nat' insurance initiatives in the early 1980s evolved with the implementation of the Law Barnier in 1995, and the establishment of 'Plans for the Prevention of Risks' (PPRs), these remain today the main tool for the management of natural risks. The PPRs are planning documents attached to 'Local Zoning Plans' (PLUs) that regulate the use of land at the local level.

By 2007 270 coastal communities benefitted from approved PPRs being in place, and this represented 30% of coastal communities in France. The PPRs, supported by the Barnier Law, have provided a tool for the management of natural risks along the coastline of La Manche and elsewhere. The law makes the provision for the expropriation of properties and indemnification of affected residents where it is uneconomic or environmentally unacceptable to carry out coastal protection measures. An example of the implementation of this approach was in the village of Criel-sur-Mer in Upper Normandy, where, between 2004 and 2006, a row of coastal

properties at risk were demolished and the owners compensated, thereby allowing the coast to continue to retreat naturally.

Figure 1.36. Chalk cliffs at Criel-sur-Mer, Upper Normandy. The properties on the cliff edge were demolished and property owners compensated for their loss under the provisions of the Law Barnier. Image courtesy Robin McInnes

Figure 1.37. Vulnerable coastal villas at Mesnil-Val, Upper Normandy.Image courtesy BRGM

1.5.5.3. Coastal Research

Apart from the European Commission and French government funded studies and projects described above, coastal research has been undertaken by organisations such as IFREMER who, although having primary interest in the marine environment, have also been actively involved in the fields of sustainable development and integrated coastal zone management.

Elsewhere, funding through the European Union 6th Framework Programme allowed the creation and development of the European Encora network (www.encora.org).

The Conservatoire du Littoral, the French Geological Service BRGM and others have undertaken a range of research projects with financial support from the government and the European Commission, whilst networks of regional and local authorities have further developed coastal management through the LIFE Environment and Interreg programmes. Coastal management networks along the French Channel coast such as the Syndicate Mixte de Côte d'Opale and, more widely, the Arc Manche network have played influential roles in raising awareness and implementing sustainable coastal management on the French coast.

1.5.6. Coastal Management: Belgium

The Belgian coast extends for a distance of 67km from the nature reserve of Zwin in the north east bordering the Netherlands to Dunkirk and the Cote D'Opale of France to the south west. Most of the Belgian coast is low-lying with over 85% of its length below 5m. Approximately 60% of the coastline is relatively stable although 40% is eroding. Nearly two thirds of the coastline is protected by hard defences whilst the remainder is defended by soft engineering measures including beach replenishment, sand fences and Marram Grass. Behind the man-made coastal defences and beaches are developments as well as extensive low-lying polders, which are largely devoted to agriculture.

The coastline of Belgium is densely developed with hotels, holiday apartments and infrastructure to support the tourist industry and the economy more widely. Coastal defences are vital to protect these assets in the face of sea level rise and climate change impacts.

1.5.6.1. The History of Coastal Management

In Belgium coastal zone management is an activity in which all the administrative tiers of government have roles – national (Federal), regional (Flemish), Provincial and Local government. This has necessitated close collaboration in terms of developing coastal policies. Following its participation in the EU Demonstration Programme on ICZM (1996-1999) a 'Co-ordination Centre for Integrated Coastal Zone Management' was created in 2001 (www.west.viaaderen.be). In response to the 'Recommendation on ICZM' (European Commission, 2002) a 'National Belgian Report on the Implementation of 'Recommendation 2002/413/EC' was published jointly by North Sea & Oceans Steering Committee and the Co-ordination Centre (Co-ordination Centre, 2002); this report was updated subsequently for the European Commission to cover the period 2005-2010 (Coordination Centre West Flanders, 2010).

The report described the various initiatives and actions that had been implemented including the use of sustainability indicators to monitor the state of the coast, the establishment of a coastal forum, improved integration between the competent bodies in the field of ICZM, improving integration between the various policies and instruments, developing the concept of adaptive management and active participation in a range of research and demonstration projects (Coordination Centre for ICZM, West Flanders, 2010). The Centre continues to play a proactive role in coastal management at the European and national levels.

1.5.6.2. Flood Risk Management

The Belgian coastal plain and the Scheldt estuary are both threatened by sea level rise. Low-lying polders are most vulnerable to sea level rise where drainage off the land is a significant problem during rainy periods. Freshwater lenses developed within the coastal dune systems are also vulnerable to sea level rise, leading to the issue of saltwater intrusion (Lebbe et al. 2008).

Land at risk from flooding in Belgium comprises a zone up to 15km in width and is located on average 2m below annual storm surge level (Verwaest et al, 2009). Some sections of the coastal defences are at risk of breaching, for example between Nieuwpoort and Zeebrugge, where they are narrower, as well as in some of the harbours where overtopping may occur. Historically the most serious flood event on the Belgian coast was the 1953 storm, which also led to serious loss of life in the Netherlands and England. A failure of the present defences would have very serious consequences and a risk-based approach is adopted towards investment in flood and coastal defence.

1.5.6.3. Coastal Research

The vulnerability of the Belgian coast to flooding has necessitated an active programme of research that has been undertaken within universities, research institutions and by the Co-ordination Centre and others with financial support from EU funding. The Flanders Marine institute (VLIZ) was established in 1999 and has evolved into the central coordination and information platform for marine and coastal scientific research in Flanders. As a partner in various projects and networks VLIZ also promotes and supports the international face of Flemish marine science research and education (www.vliz.be).

In Belgium programmes including LIFE Environment/TERRA and Interreg, in particular, have supported research, demonstration projects and networking often addressing common challenges around the Channel – Southern North Sea region. These included the EU Demonstration Programme on ICZM (1998-2000), the SAIL and DEDUCE Interreg IIIC projects (2004-2007) (www.vliz.be/projects/SAIL and www.deduce.eu), which helped develop indicators for sustainable coastal management, the Interreg IIIB COREPOINT project (2004-2008 corepoint.ucc.ie), which aimed to orientate coastal research towards problem solving at the local level, and the Interreg IVB IMCORE project (2008-2011 www.imcore.eu), which investigated issues surrounding the management of coastal change.

1.5.7. Coastal Management: The Netherlands

The Netherlands is situated on the delta of three of Europe's largest rivers - the Rhine, the Meuse and the Scheldt, that discharge into a shallow regional sea - the North Sea. Without flood defences more than half of the area of the country would be flooded. The Netherlands is threatened from one side by storms that can generate huge surges, due to the shallow sea and the funnel shaped geometry of the Southern North Sea, and from the other side by river flooding (De Ronde *et al.*, 2003).

Coastal erosion is a continuous process along parts of the sandy shorelines of the Netherlands. Since 1990 policies have been put in place with the objective of controlling erosion through beach nourishment. This approach has proven effective in terms of retaining the coastline at its 1990 position, however, there is increasing concern with regard to the availability of essential sediment reserves in deeper water particularly in view of sea level rise, increased offshore dredging and the construction of new harbours.

The south-east section of the North Sea coast consists of straight sandy beaches with large-scale tidal inlets. Long stretches of the coast have dunes that prevent the low-lying hinterland, which in many places is below sea level, from being regularly flooded. Where dunes are absent, defences have been constructed as a flood defence measure.

1.5.7.1. The History of Flood Risk Management

The 1953 big storm caused a flooding disaster that resulted in enormous damage and led to nearly 2,000 deaths in the Netherlands. In 1995 fluvial flooding was so serious that flood

defences could no longer be guaranteed and 200,000 people together with many millions of animals were evacuated. Following these events, flood safety standards were developed and, in 1996, a new Flood Protection Bill including a five-yearly inspection of all flood defence structures and dunes was implemented.

The coastline of the Netherlands, including all the estuaries, has a total length of approximately 1,000km. The coastal frontage directly facing the North Sea is about 350km long, of which 75% consists of dunes, ranging from less than 100m up to several kilometres in width. The primary function of the coast is, therefore, to protect the low-lying hinterland from flooding.

Although a new policy for coastal defence of the Netherlands dune coasts commenced in the 1980s, it was in 1990 that the Dutch Parliament decided to adopt a new policy called 'Dynamic Preservation of the Coastline' in order to stop further retreat of the coast, meaning that the entire coastline would be maintained at its 1990 position. Further erosion would be reduced or prevented by beach nourishment. Sand nourishment has been a common measure to combat coastal erosion in the Netherlands since the end of the 1970s. When a nourishment project is carried out, sand excavated from the bottom of the North Sea (outside the -20m depth contour), is added to the near shore zone (De Ronde *et al*., 2003).

The strategic objective of the 'Dynamic Preservation' policy was to implement a sustainable safety level and preservation of values and functions in the dune area. This objective was translated into the tactical objective to maintain the coastline at its 1990 position. The National Spatial Strategy (2004) reaffirmed the strategic objective of the large-scale coastal policy in the Netherlands, rephrasing is as, "to guarantee safety against flooding and to preserve spatial quality of the coastal zone" (Waterhout, 2008). As an additional large-scale tactical objective, the Strategy defined the preservation and improvement of the 'Coastal Foundation': the area between dunes and the -20m depth contour. The 'Coastal Foundation' is a new large-scale coastal state indicator acknowledging sand as 'the carrier of all functions'.

Since the thirteenth century the 'Water Boards' held the responsibility for the maintenance of the flood defence systems and the management of water levels. These Water Boards are, in fact, the oldest democratic institutions in the Netherlands. The contribution that citizens have to pay to a Water Board was, and is today, related to the value of their property. The Water Boards also regulate the water levels in the polders. In the first half of the twentieth century there were more than 2,500 Water Boards but over the years this number has been reduced significantly and there are currently about 85 Water Boards left. A further reduction is likely as part of efforts to create strong unitary authorities.

In 1798, the institution Rijkswaterstaat was founded to give national guidance on water management, as it has been recognised that certain aspects could be better addressed at a national level. Rijkswaterstaat is the executive body of the Dutch Ministry of Transport, Public Works and Water Management (De Ronde *et al.*, 2003). The Minister is responsible to Parliament (States General) for all aspects of flood defence and water management. The twelve Dutch provinces form the link between the central government and the local authorities fulfilling important roles in the fields of spatial planning, regional, environmental policy and integrated water management policy.

Management relationships are also clearly visible in the event of high water conditions; wherever possible the responsibilities rest with local authorities. Water Boards judge the strength of the defences, municipalities carry responsibilities for the safety of citizens and

provide public information; and if necessary the regional co-ordination is handled by the Province. Only in very special situations is co-ordination transferred to a national level.

Sand dunes and other coastal defences protect those parts of the Netherlands that are situated below sea level. The design levels of these flood defence structures are related to extreme storm surge water levels (which are related to the frequency of occurrence extreme storm events). Dunes and defences along the coasts of the provinces of Noord-Holland and Zuid-Holland are designed to withstand the effects of a storm that has a probability of occurrence of once per 10,000 years. This roughly corresponds to a storm surge level of +5m Dutch Ordnance Level. For the less populated parts along the Dutch coast, such as the province of Zeeland and the Wadden Islands, the design level is based on the frequency of occurrence of an extreme storm event of once every 4,000 years and once per 2,000 years respectively. The risk of coastal flooding is expected to increase in the future, because the probability of occurrence of flooding and the socio-economic values in the coastal zones are both expected to increase.

Without management interventions, the erosion lines would continue to advance in a landward direction due to sea level rise. In addition, relative sea level will also rise without climate change-related sea level rise due to the post-glacial subsidence of the North Sea basin. Climate change may lead to more frequent and more intense storm conditions, which could reduce the effectiveness of the dunes as flood defences. It is, therefore, of great importance to gain an improved understanding of how different people and coastal economies can adapt in the long-term (de Ruig, 1998).

1.5.7.2. Research

The Netherlands Centre for Coastal Research (NCK) is a co-operation of Dutch universities and institutes engaged in coastal research and management. Founded in 1991, the NCK aims at increasing the quality of coastal research in the Netherlands, enhancing the exchange of knowledge to the applied research community, reinforcing coastal research and education capacities at Dutch universities and strengthening the position of Dutch coastal research in a United Europe and beyond.

NCK research (interaction) is concentrated in five themes, Seabed and Shelf, Beach and Coast, Tidal Inlet Systems and Estuaries, Sand and Mud and finally Hydrodynamics. Added value is realised by carrying out joint research programmes in the Netherlands, as well as abroad, through exchange of senior research staff between partners and via dissemination of knowledge during dedicated meetings as well as the annual NCK days.

NCK activities have contributed importantly to the establishment of strong relationships between research and management groups of various NCK partners. This has actively stimulated the development of in-depth knowledge through interaction of key specialists from different backgrounds, facilitating a multi-disciplinary approach towards coastal problems and improved links between specialist knowledge and end-user interests.

1.6. Summary

Past coastal planning regimes have suffered from a poor understanding of the ongoing processes and natural trends that are shaping our coastal zone. Consequently, many coastal settlements are becoming vulnerable as the frequency of coastal erosion, flooding and coastal instability events increase, and the relationship between the land and sea evolves.

In prehistoric times the Channel did not exist but it was an area of low lying land used by early humans. Archaeological traces left in the landscape are common across the region, showing how people adapted to coastal change and a rising sea level. Later historical development includes comparable maritime coastal infrastructure and coastal industries that are represented in the archaeological and artistic record. The evidence can provide high resolution data on coastal change spanning thousands of years. This contribution to our understanding of coastal evolution enhances our appreciation of past change and provides tools to help predict future impacts on coastal communities.

The Arch-Manche project has sought to advance our understanding of the scale and rate of long-term coastal change by addressing sources including archaeology, palaeoenvironmental data, works of art, maps, photographs, as well as historical literature accounts. A unique aspect of this project is the combination of data sources to extract maximum amounts of information. By characterising areas of long-term erosion, coastlines under ongoing stress can be identified. Some areas subject to human intervention have been stabilised while others have not and the effect of hard defenses in one area can have a knock-on impact elsewhere. Long-term assessments over broad areas are necessary to recognise cumulative consequences, while an understanding of long-term coastal responses can provide continuity to help predict future trends.

The next section will look at the methodology used in the project for assessing these various data sources, this will be followed by detailed case study reports, analysis, conclusions and recommendations.

Complimenting this technical report is a non-technical guide, *'Coastal Management: A guide to using archaeological, palaeoenvironmental, historical and artistic resources'*. Click here to download a copy in English, or here for a copy in French, hard copies are also available from the Maritime Archaeology Trust. The project results are also available through our interactive portal www.archmanche-geoportal.eu.