Interreg

EUROPEAN UNION

2 Seas Mers Zeeën

European Regional Development Fund

SARCC

Oostende Pilot Study: Report in Support of the Maritime Atlas

Report in Support of Maritime Atlas

PILOT STUDY: Oostende

Contents

1. Introduction/ Summary

The Oostende scheme to create planted dunes is one of seven pilot sites within the SARCC project that are developing Nature Based Solutions to coastal management in urban settings along the 2Seas coasts. Full details of the Oostende scheme are provided on the SARCC Website: https://www.sarcc.eu/pilots/ostend

This report concentrates on presenting details in support of the Maritime Atlas which considers how data from archaeology, paleoenvironmental material, historical sources, art, charts, maps and photographs can provide vital information on long term coastal change. This, in combination with datasets on storms, flooding patterns and sea-level changes, ensures schemes incorporating Nature Based Solutions for coastal management have the full benefit of hindsight when planning for future changes.

Humans have interacted with the environment and landscape for thousands of years during which time the coastline has changed and evolved. The coast has been attractive for human use due to a wide range of social and economic reasons which include trade and defence, and in the last few centuries tourism and leisure activities. The resulting construction of settlements which have grown into urban centres and conurbations and their shoreside harbours, facilities and buildings have then required the establishment of coastal defences to prevent flooding and damage.

This report introduces the pilot area with Section 1 providing data on geomorphology, coastal processes and environmental impacts. The results of the archaeological and palaeoenvironmental study and scoring are then presented (Section 2), followed by the maps and charts (Section 3) and then the pictorial resources – art and historic photographs (Section 4). The analysis of these results in combination as applied to a number of areas along the Oostende frontage then demonstrate the scale and rate of coastal change and are presented in Section 5.

1.1 Introduction to Pilot Study Area

The Oostende case study area is located in the central Belgian coastal region, between Oostende and Middelkerke (Figure 1). The Belgian coast is largely marked by a rigid coastline, consisting of a small strip of beaches, directly bordered by human reinforcements, sometimes intersected by dune sections. This rigid coastline only came into existence after the Early Middle Ages, due to human embankment activities. In the Holocene pre-medieval period, the coastline was characterised by barrier beaches with tidal flats extending landward. The present beach of Raversijde a little to the SW of Oostende, is a low lying, slightly seaward sloping intertidal area. Since the 19th century, many archeological traces and structures have been found, almost all being located in the intertidal zone (Pieters et al., 2013).

The SARCC pilot project is situated at the shore of Oostende in an area where there are no buildings along the beach and seawall. Despite the absence of buildings along this stretch of coast, the area has an urban character due to the presence of the coastal road, the tramline and the seawall with cycling path and walkway.

In the pilot area the excessive sand transport caused by heavy winds lead to a lot of problems for the use of adjacent infrastructure, such as the walk and cycle paths, the tramway and the coastal road. Several times a year, sandy hills are formed that make the use of the road and tramway too dangerous, forcing them to be closed. Cleaning up the sand requires a lot of effort, is costly and takes time. Furthermore, the sand that is being cleaned up can't be used to nourish the beaches, shore face or dunes because there is a risk that it has been polluted by the road or the tramway.

That is why the City of Oostende and the Coastal Division are working together in this pilot by creating a natural landscape with planted dunes along the seawall. This should lead to an ecosystem that keeps the sand on the beach instead of it reaching the tramway and the road. The natural dynamics of waves and wind will allow a dune landscape enough space to develop.

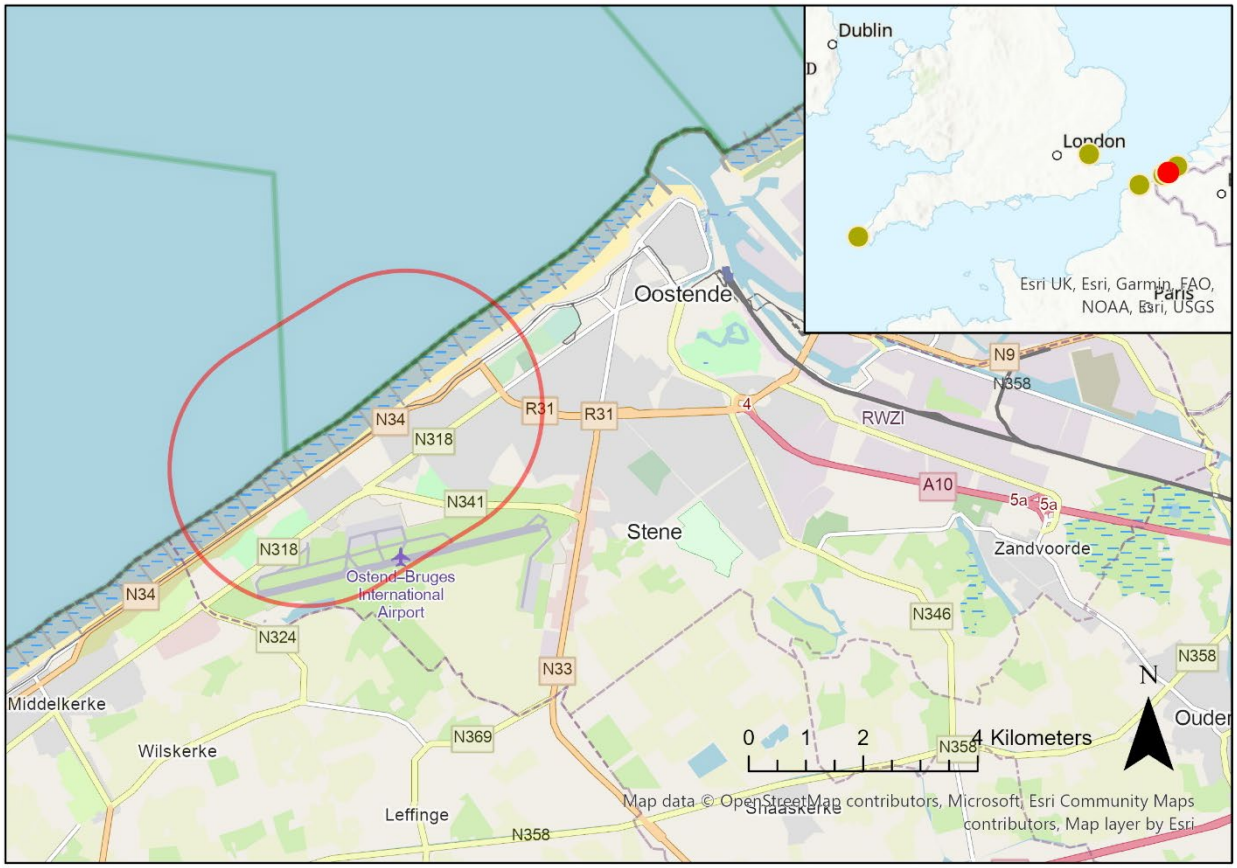

Figure 1: The location of the Oostende Pilot Study area, inset map shows Oostende(red) and the other SARCC Pilot Sites (green).

1.2 Geology, Geomorphology and Topography of the Pilot Area

Understanding the geology which underlies and influences the form of the coast and the geomorphological processes that have, and continue to, play a part in shaping the coast is important for providing context to the human use of the area and its long-durée. The summary presented below draws on previous work undertaken as part of the Arch-Manche project (https://archmanche.maritimearchaeologytrust.org/) with additional detail in relation to Oostende. Similar background information is also presented in the SARCC case study reports for Blankenberg and Middelkerke as they share comparative geology and geomorphology.

The pre-Holocene evolution of the Belgian coastal plain is highly intertwined with 4 major palaeovalleys: the IJzer, Oostende, Coastal and Flemish valley. An overview map of these valley systems and the surrounding top-Pleistocene (i.e pre-Quaternary or top-Paleogene) surface of the Belgian continental shelf and coastal area is shown in Figure 2, with the position of the Oostende pilot area being indicated by the red circle in the centre.

The shallow sediments of the study area are made up of a highly variable (laterally and vertically) sequence of sand, peat, silt and clay layers that reflect the complex history of the Holocene during which marsh-like environments, sandy dunes, and intertidal mud- and sandflats alternated.

At that time the North Sea was dry land and large rivers incised the landscape. Gradually, river sediments were deposited in the valley. When temperatures started to rise at the end of the Saale ice age, the permafrost melted and the river started to incise even further. During the warmer Eem period (ca. 130,000 - 116,000 yrs BP) sea level rose again and the Oostende valley transformed into a tidally influenced estuarine area. It is then that it obtained its typical funnel shape.

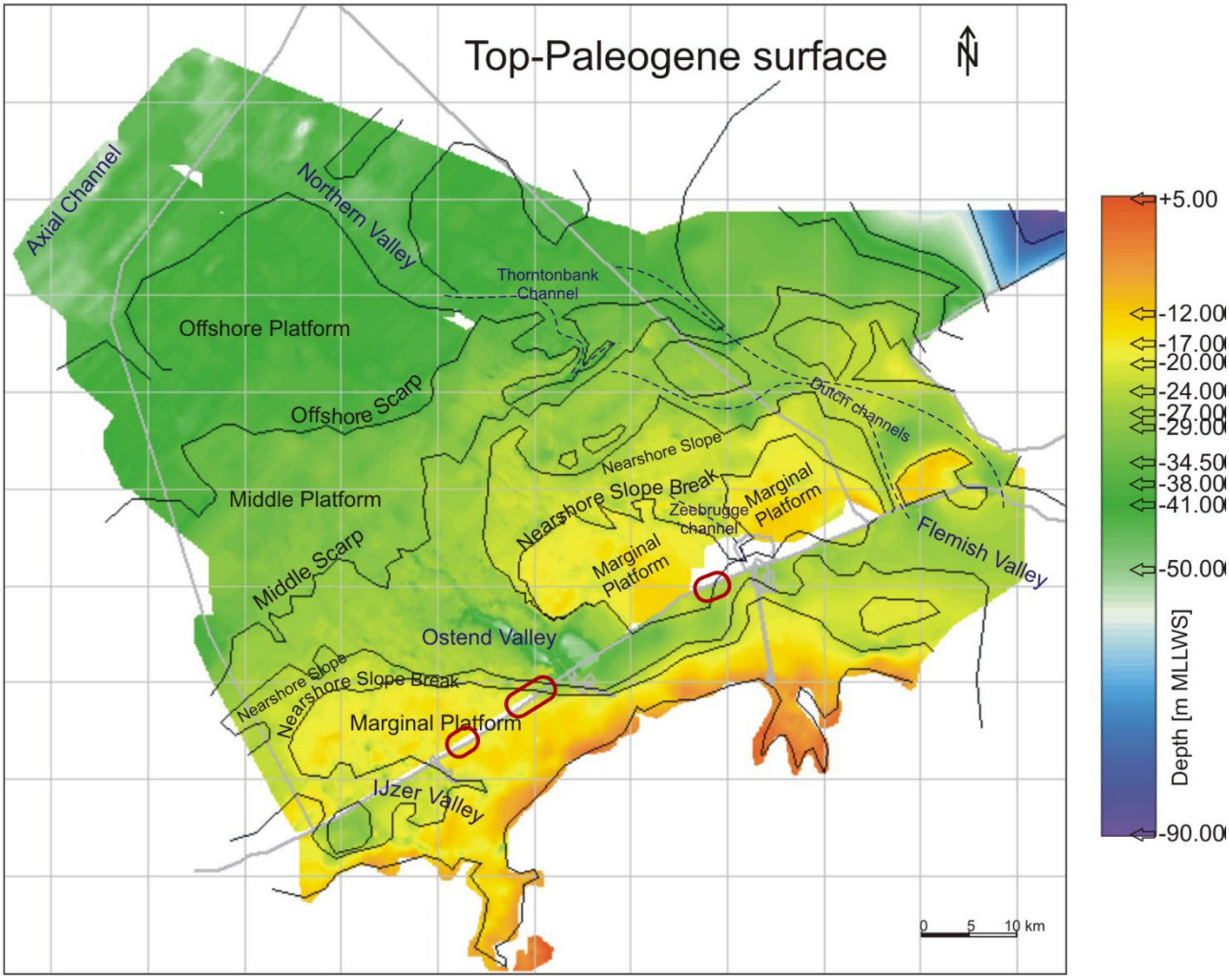

Figure 2: Belgian coast showing major palaeovalleys (the three Belgian SARCC case study sites are indicated in red).

During the Early Holocene sea level rose very fast and a large part of the Belgian continental shelf was already inundated. A large coastal plain came into existence, roughly 20-30 km offshore from the present coastline (see Figure 3). Because of the increasing wave action a large dune barrier system developed in front of the coastal plain. Behind the dune barrier, the coastal plain most likely consisted of a large (inter)tidal flat environment marked by constantly changing tidal channels, tidal flats and marshes. The landward part was most likely cut my numerous rivers that flowed towards the sea. Together with sea level rise also the groundwater level started to rise, and coastal peatland started to develop for the first time (so-called 'basal peat') (Baeteman, 2013) (see Figure 4 for a tentative reconstruction of changes to the coastal morphology over time).

Over the next 2000 years, sea level kept on rising fast and the coastline shifted further towards the land (green line in Figure 4). This caused considerable infilling of the tidal gullies with marine sand and clay. In the western part the sea intruded far inland. Around 7,000 yrs BP sea level rise started to slow down and the dune barrier system stabilised. This finally resulted in rising of the intertidal area to a level that prevented frequent flooding. For the second time, a fresh water marsh developed and peat growth was started (so-called 'surface peat') (Figure 4) (Baeteman, 2013; Mathys, 2009).

Around 5500 BP sea level rise slowed down even further, causing a constant accumulation and growth of peat. An extensive coastal marsh, characterised by reed vegetation, started to cover almost the entire coastal plain (Figure 4:c).

The process was replicated along the Belgium coast, where by the middle of the 2nd millennium BC, modelling by De Clercq shows how the land at the mouth of the Oostende valley extended further out to sea when compared with the contemporary coastline, while, coastal peat marsh stretched almost 20km inland (Ervynck et al 1999; De Clercq et al 2013; Baeteman 2013). Progradation of the coastal zone in the region continued until the end of the first millennia BC when a stable equilibrium might then have been established if it were not for human influence.

Over the next 2000 years peat growth expanded over a vast area. Around 2,500 yrs BP peat growth started to slow down. Tidal channels cutting through the marsh were now becoming eroded by enlarged precipitation run off from the hinterland (due to climate change and deforestation). At the fringes of the tidal channels, the peat eroded completely, causing drainage of the peat layer and subsequent lowering of the surface (ca. 1 to 1.5 meters). Due to this compaction, the fresh water marsh was converted to an intertidal area again. By 1,500 BP the peat growth comes to a definitive halt (Baeteman, 2013).

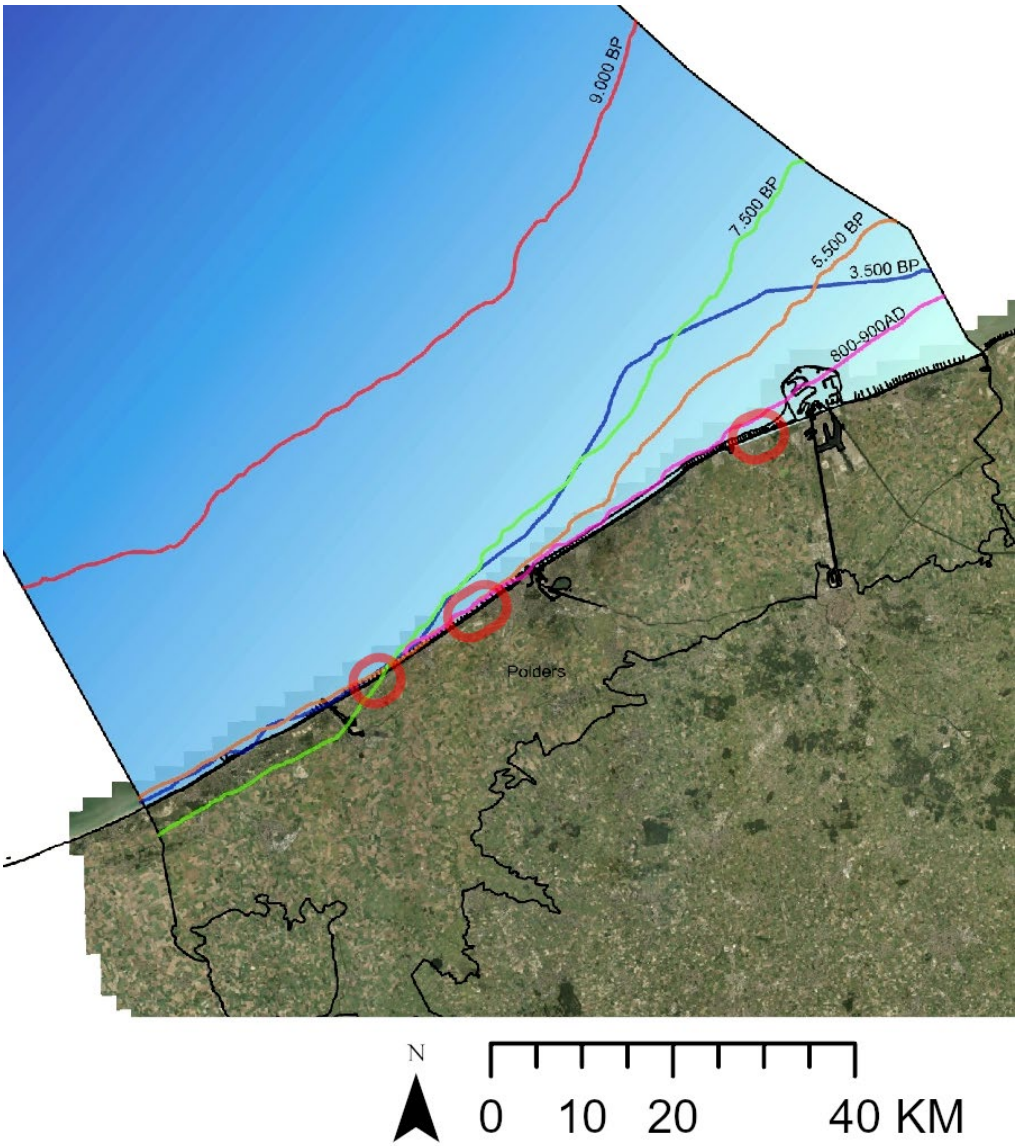

Figure 1: Schematic evolution of the Belgian coastline during the Holocene (De Clercq, 2013, after: Mathys, 2009). The red circles mark the position of the SARCC pilot areas.

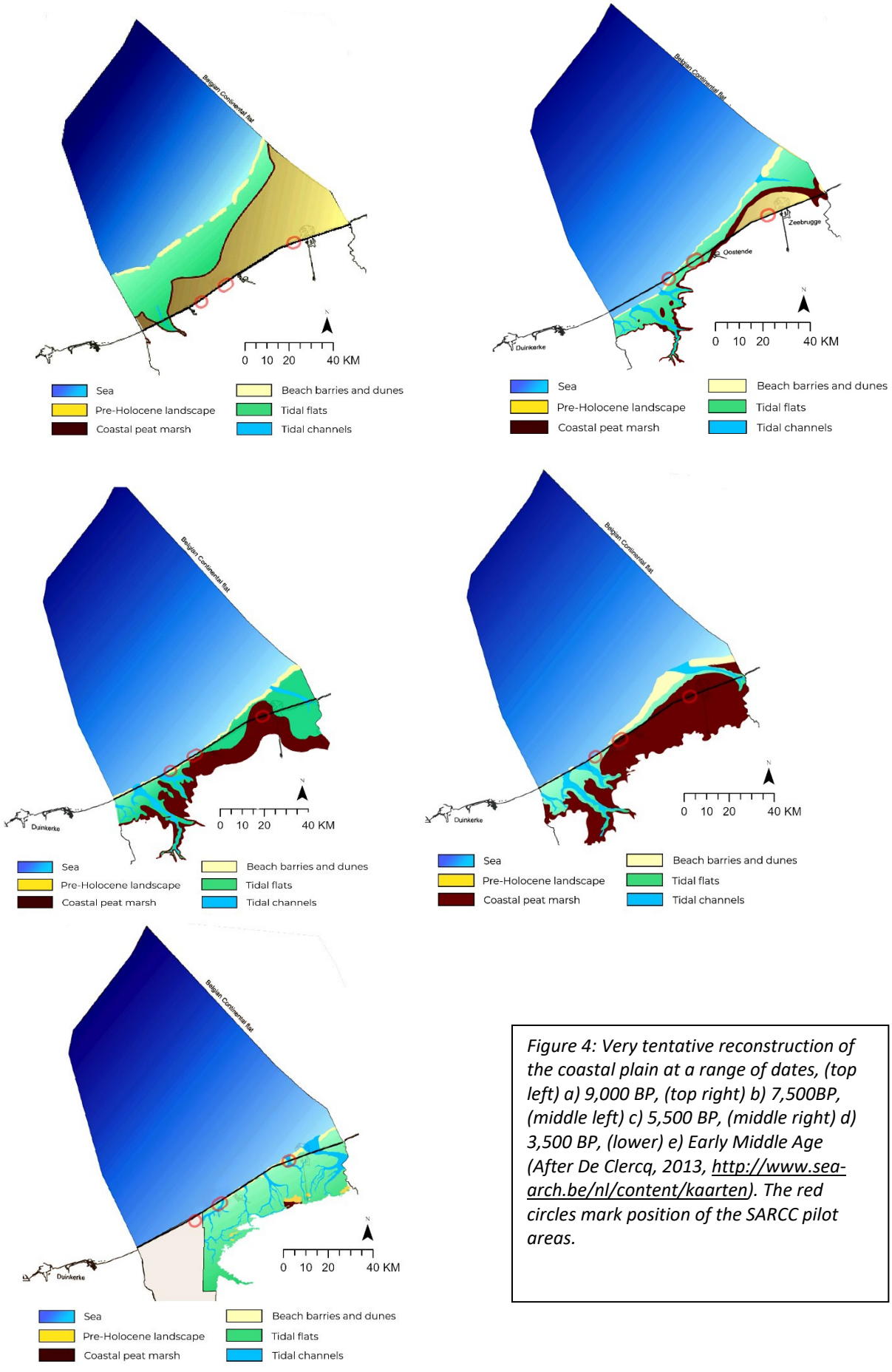

Figure 4: Very tentative reconstruction of the coastal plain at a range of dates, (top left) a) 9,000 BP, (top right) b) 7,500BP, (middle left) c) 5,500 BP, (middle right) d) 3,500 BP, (lower) e) Early Middle Age (After De Clercq, 2013, http://www.sea-arch.be/nl/content/kaarten). The red circles mark position of the SARCC pilot areas.

During the Iron Age and Roman era the sea was located a few miles offshore from today's coastline and an area of sandy dunes formed the border between sea and land. The area behind the dunes was marsh-like and crossed by numerous creeks and tidal gullies.

From the Roman period onwards the coastal plain noticed a growing human influence. Drainage and peat extraction further caused the surface to be lowered. After the Roman period the sea slowly progressed more inland, and a tidal flat was again installed in almost the entire coastal plain (Baeteman, 2013). It has been suggested that this increased tidal activity was possibly the result of increasing neglect of the water management systems during the late Roman period (Ervynck et al., 1999).

Although coastal changes have been more stable from the Early Middle Age, from Figure 4:e, it is clear to see that Oostende is situated in an area that continues to be influenced by a tidal channel. Evidence of human occupation and use of the coast helps understand these changes at a micro scale as it can reveal the specific topographic and environmental conditions at a particular time, which can be attributed through scientific dating techniques.

1.3 Storms and Flooding Patterns

The relationship of humans to the coastline and their use of the area, whether as seasonal areas, or for more permanent occupation and building is influenced and impacted by storms and flooding patterns. A review of patterns of these over time from known historical sources provides a useful background to understanding the impacts on human populations and damage to associated structures, and on the coastline morphology.

Oostende is situated in a low-lying coastal basin plain. Flooding along the Flanders coast is commonly caused by storm surges, the result of storm winds above the North Sea, or by the overwhelming of its dense network of rivers following periods of heavy and prolonged rain. Between 200-650 AD, three periods of marine transgression (see Figure 5) made large parts of the low countries uninhabitable. The worst, Dunkirk II 350-700 AD, submerged northern France, Belgium, the Netherlands and parts of Denmark. Evidence from soil surveys together with the lack of archaeological artefacts suggests that these areas were underwater between the mid-third-century and c.1050.

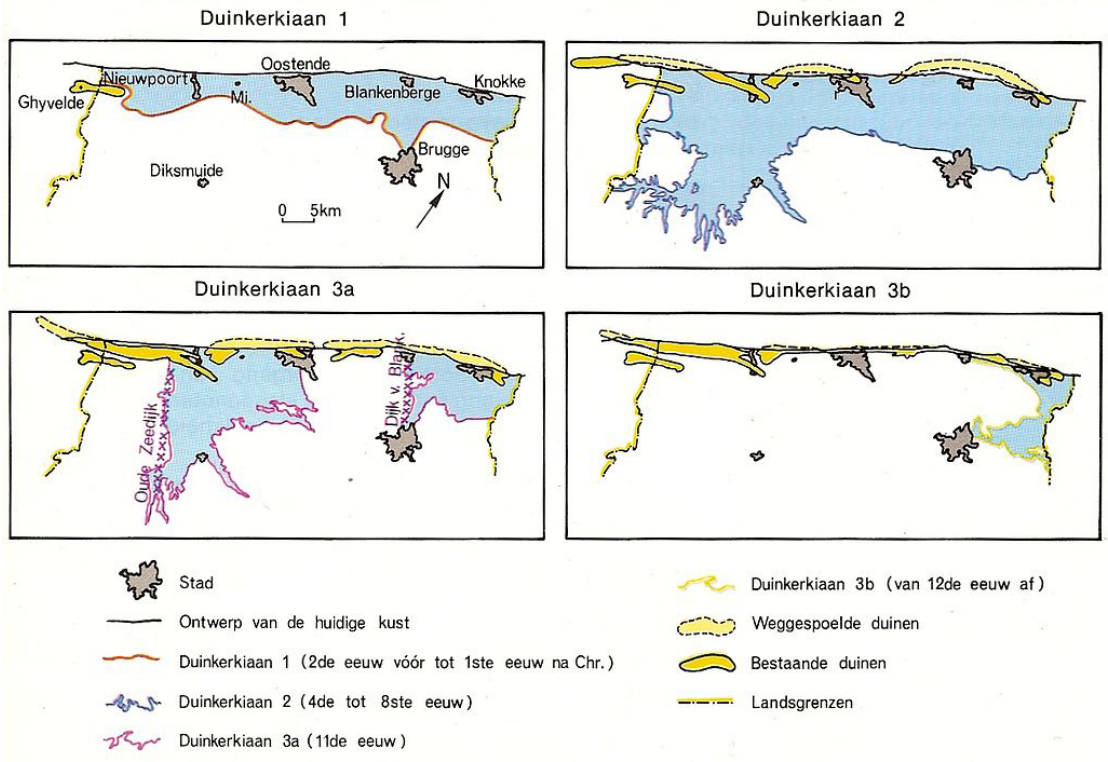

Figure 5: The three phases of Marine Transgression by J. Amerijckx en F. Depuydt - Fysische Bouwstenen voor de mens, Taken Aardrijkskunde 5, CC BY 3.0 nl, Source: https://commons.wikimedia.org/w/index.php?curid=5078044

The following significant storms and flood events in Flanders have been recorded:

- 1334 the St Clemens flood on the 23rd November struck the coasts of Flanders, Netherlands, Zeeland, Holland and England.
- 1362 the Second St Marks Flood or First Great Mandränke (great drowning of people) took place from January 15 to 16, 1362, the day of St. Marcellus. (The first St. Mark's flood took place in 1219). All countries adjoining the North Sea were affected.
- A storm in 1374 and two in October and November 1375 again caused widespread flooding in Flanders and Zeeland.
- 1394 the St Vincentius storm surge destroyed many settlements along the Flanders coast, including Oostende, Middlekerke, and Walraversijde.
- Three catastrophic storm events were recorded in the early 15th century. All occurring on St Elisabeth's day, the 19th November 1404, 1421 and 1424. Each lasted around 36 hours and caused wide-spread flooding in large parts of Flanders, Zeeland and Holland. The 1421 floods are ranked 20th in the list of the worst floods in history. Many lives were lost as villages were washed away.
- The weather during the 16th century was particularly stormy. At least seven storm surges were recorded: 1509, 1511, 1530,1532, 1552, 1570, 1594.
- 1570 All Saints Flood (1st November) - Despite the first ever flood warning being issued, little could be done to prevent the national disaster caused by the All Saints Day flood on the 1st November, 1570. The collapse of numerous dikes resulted in flooding of the entire coast between Flanders and Groningen, up to the northwest of Germany. The Duke of Alva informed King Phillip II that 'no less than five sixths of Holland were underwater'. Thousands of people died, tens of thousands were left homeless and livestock and winter supplies were destroyed.
- 1682 the Storm Flood of 1682, the result of a spring tide and a north-westerly storm combined, resulted in flooding in Flanders and the South Western Netherlands.
- 1703 the Great Storm, the famous windstorm which began on the 26th November and was recorded by William Defoe, caused flooding and destruction throughout Belgium, Netherlands, Germany, Denmark and UK.
- In 1714, three storms in quick succession 26th February, and the 2nd and 7th March, caused damage and flooding along the coast of Flanders and Zeeland.
- 1715, 3rd March, a major storm surge hit the same area causing widespread flooding, one of the severest storm surges of the 18th century.
- 1808, 15th January, a storm surge combined with a severe gale hit the Flanders– Zeeland area, causing flooding in many areas.
- 1906 a large storm surge on the 12th March caused considerable damage in Flanders and Zeeland.
- 1953 the North Sea Flood. A storm on the 31st January combined with high spring tides, developed along the coasts of the UK, Belgium and the Netherlands.

In recent decades the frequency of flooding in Belgium has increased. Major floods occurred in 1995, 1998, 2002, 2003, 2005, 2007, 2013, 2016 and 2021.

- 2007 the North Sea flood of the 8th November 2007 was caused by the remnants of Hurricane Noel combining with a storm surge, affecting the coastlines of northern and western Europe.
- 2016 in late May and early June 2016 flooding began after several days of heavy rain in Europe. In Belgium four days of torrential rain caused the rivers to flood.
- 2010 in November, Belgium experienced its worst flooding and mudslides in fifty years as extratropical Cyclone Carmen hit.
- 2013 a storm caused major damage to the beaches and flooding in the port, many houses were flooded as the drainage systems could not cope.
- 2021 12-15th July intense and prolonged rainfall across Europe caused several major rivers to burst their banks, causing much destruction and loss of life. On this occasion, the coast was relatively unaffected as the flooding was inland.

1.4 Current Environmental Impacts/ Threats & Management Approaches

The Belgian coast is one of the regions directly impacted by climate change. The sea defense is formed by only a small strip of land, which is, in most areas, strengthened by sea dikes and other 'hard' structures, leaving little space for natural responses to instances of storms or sea level rise. The Flemish government is aware of these threats and in the early 1970's breakwaters were constructed at regular intervals along the coast to protect the beach from erosion.

The Flemish Government approved the Master Plan for Coastal Safety in June 2011. That proposes a series of measures to protect the 67-kilometre-long coast against a 1000-year storm surge. In the Master Plan, flood risks are established and the risk zones charted. For each risk zone, measures and possible alternatives are studied. The emphasis is primarily put on the achieving of the chosen measures necessary to ensure the coastal safety until 2050. Thereby the expected rise in sea level is being taken into consideration.

The SARCC pilot that is being undertaken at Osotende is situated in one of the areas that was identified as weak, where safety standards regarding coastal flooding were not being fulfilled. Here the Coastal Division of the Flemish Agency for Maritime Services and Coast has nourished the beaches of Oostende to upgrade the safety level to a 1000 year storm surge event.

In the pilot area of Oostende the works to create the natural landscape with planed dunes along the seawall is harnessing the natural power of waves and wind to allow a dune landscape to develop, thereby creating a nature based solution to this coastal risk issue.

2. Archaeology & Palaeoenvironmental Resource Scoring

This section provides initial background to the palaeoenvironmental, archaeological and historic development of the area surrounding the Pilot Project to put its development into longer term context. It then presents the results of the scoring of a range of sites, buildings and features within the pilot study area to identify those which provide the most potential for informing on the scale and pace of coastal change.

2.1 Archaeology and History of the Pilot Study Area

Evidence from prehistoric periods through to modern day includes a wide range of traces of the environmental changes through preserved deposits and land surfaces in addition to the many finds, traces of buildings and burials through to historic development of coastal hamlets then towns. This evidence provides the long-duree of human use and occupation at the shore, including how people have both influenced coastal change through structures and have themselves been impacted through storms and coastal changes.

Oostende, the largest city on the Flemish coast, started as a small fishing community on a coastal island. It has been relocated and rebuilt several times due to destruction caused by nature and humans. The current settlement at Oostende developed in the early Middle Ages, having moved inland from its coastal origins.

Prehistory

The earliest evidence of human activity in the area has been found on the beach at nearby Raverjside, where evidence dates back from the final-Palaeolithicum (14,000-12,000 yrs BP) to the Neolithicum/Early Bronze Age (around 4000 yrs BP). In the surface peat layer a wooden paddle, dating back to 5000-2800 BP was found (Pieters et al., 2013; Pieters, 1993).

Roman

As the first marine transgression began to displace people early in the first century AD, Germanic tribes invaded Flanders, where they settled as farmers and began to trade with the Mediterranean. Julius Casear referred to the inhabitants of Belgium, North Western France and the German Rhineland as the Belgae and

considered them part of Northern Gaul. There are relatively low levels of large-scale Roman activity in Belgium, the only Roman administrative capital was at Tongeren, 200km east of Oostende.

At nearby Oudenburg (8km south-east of Oostende), a roman vicus developed in the middle of the first century, but was submerged during the second Dunkirk marine transgression in the second half of the third century. The remains of wooden houses, pottery and other artefacts have been found during excavations. As the waters regressed, leaving the new coastline north of the old vicus, a castellum was built on top of the ruins, part of the Litus Saxonicum defence system. The remains of three successive castella have been discovered. A roman road linked Oudenburg to Blicquy and Bavai, and other roads probably led to Cassel and to Bruges and Aardenburg. Soil analysis revealed that at the end of the third century, the castellum was located on a slightly raised sandy strip, surrounded by a lagoon. Other small fortifications and watch towers were likely to have been constructed all along the coast. Today, Oudenburg is 8km inland.

Closer to the SARCC pilot site numerous artefacts found at the Oostende-Raversijde site date back to the Roman period. Next to pottery, waste pits, and ploughing traces there are also traces of peat and salt exploitation which were found (Pieters et al., 2013; Thoen, 1978; Pieters et al., 2010).

The remains of a Roman dike were discovered (Pieters et al., 2013). The dike is mainly built of stacked clay blocks, on its western side reinforced with peat blocks. The dike is oriented roughly perpendicular to the present coastline, which suggests that its purpose was most likely to embank a tidal gully that stretched further inland. Until the 1970's these intertidal remains were still visible on the beach, but beach supplementation works and groin construction has resulted in them being buried by several metres by sand.

Middle Ages

The fishing village of Oostende is first mentioned in 1087. At that time, Oostende was at the eastern end of Testerep, a salt marsh spit (see Figure 6), naturally created by tidal action in the fifth and sixth centuries. The island was owned by the Counts of Flanders and rented to the Saint Pieters Abbey of Ghent. The island was separated from the mainland by a tidal gully (the Testerepvliet) that was completely submerged at high tide. In the tenth century, a natural dune belt developed that protected the island from the sea and encouraged settlement. Shepherds and fisherman moved onto the island, and at the east end, the town of Oostende began to develop from the 990's. Peat was extracted to produce the salt required by the fishing industry. By the twelfth century, the Testerepvliet had been in filled and Testerep was part of the mainland.

Figure 6: Map of the medieval island "Testerep", with the most likely location of Walraversijde indicated in red. Source: http://www.oostende.be

Peat extraction, land reclamation and the creation of dikes adversely resulted in rising flood levels. The grant of city rights in 1266 further added to the problems. The resulting expansion included a systematic flattening of the natural dune belt and the widening of the tidal channel in 1284. As a direct result, parts of the city were destroyed by the Christmas Eve flood in 1330, and three years later in 1334, the whole island was inundated following the St Clements storm. The remains of the old city were discovered 200m off the coast in 2016.

Oostende was rebuilt further inland. The official deeds of the new town specified that a dike must be built to replace the dunes. A small population had remained on the island, but the St Vincentius storm surge in 1394 wiped out all the settlements on the Testerep. Storm surges in the fourteenth and fifteenth century completely submerged the northern half of Testerep as the coastline retreated more than 1km. The coastline has remained in more or less its present position since the 16th century.

Since 1992 detailed archaeological investigations have been carried out in the polder area behind the present dike. Excavations revealed two phases of occupation. The earliest site on the beach inhabited between 1200-1400 (Figure 8) and the new village built on a polder inhabited between 1400-1600. The final abandoning of the village in the 15th century was a gradual process, induced by flooding and war (Tys and Pieters, 2009). The Walraversijde Museum houses the artefacts recovered and has many reconstructed buildings and scenes depicting life in the medieval fishing village, that would also have been typical of life in medieval Oostende (Figure 7).

Figure 7: Reconstructed buildings at Walraversijde 1465 creative commons Source: https://commons.m.wikimedia.org/wiki/File:Walraversijde_1465_-_368372_-_onroerenderfgoed.jpg accessed 07/07/2021

Figure 8: Remains of a late medieval house discovered on the beach of Raversijde, picture taken in 1950's. Photo E. Chocqueel (courtesy T Missiaen, D Evangelinos and I Jongepier).

Modern

Flanders experienced a Golden Age of prosperity in the sixteenth century. During this time, canals and dykes were built to join Testerep to the West Flanders mainland. Oostende was reborn, in a new location and became an important harbour (Figure 9).

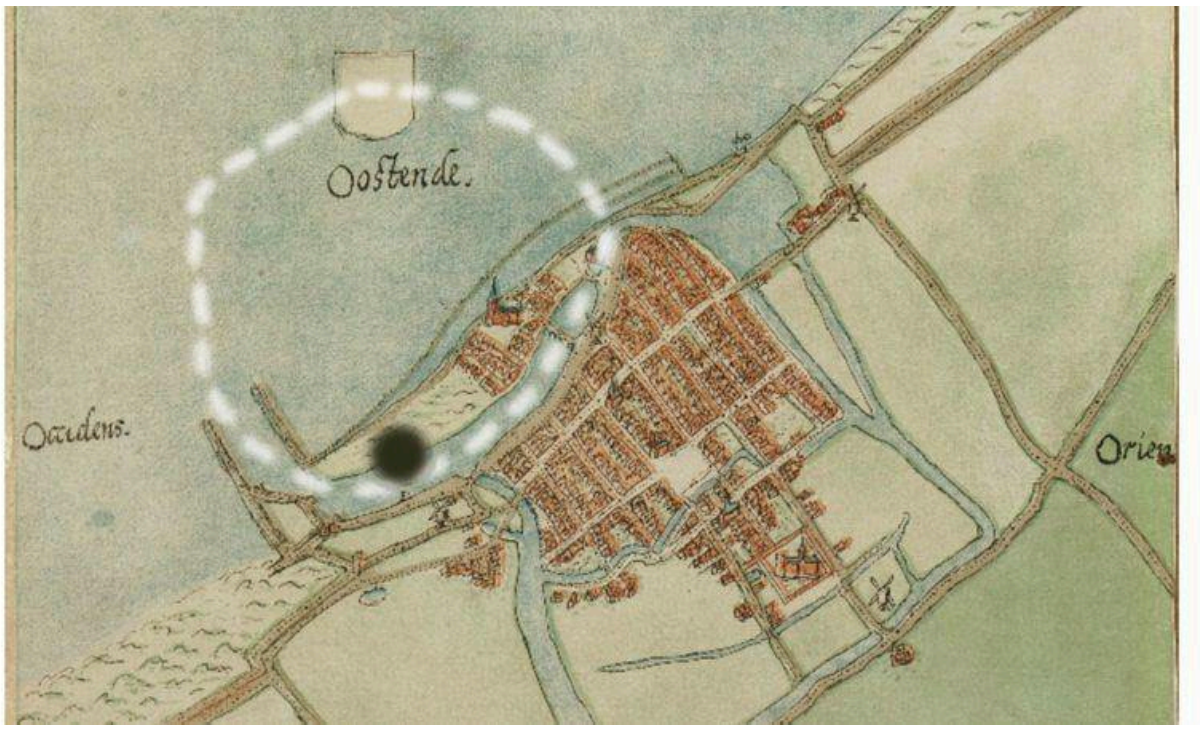

Figure 9: Oostende 1560_Fase1Doc_DB

With its strategic position on the North Sea, the town of Oostende was frequently under attack by invading armies as the region became politically unstable and mercenaries plundered the coast. Oostende was sacked and burnt in 1489, starting a series of Dutch wars. The city was conquered by the English and Dutch in 1548 and the port was founded, it was then moated and fortified and served as a major military port between 1584-1590. The area south of the city was tactically flooded. Ostend held out for three years during the siege of Oostende (1601-1604) before being the last Dutch Protestant stronghold in Belgium to fall to the Spanish in 1604. With the loss of over 80,000 lives, this was also the bloodiest battle of the Eighty Years War and once again destroyed Oostende.

The next period of growth began in 1722, when the world's biggest harbour at Antwerp was closed. Oostende grew in importance as it provided an alternative exit to the sea. The Holy Roman Emperor Charles VI of Austria founded the Oostende Company and granted a trade monopoly with Africa and the Far-East, but by 1727 this had been quashed by the Dutch and British merchants. Commercial activity resumed under the Austrian Emperor Joseph II (1780-90). The Ferrais map of 1775 shows the rebuilt town completely contained within strong city defences (Figure 10).

Figure 10: Oostende (c. 1775) Joseph de Ferraris. Public domain, via Wikimedia Commons Source https://commons.wikimedia.org/wiki/File:Ostend,_Belgium_;_Ferraris_Map.jpg accessed 07/07/2021

Under French occupation, Napoleon built a polygonal fort 'Fort Napoleon' in 1811 (Figure 11). Situated in the sand dunes close to the mouth of the harbour, it was designed to defend against British attacks. Although the British attacks never came, an explosion in the artillery magazine in 1826 caused widespread destruction throughout the city, with barely a building escaping damage and the whole of the affluent quarter of d'Hargras levelled.

Figure 11: Fort Napolen. Commons Wikimedia Source https://en.wikipedia.org/wiki/Fort_Napoleon,_Ostend#/media/File:Dia17.JPG accessed 07/07/2021

Under Dutch rule 1815-1839, the docks were redeveloped. The arrival of the railway in 1838 and the introduction of the Oostende to Dover passenger ferry in 1846 bought many tourists from England to the continent. Oostende attracted the interest of the Belgian Kings Leopold I and Leopold II who spent their holidays there. Their presence prompted the construction of the Hippodrome Wellington Racetrack and the Royal Galleries; Oostende became known as "the queen of the Belgian sea-side resorts".

During World War One, Oostende was occupied by German forces and used as a major submarine base, as a consequence, the port was twice raided by the Allied forces. Occupied again during World War Two and fortified as a German coastal fortress of the Atlantic Wall, the city was subject to much devastation. The public buildings were rebuilt and the city was fortunate to survive the 1953 floods that broke the dike. Today, Oostende is a thriving resort and important fishing port.

2.2 Results of Archaeology Scoring

This section outlines the results of the archaeological and palaeoenvironmental scoring from the Oostende study area, followed by a discussion of the results. The scoring methodology applied is detailed in *SARCC Maritime Atlas: Methodology Report* (MAT 2022). It should be noted that the scoring is not providing any measurement of historic or cultural significance of a site, only its potential to inform on coastal change.

Within the pilot area data was obtained from online heritage database sources. Where data indicated there were sites with potential to inform on past change then further research was required in order to understand the full nature and extent of the site. A total of 78 sites were assessed and scored.

The highest combined scoring sites are shown in Figure 12 and listed in the table below, the total score has been normalised to give each site a score out of 100. It is possible for a site to score highly in one of the three scoring categories and still be important for informing on coastal change over time. The combined approach identifies those scoring highly across all of the scoring categories.

ID	Site Name	Period	Score – sea level	Score – Environmental	Score – Temporal Continuity	Total Score	Coastal Context
4986	Dunes near Raversijde	Medieval	High	High	High	100	Dunes
5100	Dune and polder landscape Zeedijk and the Nieuwpoortsesteenweg	Medieval	High	High	High	100	Dunes
1494	Raversijde peat excavation	Roman & Medieval	High	High	Medium	88	Intertidal
4913	Domein Raversijde	Roman & Medieval	Medium	High	High	88	Above high water
2430	Raversijde Roman dyke	Roman	Medium	Medium	Medium	66	Dunes
2432	Raversijde buried tidal channel	Medieval?	Medium	Low	Medium	55	Dunes
2433	Raversijde medieval waste pits	Medieval	Medium	Low	Medium	55	Intertidal
2434	Raversijde medieval dyke	Medieval	Medium	Medium	Low	55	dunes
4971	Parish church of our Lady of the Ascension and surroundings (inc. fisherman's house)	Medieval	Medium	Medium	Low	55	Above high water.
4980	Duinenstraat	Medieval	Medium	Medium	Low	55	Above high water.

Table: Archaeological and palaeoenvironmental sites with high potential for informing on coastal change, all sites with a total score of 55 or above.

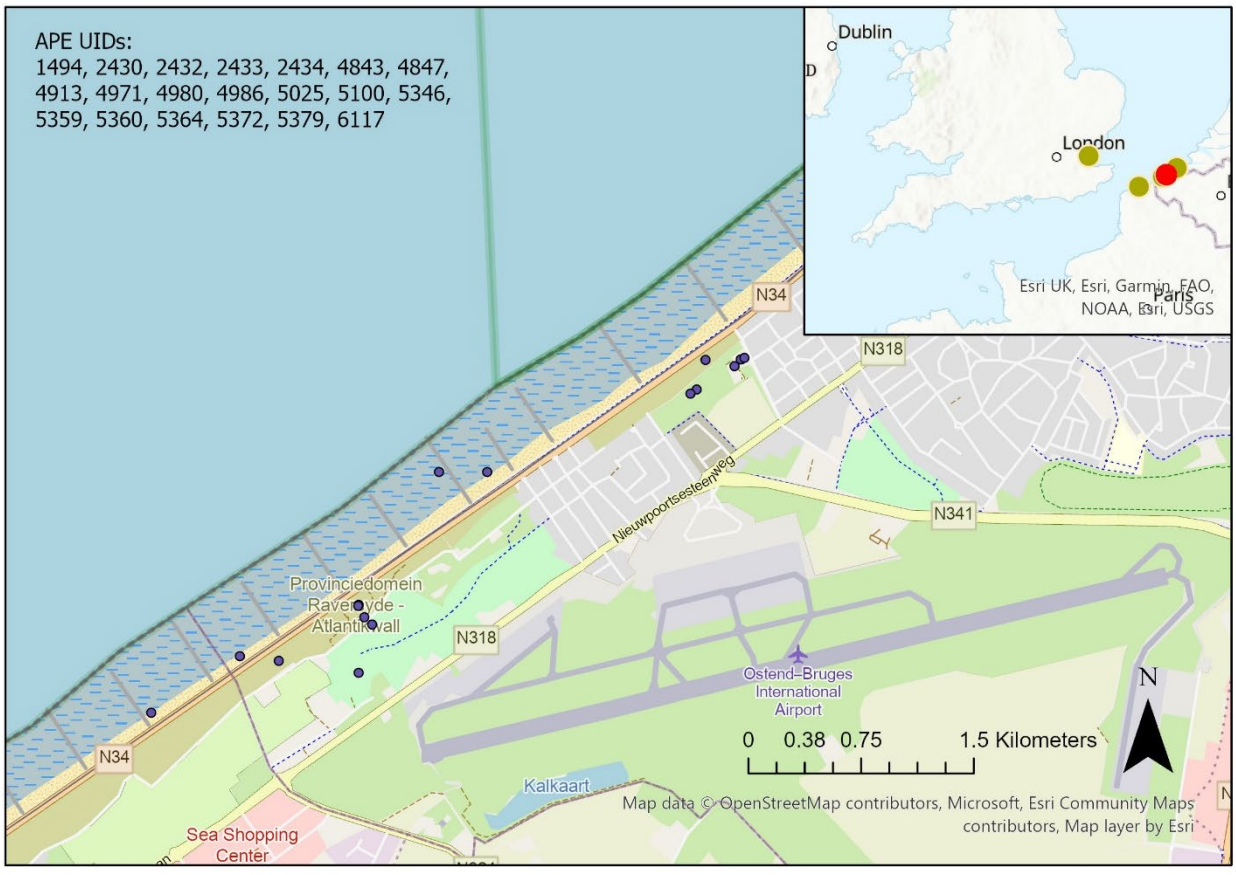

Figure 12: showing the distribution of the highest scoring archaeology and palaeoenvironmental sites in the Ostende study area.

2.3 Discussion of Scoring Results

The table of highest scoring sites includes a range of sites and landscape deposits. Those scoring highest were the dunes that can still be found near Raversijde (ID:4896) and at Zeedijk - Nieuwpoortsesteenweg (ID:5100). In addition, archaeological evidence for dunes also exists at Duinenstraat (ID:4980). South of the dunes, towards Nieuwpoortsesteenweg, geologcial samples identified high coastal dune soils with humous horizons indicating vegetational surfaces that have been flooded, resting on polder deposits (ID:5100). Dunes are good indicators of sea levels and coastline change.

During WW1 and WW2, military bunkers were built into the dunes. While these sites are relatively recent, they do provide the opportunity to measure subsequent coastal change with accuracy as their solid form provides reliable data points.

At Raversijde, the remains of a medieval fishing village, 'Walraversijde' (ID:4913) were discovered behind the seawall. The village disappeared during the Seige of Oostende (1601-1604) and was not rebuilt. Excavations revealed a Roman dyke (ID:2430), a Medieval dyke (ID:2434) an undated tidal channel (ID:2432), Medieval waste pits on the beach (ID:2433) and evidence of Roman/ Medieval peat extraction (ID:1494). In later years this site was part of the Royal domain of King Leopold II and formed part of the Atlantic Wall fortifications in WW2.

Peat was extracted in the Roman and Medieval period as a source of fuel for salt ovens (Figure 13). The salt extraction process necessitated the cutting of drainage ditches. These two processes combined, resulted in the lowering of the surface, allowing the sea to progress further inland. A tidal flat was created, but this was reclaimed in the late medieval period. The building of dikes perpendicular to the coast, suggests the inhabitants were experiencing problems with flooding. Storms in the 14th and 15th centuries resulted in the coastline retreating 1km inland and by the 16th century, the old town of Oostende was destroyed by flooding. The presence of peats, which can be dated, provide a record of the position and height of sea level at a particular time. The analysis of peat deposits provides very detailed information on the environment including the flora and fauna, but also the extent to which the water conditions were fresh, brackish or marine – which provides data on how the environment has changed in response to sea level rise at a particular dated period.

Figure 13: Aerial photo of peat excavation remnants (site: 1494) at the beach of Raversijde (Photo E. Cools, c. 1970).

The Parish Church of Our Lady of the Ascension (ID: 4971) and its cemetery are protected as monuments and established architectural heritage. The wider area surrounding the church is also protected as a cultural heritage landscape and an Intrinsic cityscape. The first church on this site behind the dunes was built between 1350-1400 and dedicated to Our Lady of the Assumption. It was destroyed during the siege of Oostende (1601-1604) and rebuilt in 1625. The church alternated between periods of extension and restoration, with further damage inflicted by a storm in 1716 and both World Wars.

Further evidence of the coastline retreat seen as Walraversijde is apparent in Figure 14. Our Lady of the Ascension was built to replace the Chapel of Our Lady. First mentioned in 1171, the Chapel of our Lady was sited further forward, at a time when the coastline extended further. It was completely destroyed by storms in 1334 and this area has remained underwater as the coastline retreated.

The last remaining fisherman's house can be found at the south-eastern corner of the cemetery (Figure 15), on Dorpstraat, and is preserved as part of the wider cultural heritage area. It is a traditional style white painted house with a red saddle roof of Flemish tiles. The house was built for the Corveleyn family in 1822.

There are a range of other archaeological and historic sites which scored lower as a total score that feature within the dataset. It is possible for a site to score highly on one of the categories and within that still have the potential to help understand changes over time.

Figure 14: Position of the Parish Church of Our Lady of the Ascension (ID 4971) in relation to the modern frontage.

Figure 15: The last remaining fisherman's house at Walraversijde.

2.4 Photographic Survey of High Scoring Features

Some of the sites and features that scored highly are in existence today and are above the low water mark so can be visited. A site visit was undertaken to capture current day images of a number of the archaeological and historic features, a range of key examples are included below (Figures 16 – 19). These can now be used to directly compare with other available resources to demonstrate the extent to which there have been changes to the coast.

Figure 16 A section of dunes south of Zeediijk (Site: 5100). Taken November 2021.

Figure 17: Historic postcard of c1900 showing the same section of dune frontage.

Figure 17 is an historic postcard c1900 which shows the same area as the modern image above (Figure 16). The dunes on the right of the road are now lower and a tramway runs along the road. The pilot scheme seen in the modern photograph, is an attempt to help alleviate the problem of the sand, which has been used to replenish the beach, inundating the tramway during strong winds.

The WW1 and WW2 defences built into the dunes (ID: 4986) at Raversijde are among the best-preserved remains of the German Atlantikwall defences (Figure 18). They are open to the public at certain times of the year. Although the wooden buildings at WW1 Battery Aachen have disappeared, the remains of the bunkers and gun beds are preserved. The WW2 Battery Saltzwedel-neu is considered one of the most important military defence museums in Europe.

Figure 18: A German bunker of the Atlantic Wall near Ostend. Marc Ryckaert (MJJR), CC BY 3.0 <https://creativecommons.org/licenses/by/3.0>, via Wikimedia Commons source https://commons.wikimedia.org/wiki/File:Oostende_Hundius_R01.jpg accessed 11/01/2022

The tarmac road shown in Figure 19 is known as 'Duinenstraat' (ID: 4980), it runs betweeen Raversijde and Middelkere. It follows the trajectory of a former drift, a path along which the cattle were herded between the dune and polder area, and was built on small dike, dating back to the 12th or 13th century.

Figure 19: The Duinenstraat Taken by Strobbe, Marika on 17-04-2018 Model license for free reuse , Attribution 4.0 International Source: https://beeldbank.onroerenderfgoed.be/images/289047 accessed 11/01/2022

3. Maps and Charts

This section provides a background to the development of maps and charts over time which have relevance for the area surrounding the Pilot Project. It then presents the results of the scoring of a range of maps and charts which cover the pilot study area with details that allow them to help demonstrate changes to the coastline over time.

3.1 Maps and Charts Background

Prior to the Middle Ages, early maps were little more than a sketch of a small area, accompanied by a more detailed written report. In the fifteenth and sixteenth centuries, more traditional maps began to appear, but were usually drawn by artists and were of a pictorial nature. Focusing on the location of towns, castles and fortifications, rivers, lakes and woods, these large works were commissioned to be displayed in palaces and castles. It wasn't until the mid-sixteenth century when systems of survey and measurement were introduced, that the potential of maps as reliable tools for a variety of purposes was realised. Local surveying and map making developed in the Southern Provinces a century earlier than in the Northern Provinces. The oldest surviving property map of a piece of land in Flanders dates to 1307.

Oostende can be seen on this early pictorial map by Pieter van der Beke dated 1538 (Figure 20). Produced on four wooden sheets, this map reflects the defiant independence of the Flemish cities against Spanish rule, containing heraldic shields, a genealogical log and the four bears representing the oldest families.

Figure 20: Charte van Vlaendren Pieter van der Beke 1538 dated Source https://commons.wikimedia.org/wiki/File:Charte_van_Vlaendren_1538_Pieter_van_der_Beke.jpg Public domain Accessed 15/07/2021

In 1540, Gerard Mercator, a Flemish pioneer of cartography was commissioned by the Merchants of Ghent to produce a map of the county of Flanders (Figure 21). The merchants hoped a more respectful portrayal of the county would replace the 1538 map and appease the Spanish Emperor Charles, following their rebellion.

Mercator signed the map “Dedicated to Charles V most Holy Roman Emperor by the most devoted Gerardus Mercator of Rupelmonde.”

The accuracy of Mercator’s map is attributed to triangulation already carried out by Jacob van Deventer. The nine copper engravings together form a wall chart measuring 96 x 125cm. The map is on display in the Museum Plantin-Moretus. The museum in Antwerp is the original residence and workshop of the Plantin and Moretus publishers and is a UNESCO world heritage site. Mercator’s map was included in the Theatrum Orbis Terrarum by Abraham Ortelius. Printed in 1570, considered to be the first true modern atlas.

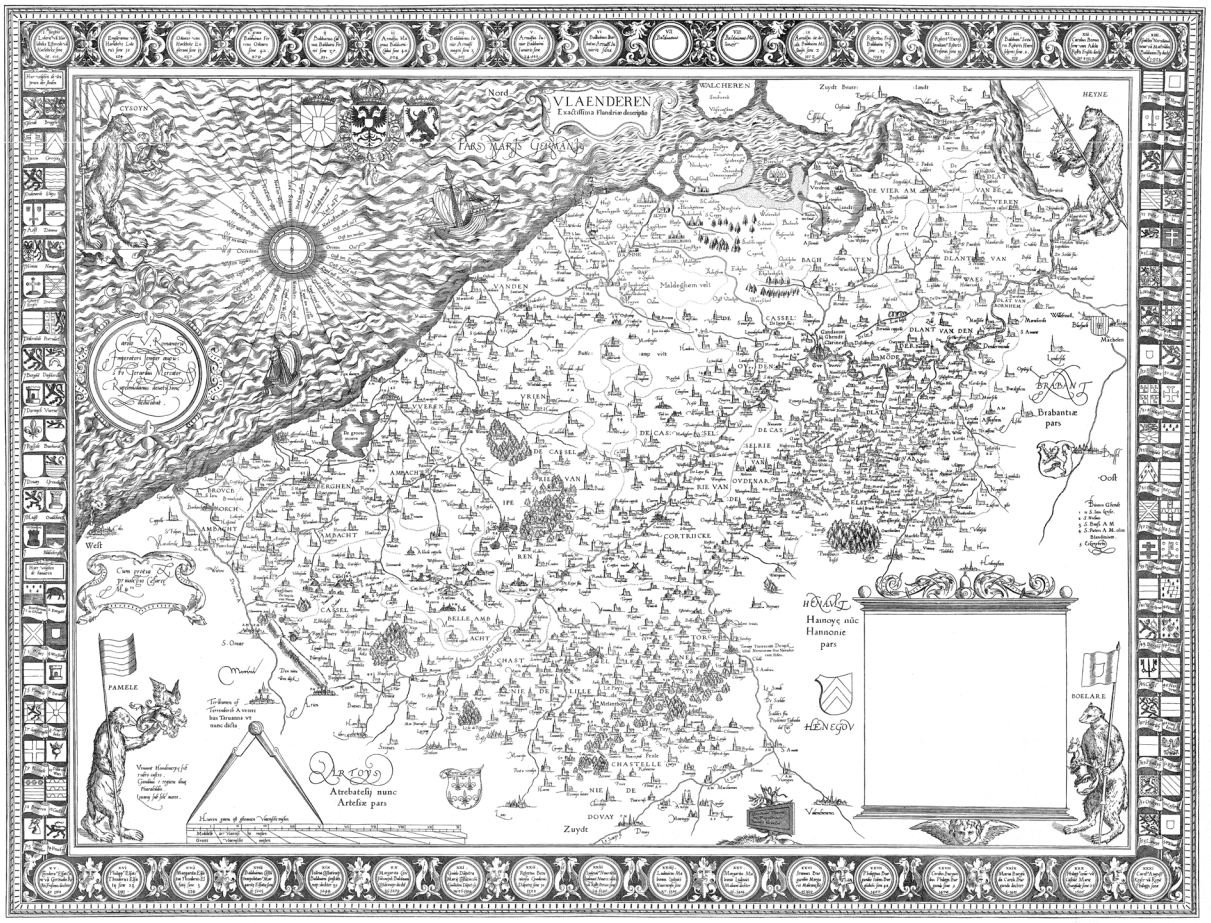

Figure 21: Flanders By Gerardus Mercator 1540 - landkaart, Public Domain, Source https://commons.wikimedia.org/w/index.php?curid=9557902 1540 Gerard Mercator accessed 22/07/2021

Jacob van Deventer, a leading Dutch Renaissance Cartographer, was commissioned first by the Emperor Charles V and then in 1559 by King Philip II to create manuscript topographical plans for all of the cities of the low countries. This was to be his life’s work. By the time of his death in 1575, he had created over 250 city maps. King Philip II required these maps to suppress the cities that revolted against him. Deventer pioneered triangulation to produce accurate scale maps. Drawn in plan, buildings were drawn side on for easy recognition by the soldiers. Important buildings, roads, rivers and fortifications were all mapped in water coloured detail. These plans were not published due to their secret military nature and were only rediscovered in the late nineteenth century. Oostende was mapped by Deventer in 1562 (Figure 22).

The pictorial map by Braun & Hogenberg dated 1625 contains terrific detail of Oostende and the surrounding area (Figure 23). This was based on an earlier map by Guicciardini dated 1581.

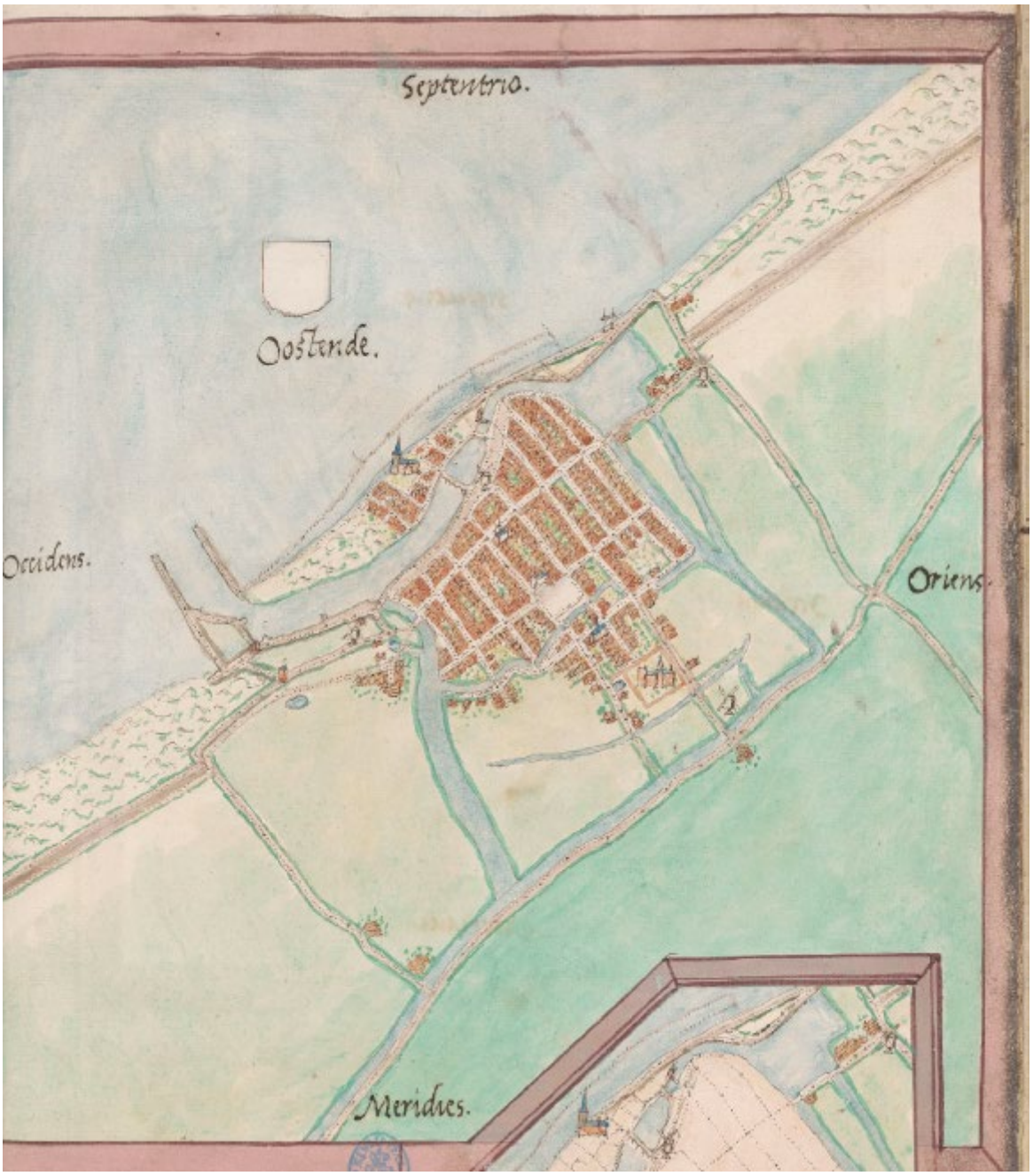

Figure 22: Jacob van Deventer, Public domain, via Wikimedia Commons Source https://upload.wikimedia.org/wikipedia/commons/9/96/Oostende_map_Jacob_van_Deventer.png Accessed 22/07/2021

Figure 23 Siege of Oostende (1601-1604) in an early stage. Map by Braun & Hogenberg. Date of the first edition: 1617 Date of this map: c. 1625.Public domain. Source https://en.wikipedia.org/wiki/Siege_of_Ostend#/media/File:Braun_&_Hogenberg_Ostend_1601.jpg Accessed 07/07/2021

Meanwhile, topographical maps were produced at provincial levels, rising from the desire for self-representation. Printed province maps were produced in almost all the countries of Europe between 1575-1700, many of these maps clearly show Oostende as a named town. The map of Flanders by CJ Visscher, 1621, shows the fortifications and harbour at Oostende (Figure 24).

Figure 24: Extract from: CJ Visscher, Comitatus Flandria 1621.Source: https://sanderusmaps.com/our-catalogue/antique-maps/europe/low-countries-belgium/antique-map-of-flanders-vlaanderen-by-c-j-visscher-22491 Copyright Unknown. Accessed 22/07/2021

In 1638, Henricus Hondius in Amsterdam and Alexander Serhanders in Ghent, published a multi-sheet map of Flanders (Figure 25) that superseded Mercator's map. This was the basis of Blaeu's six sheet wall map of Flanders published in 1638 (Figure 26).

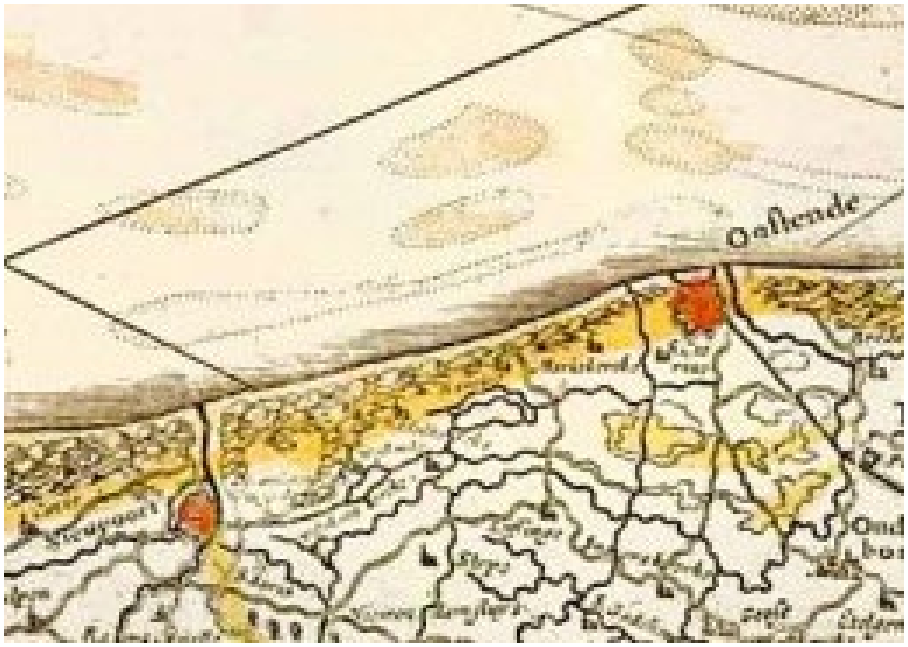

Figure 25: Extract from: Henricus Hondius 1638. Source https://sanderusmaps.com/our-catalogue/antique-maps/europe/low-countries-belgium/old-antique-map-of-flanders-vlaanderen-by-henricus-hondius-26316 Copyright unknown. Accessed 07/07/2021

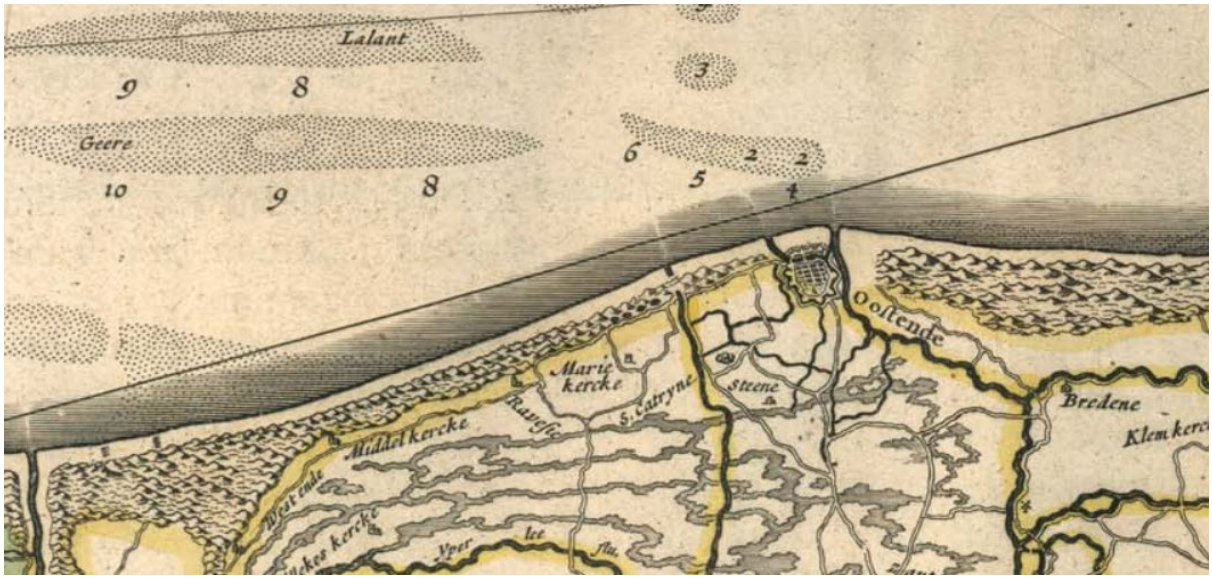

Figure 26: Willem and Joan Blaeu, 1643. Source https://upload.wikimedia.org/wikipedia/commons/c/ce/Blaeu_1645_-_Flandri%C3%A6_Teutonic%C3%A6_pars_orientalior.jpg public domain. Accessed 07/07/2021

Other topographical maps of Flanders were produced by: Seutter (1678), Jalliot (1695), Mortier (1700), Masse (1729), Visscher (1730), Bodenehr (1740), Frickx (1744) and Ferraris (1777). From the 1700's maps start to be produced on a smaller scale and contain much more detail. A good example is Ferraris map (1770's) (Figure 27).

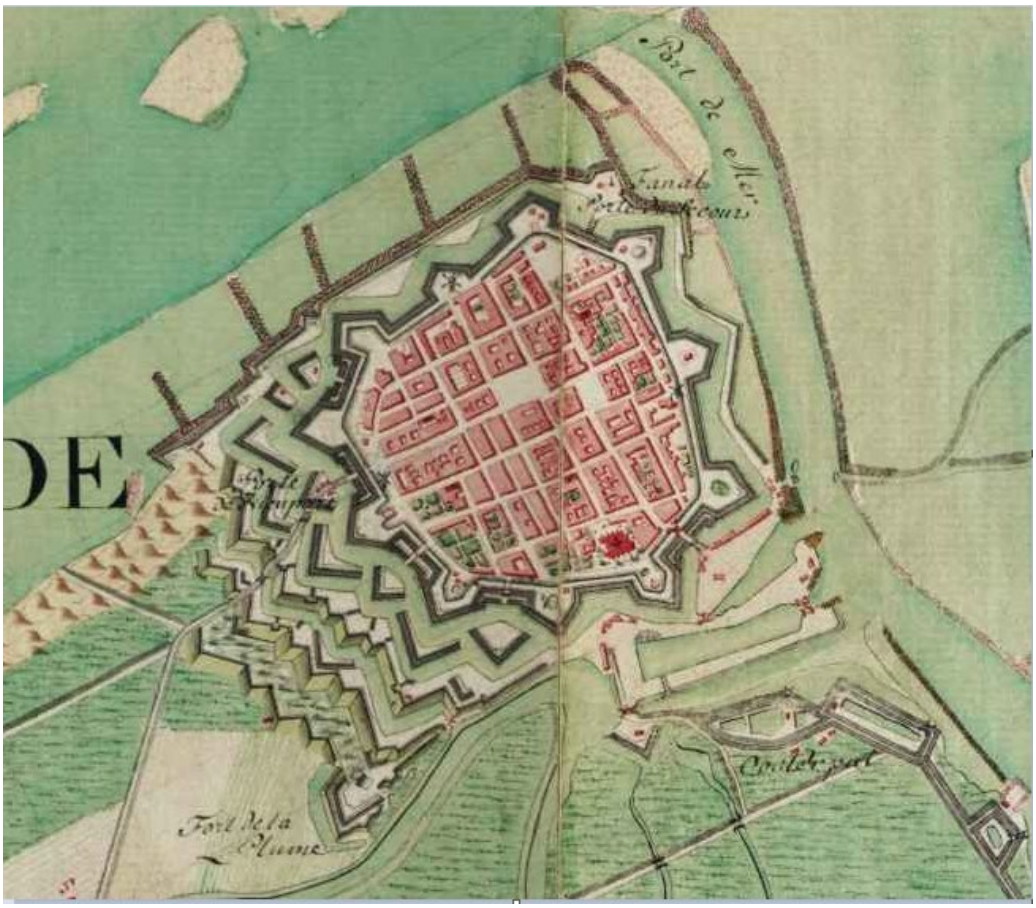

Figure 27: Ostende by Ferrais 1770's. Public domain. Source https://en.wikipedia.org/wiki/File:Ostend,_Belgium;_Ferraris_Map.jpg Accessed 07/07/2021

Oostende features on the British First World War Trench Maps which are available from the National Library of Scotland (https://maps.nls.uk/ww1/trenches/info1.html). Accurate spatial positioning was essential for both defensive and offensive operations. These maps were produced using the British Trench Map Grid System, based on existing maps and aerial photography which was being pioneered at this time. The maps chart the changing front line and the location of enemy positions, detailing the position of communications trenches, gun emplacements, obstacles, observation posts. Between 1914-1918, the Ordnance Survey printed over 34 million maps. The originals are held in the National Archives and the Imperial War Museum. Scanned copies can be viewed online at the Royal Library of Scotland. The War Office also produced maps, including an annotated Map of Water Supply Oostende, dated 1916 held by the British Library (http://www.bl.uk/onlinegallery/onlineex/maps/europe/ww1/largeimage150750.html).

Oostende was mapped again during WW2 and the defences along the coast are clear to see (https://maps.nls.uk/geo/explore/#zoom=12&lat=51.22846&lon=2.81167&layers=159&b=1). The *Institut Cartographique Militaire* produced maps for the Belgian army between 1878-1947 (http://www.vliz.be/hisgiskust/en/image-library?pic=119205).

Charts have also been produced over the years to map the changing Flemish coastal geomorphology. The Historical Maps Coastal Zone website http://www.vliz.be/hisgiskust/en/image-library?p=search&term=oostende&search.x=3&search.y=1 hosts these charts for the years 1866, 1966, 1968, 1971, 1973, 1974, 1980, 1982, 1984, 1985, 1998, 1991 and 1996. The earliest (1866), latest (1996) and a middle example (1966) are shown below (Figures 28 - 30).

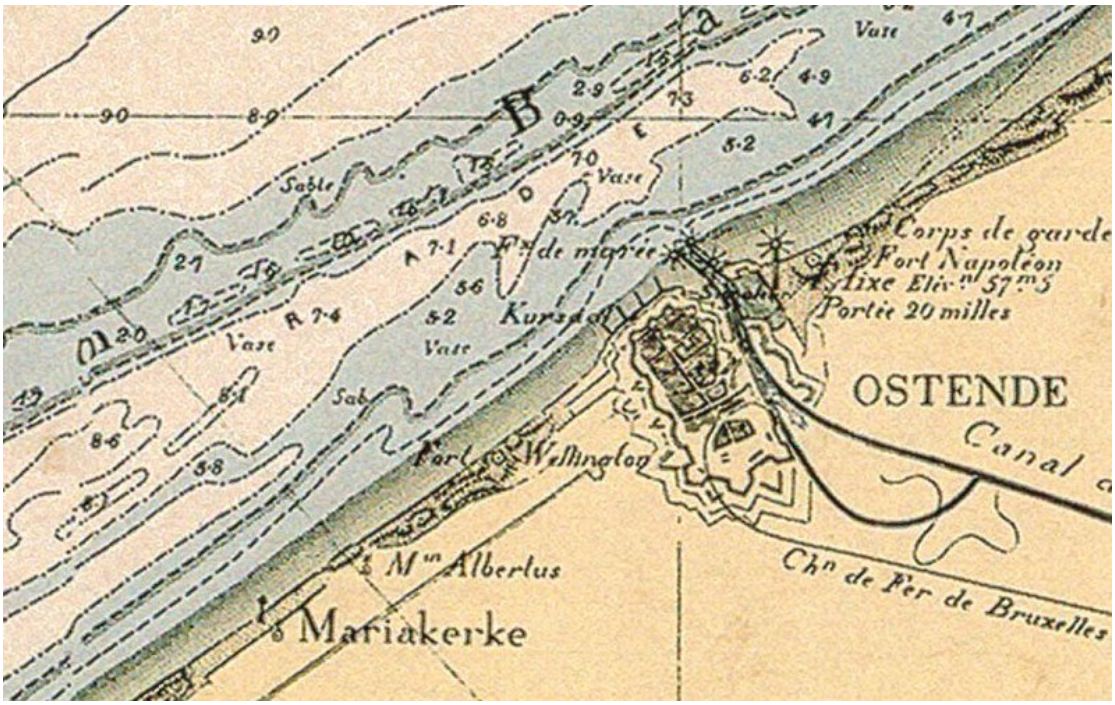

Figure 28: Vlaamse Banken (1866) http://www.vliz.be/hisgiskust/en/image-library?album=4904&pic=15526 Creative Commons Attribution-Noncommercial-Share Alike 4.0 License Accessed 07/07/2021

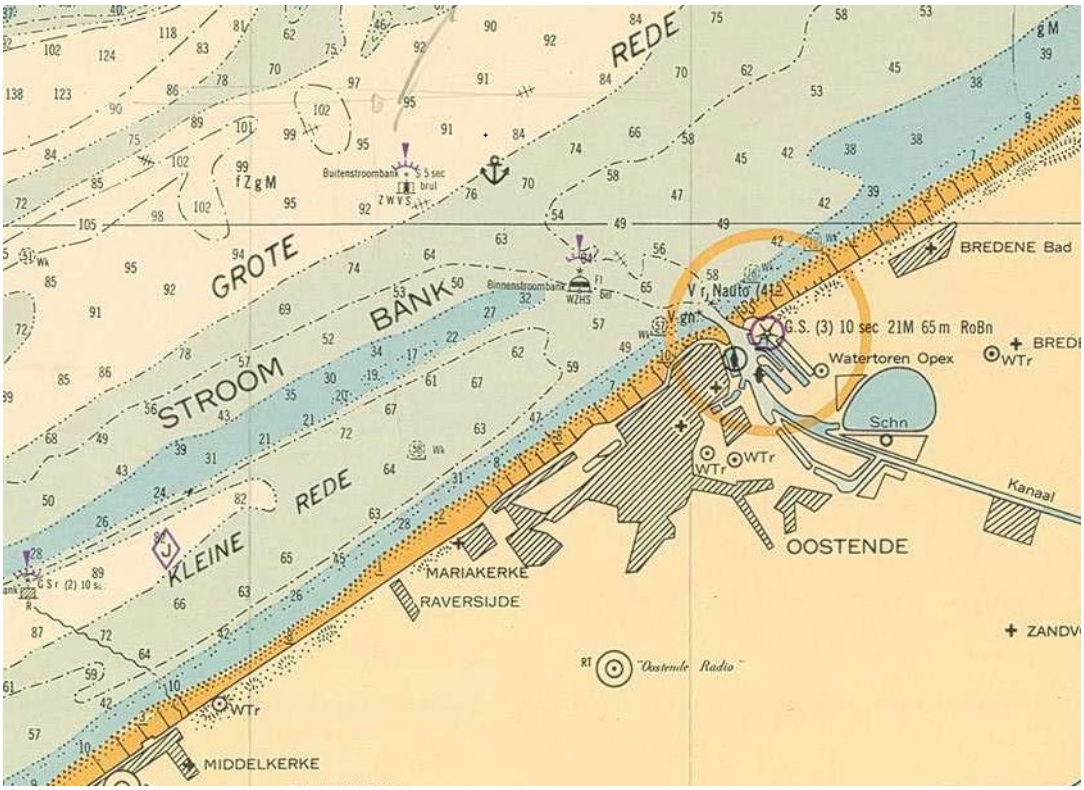

Figure 29: Vlaamse Banken (1966) Hydrografische Dienst der Kust Source http://www.vliz.be/hisgiskust/en/image-library?album=4905&pic=15527 Creative Commons Attribution-Noncommercial-Share Alike 4.0 License Accessed 07/07/2021

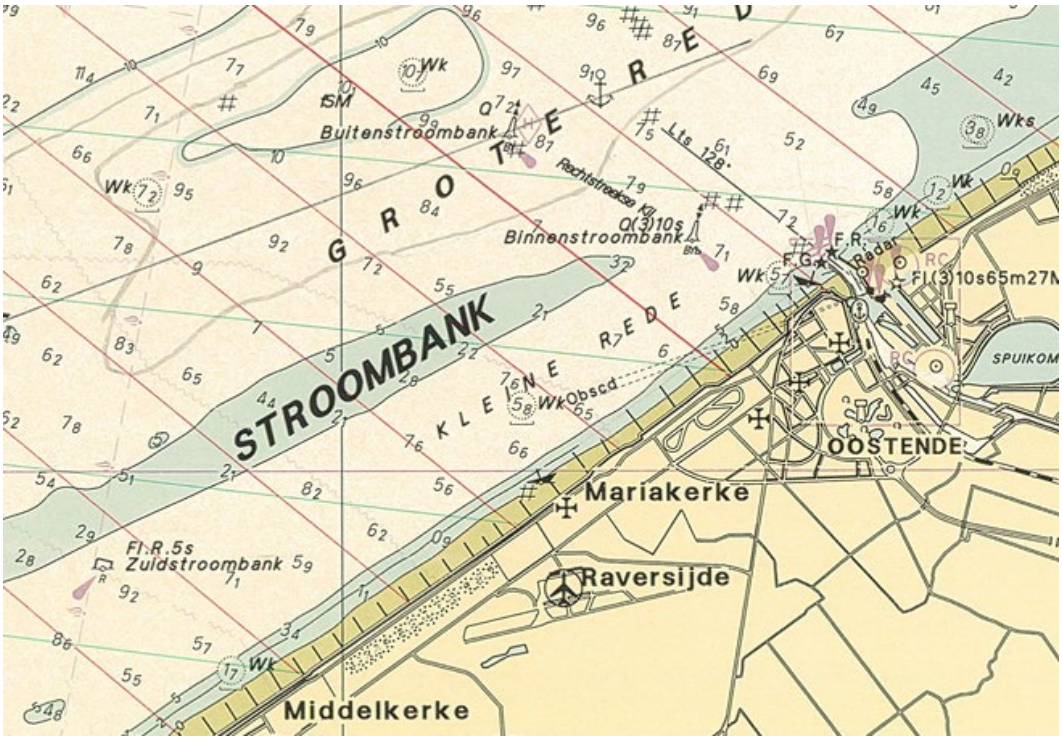

Figure 30: Vlaamse Banken (1996) Hydrografische Dienst Oostende, Afdeling Waterwegen Kust Source http://www.vliz.be/hisgiskust/en/image-library?album=4905&pic=111856 Creative Commons Attribution-Noncommercial-Share Alike 4.0 License Accessed 07/07/2021

3.2 Results of Scoring

The ranking system for maps and sea charts as set out in *SARCC Maritime Atlas: Methodology Report* (MAT 2022) and has been applied within the Oostende pilot area. A range of historical maps and charts of the area were assessed as part of the project, with some dating back over 500 years.

The study of maps and charts has utilised a range of online resources, it has been designed to show the potential of this type of resource for coastal change, but it is not an exhaustive study as other examples exist within archives, museums, libraries and galleries that is has not been possible to access due to Covid-19 restrictions. 59 maps and charts were analysed through the scoring system, the top scoring examples that score over 60 are detailed below:

MAP _uid	Title	Year	Score Chronometric Accuracy	Score Topographic Accuracy	Score Detail in non-coastal area	Score Geometrical Accuracy	Total Map Score
182	Map of Ostend 1602	1602	100.00	52.78	100.00	66.67	79.86
424	Plan of Oostende 1706.	1706	100.00	50.00	100.00	66.67	79.17
397	Ostende and ships 1706.	1706	100.00	50.00	100.00	66.67	79.17
400	C17 Ostende.	17th Century	100.00	50.00	100.00	66.67	79.17
398	Ostende Plan.		100.00	38.89	100.00	66.67	76.39
184	Old map - birds eye plan of Ostend.	1617	100.00	44.44	66.67	83.33	73.61
214	Ostend 1860.	1878	100.00	27.78	66.67	83.33	69.44
380	Oostende and Middelkerke 1913.	1913	100.00	44.44	66.67	66.67	69.44
390	Siege of Oostende early 1601-1605.	1605	100.00	44.44	66.67	66.67	69.44

391	Siege of Oostende early 1601-1606.	1606	100.00	44.44	66.67	66.67	69.44
392	Siege of Oostende early 1601-1607.	1607	100.00	44.44	66.67	66.67	69.44
393	Siege of Oostende early 1601-1608.	1608	100.00	44.44	66.67	66.67	69.44
394	Ostende Map 1745.	1745	100.00	44.44	66.67	66.67	69.44
395	Ostende Map C18.	18th Century	100.00	41.67	66.67	66.67	68.75
344	Blaeu 1645 - Eastern part of German Flanders.	1645	100.00	63.89	66.67	33.33	65.97
240	Oostende 1601.	1601	90.91	38.89	100.00	33.33	65.78
213	Germaniiae inferioris sive Belgii pars Meridionalis.	1740	100.00	27.78	66.67	66.67	65.28
324	Flandra Parte Occidentale.	1697	100.00	61.11	66.67	33.33	65.28
379	Nieuport to Ostend C17.	17th Century	100.00	44.44	66.67	33.33	61.11
239	Belgium 1584.	1584	100.00	44.44	66.67	33.33	61.11
183	Map of the flemish coast 17th century.	17 Century	100.00	41.67	33.33	66.67	60.42
336	Vlaamse-banken-1966.	1966	100.00	41.67	33.33	66.67	60.42
396	Ostende 1794.	1794	100.00	41.67	33.33	66.67	60.42

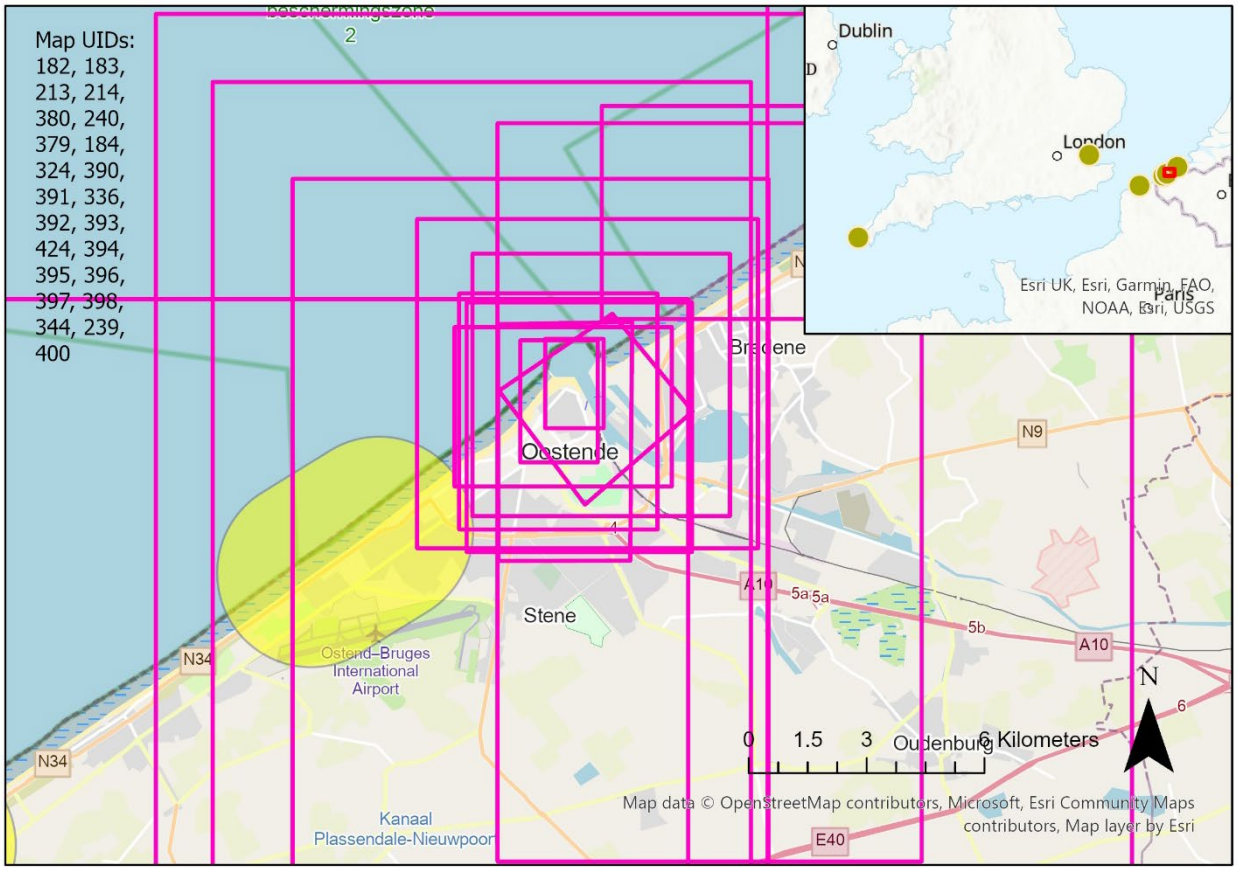

Figure 31: Distribution of high scoring maps and charts covering the Oostende study area.

3.3 Discussion of Scoring Results

A high number (59) of maps and charts were found for Oostende, many of them were drawn for military purposes, many of these can be accessed through the project online Visualisation Tool. The majority of the 23 top scoring maps are dated 1600-1700's and show the natural dune frontage extending west of the city,

over the pilot area and all the way to Nieupoort (ID 379). The church of Our Lady of the Accession was built in the mid to late 14th century, and pre-dates these maps.

The second highest scoring map ID 424 (Figure 32), a hand-coloured etching by Jacobus Harrewijn, is dated 1706. It records the Seige of Oostende. Zooming in on Mariakerke, the church can be seen, surrounded by fields behind it and dunes in front. Small bodies of water separate the dunes and the fields along which a road has been made that leads past a small fortification on the shore towards the harbour. The heavily fortified city of Oostende stands alone. I t cuts into the dune frontage and has a vast expanse of salt marsh behind. Four more seige maps feature in the top scoring results (ID 390-39).

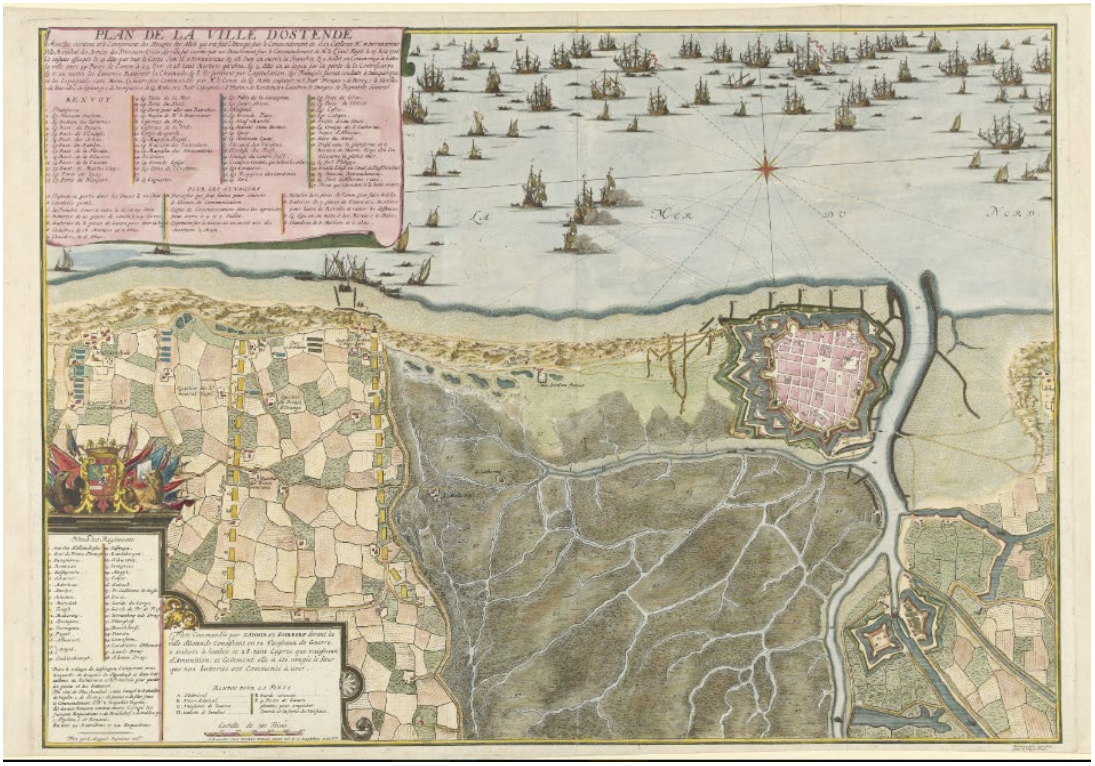

Figure 32 ID 424 1706 Second highest scoring map (by Jacobus Harrewijn dated 1706). Inset is zoomed in on Mariakerke.

Through the 18th and 19th centuries, maps chart the expansion of the city, with increasing fortification and development of the harbours and docks. The dune belt to the west of the city remains unaltered until tourism begins in the 1830's. A military map dated 1860 (ID 214 restricted) shows the sudden development of Oostende and Mariakerke. The city of Oostende expanded along the coast to the west. Hotels and other

tourist facilities were built just outside the city to the west, and roads were built through the dunes all along the seafront to Nieupoort. The 1913 map (ID 380) Figure 33 shows that development continued along the coast to the west and all along the seafront at Mariakerke, with development completely replacing the dune frontage.

Figure 33: Extract from Map Oostende and Middelkerke 1913 (ID380).

The extensive map and chart resource available for this case study area means there it further potential for more detailed work to examine the specific changes to the coastline shown within these resources.

4. Pictorial Resources Scoring

This section presents the results of the research, scoring and analysis of artistic images and historic photographs. The scoring approach for these resources has been developed to take account of the various styles, approaches and potential subjectivity (particularly of art images), and the potential of the resources to provide information on coastal change.

Artistic resources provide a similar time-depth to maps and charts in terms of the periods over which they have been produced, with photography being available for periods from the mid – late 19th century. Whereas maps and charts were designed to be as accurate as possible in producing 'plan views' which include the coast, art and photography provide a range of landscape and oblique views which give a different type of evidence of coastal change.

4.1 Artistic Images

The use of artistic images to help understand coastal processes, measure coastal change and inform approaches to coastal management has been developed over the past 20 years. Initial reports focused on the use of art resources to demonstrate coastal change in relation to issues for life and for economic assets (McInnes & Stubbings 2010, 2011; McInnes & Benstead, 2013, 2013, 2015). They demonstrated the potential for the resource to provide more data on other aspects of coastal management. The use of art images alongside archaeology and heritage data was further developed through the Arch-Manche project (https://archmanche.maritimearchaeologytrust.org/) which focused on long-term coastal change and included the assessment of artwork, cartography and photograph for more recent periods.

This section briefly outlines the art history relevant for the Oostende Pilot Area before looking in detail at the high scoring art works, what these examples show us and how modern photos can be compared to the artistic views.

4.1.1 Summary of Art History of the Channel Coast

The development of coastal artistic representations across the area of the SARCC Pilots has a common history which reflects broader trends in social and economic development and their impacts on art and artists. This brief review of developing trends draws on the work of Professor Robin McInnes within the Arch-Manche Project and is a summary of the background to the art of the Channel-Southern North Sea Region from the Arch Manche Technical Report https://archmanche.maritimearchaeologytrust.org/uploads/images/Documents/Technical_Report_Section_One.pdf. It provides a review of the development of coastal art applicable across the Channel coast SARCC pilot areas, with additional detail on further research related to the specific pilot area.

The beginnings of coastal art

It wasn't until the early 17th century that the work 'landscape' started to be used in English to describe scenery, it came from the Dutch word 'landschap' (an area of cultivated land). But the origins of landscape painting date back to the 15th century when scenery was included in paintings of early artists such as Leonardo de Vinci. In the 16th century in the Netherlands Pieter Brueghel the Elder (1525/30-1569) painted scenes which included the countryside and coast. However, for much of the 16th and 17th centuries portrait painting was the most common work produced.

During the fifteenth to seventeenth centuries Flanders produced some of Europe's leading artists.
"Artists from the Netherlands, Flanders and Belgium played a significant role in the development of landscape art, particularly in relation to the coastal and marine environments", these included Pieter Bruegel the Elder, Rubens and Van Dyck. This encouraged other European artists to their centre of activity and Flemish Baroque painting flourished, particularly in the Antwerp School, but also in Brussels and Ghent. Following the Siege of Antwerp in 1584-85, Flanders became separated from the Dutch Republic and many artists fled to Holland, leading to the development of the 'Dutch Golden Age' of painting, which spanned the 17th century. A more naturalistic style of painting developed which included landscape depictions, with important artists being 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. Seascapes became more popular with Hendrik Vroom (1566-1640) being one of the earliest seascape painters.

The Dutch economy was heavily based on maritime trade which was captured through paintings, as was naval conflict and dangerous sea condition. Many of these paintings included detail of the coast and harbours.

Strong European trading networks meant Dutch and Flemish painters and paintings were exported, including the famous Willem Van De Velde (c.1611-1693) and his son, also Willem (1633-1707), who moved to London in 1672. Their expertise in depicting ship and the sea dominated marine painting in England and inspired a generation of English marine painters.

"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 Great Britain".

The fashion for monied young men to take the 'Grand Tour' in the late 17th and 18th centuries developed appreciation for classical remains and Renaissance art, particularly of Italy and Greece. Those returning often commissioned art work and were particularly impressed by the landscape paintings. While 'on tour' they were able to purchase engravings and paintings of coastal scenes that had been painting for the 'tourist trade'. Some travellers were accompanied by their own artists and later photographers to capture their sights while on tour.

Throughout the 18th century there was growing appreciation of landscape and subsequent interest in landscape painting including through watercolour drawings and through publication of richly illustrated

aquatinted plates. Some of the dedicated topographical artists, such as Turner, Rowlandson, William Daniell and Richard Ayton, travelled extensively to inaccessible places to develop their works. This often included areas of coastline and their paintings have left a legacy which are an important record of the state of the British coastline.

19th Century Developments

In the 19th century artists continued to follow the Dutch tradition of creating very detailed depictions of the coast capturing developing coastal settlements which developed into resorts. "This era of coastal landscape painting relied not just on the skills of the original artists in the field, but also a number of remarkably fine craftsmen, engravers and colourists, who produced illustrations through a range of techniques such as aquatint and lithography".

In particular the mid-19th century Pre-Raphaelite Brotherhood became influential in landscape painting – they wished to capture nature in its precise detail and beauty and they painted the smallest of details in their quest for realism. Their works and those of their followers coincided with developing interest in the natural and earth sciences and the development of geology. Many important geological exposures have been painted by Pre-Raphaelite artists and their attention to detail means these works can be of particular importance for studying the chronology of physical, environmental and social change around the coast.

The influence of the Pre-Raphaelites was felt throughout the art world, and many artists were inspired by their methodical approach to depicting the natural world. Although there are many example of Pre-Raphaelite coastal paintings from Britain, many artists worked in a range of countries. For example Edward William Cooke RA (1811-1880) took a keen interest in depicting the geology of the coastline with great accuracy and precision and produced works of the English, French and Dutch coastlines.

Coastal Art Colonies

A number of 'artistic schools' developed around the coastline in the 19th century and thrived until the early 20th century. They often centred on particularly aesthetic locations where artists worked together developing particular styles. 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. This trend continued until the outbreak of the First World War.

Art colonies grew in size throughout the 1800s. There were over eighty art communities around the Channel-Southern North Sea coasts of different types including villages with transient and fluctuating artist populations, for example Honfleur on the French coast and Katwijk on the Dutch coast; villages with semi-permanent visiting and residing artists, for example, Concarneau in France, St Ives on the Cornish coast and Bonchurch, Isle of Wight; and 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.

Painting by the coast was seen as a means of reverting to a simpler way of life away from the industrialisation of many European cities. The artists of the colonies shared a common aspiration to paint en plein-air (i.e. out of doors), they embraced descriptive realism and were eager to paint out of doors in front of the subject and capture the subject in its natural setting.

The presence of a coastal art colony often means there is a large legacy of paintings for the surrounding coast, many of which can contribute to understanding of changes to the coast over time.

Art and the Development of Tourism

From the mid 18th century visitors were drawn to the coast for health and leisure. In the 19th century with the expansion of the railway network and road building the numbers visiting developing seaside resorts from growing urban centres increased rapidly. The building of promenades, piers and hotels followed and fuelled this demand on both sides of the Channel coast.

Visitors wanted a record of the areas of the coast they had visited and before photography this was achieved through artworks, or copies of these. Even after the invention of photography works of art were still high in demand as they provided colour views when photographs were still black and white. For this reason paintings of the coast continue to be important for records of coastal change into the 20th century.

Early guide book publications were highly illustrated with engravings, however, in the mid 19th century they could not be printed in large enough numbers to meet demand. However, the invention of chromolithography and colour plate reproduction allowed larger print runs to be developed. Artists were commissioned to write and illustrate books which covered all part of the European coast to meet the demands of travellers and tourists. From the 1890s onwards postcards became popular with tourists, many of them featured coastal scenes. Artists were commissioned to create paintings for use as postcards.

The popularity of Oostende as a tourist resort means there are a wealth of coastal artworks showing prominent features and people enjoying the coastline. The position of the specific area of the SARCC pilot project to the west of the town means that it is not so frequently painted as areas closer to the town centre.

4.1.2 Results of Art Scoring

The development of the scoring system for works of art is described in SARCC Maritime Atlas: Methodology Report (MAT, 2022). Details of each artwork have been entered into the project database, including information on artwork type, medium, subject matter, time period and other parameters, the database was then able to calculate the scores for works of art from the pilot study site. Artworks were scored and analysed for the project, the highest scoring art works were:

Art UID	Source Title	Artist	Date	Score medium	Score period	Score style	Score heritage	Score environ	Total Score
502	View of Oostende 1854.	Unknown	1854	Watercolour	1840 - 1880	Topographical/ beach & coast	Provides detailed understanding of coast	Detail of shoreline position	96
376	HMY Victoria and Albert 1 approaching Ostende, 18 Oct 1843. Royal collection Trust	Alexandre Francia	1843	Watercolour	1840 - 1880	Marine/ shipping subjects	Provides detailed understanding of coast	Detail of shoreline position	92
467	Oostende Station.	Unknown	1846	Watercolour	1840 - 1880	Caricaturist / genre subjects	Supports understanding of coast	Riverside scene	85
503	Battle of Nieuwpoort 1600.	Unknown	1600	Etching	Before 1770	Topographical/ beach & coast	Suggests position of coast	General coastal view	81
373	Ostend et Strand.	Unknown	1862	Litho/ fine pencil/ watercolour drawing	1840 - 1880	Beach & Coastal	Supports understanding of coast	General view of beach	77
464	Oostende Early C18.	Unknown	Early C18th	Litho/ fine pencil/ watercolour drawing	Before 1770	Marine/ shipping subjects	Supports understanding of coast	General coastal view	74
465	Oostende Panarama C19.	Unknown	C19th	Litho/ fine pencil/ watercolour drawing	1840 - 1880	Beach & Coastal	Supports understanding of coast	General coastal view	70
478	Mill at Mariakerke.	Unknown		Etching	1770 - 1840	Topographical/ beach & coast	Supports understanding of coast	General coastal view	70
374	Ostend from the King's Belvedere. Royal Collection Trust	Viscountess Charlotte Canning, 1817 - 61	1843	Litho/ fine pencil/ watercolour drawing	1840 - 1880	Topographical/ beach & coast	Suggests position of coast	General view of beach	66

Art UID	Source Title	Artist	Date	Score medium	Score period	Score style	Score heritage	Score environ	Total Score
433	Mariakerke (St Amand Escuut) 1888.	Eugene Wolters	1888	Oil painting	1880 - 1920	Topographical/ beach & coast	Supports understanding of coast	General view of beach	66
483	Ostende Pavillion Du Rhin	Unknown		Litho/ fine pencil/ watercolour drawing	1840 - 1880	Topographical/ beach & coast	Suggests position of coast	General view of beach	66
375	Fisherfolk on the Beach, Ostend.	Samual Prout (1783-1852	1810	Watercolour	1770 - 1840	Topographical/ beach & coast	Suggests position of coast	General view of beach	66
466	Oostende port entry.	Unknown	1846	Watercolour	1840 - 1880	Caricaturist / genre subjects	Supports understanding of coast	General coastal view	62
479	Vue de L'ancien phare.	Unknown		Etching	1770 - 1840	Topographical/ beach & coast	Suggests position of coast	General coastal view	62
468	Ostend Bathing 1846.	Unknown	1846	Litho/ fine pencil/ watercolour drawing	1840 - 1880	Caricaturist / genre subjects	Supports understanding of coast	General view of beach	62
498	Ostende entrance to port.	Unknown	1854	Litho/ fine pencil/ watercolour drawing	1840 - 1880	Marine/ shipping subjects	Suggests position of coast	General view of beach	62

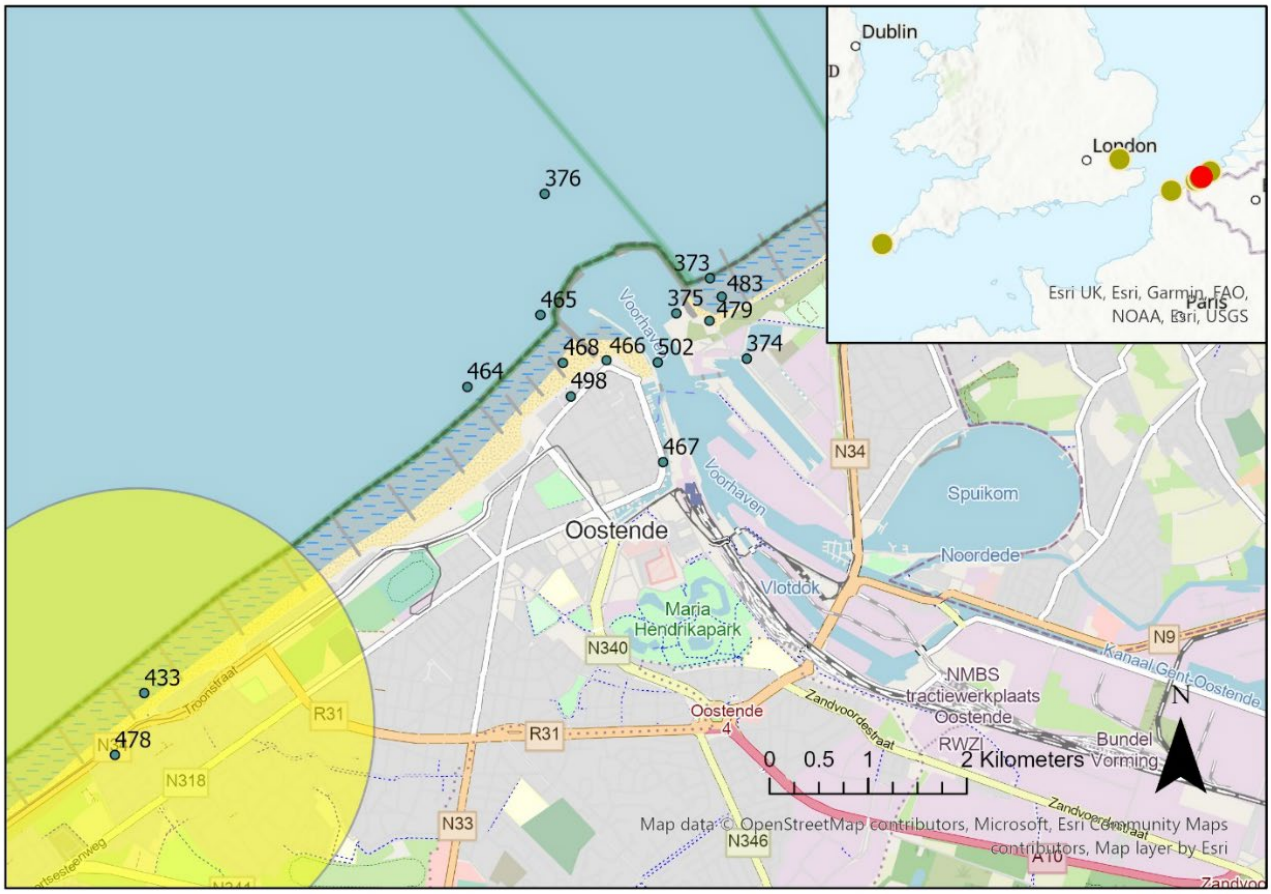

Figure 34: Distribution of the highest scoring art works within the pilot study area and those showing nearby Oostende.

4.1.3 Discussion of Scoring Results

Only three artworks were found to feature the actual pilot area itself. A painting by Eugene Wolters (ID 433) (Figure 35) dated 1888 features the foreshore in front of the church, where a sailing boat and rowing boats have been pulled up out of the water. A similar scene was painted by Alfons De Clerck c1900, this example

include the same church in the background and the rooves of two other buildings, a single sailing boat is moored alongside. An etching by an unknown artist thought to have been made 1770-1840 (Figure 36: ID 478) features a windmill in the dunes in the foreground, overlooking the sea. The church is again visible in the background, together with several houses (also in the dunes) and farmers herding a cow.

Figure 35 (Left) ID 433 Eugene Wolters: Mariakerke (St Amand Escuut) 1888.

Figure 36 (Right) ID 478 The Mill at Mariakerke

Other images to the north-east have been included within the review of art works. These are typically views from the sea, looking towards land, and so can be used to chart the changing urban frontage at Oostende. The top scoring image (ID 502) is one such view captured in 1854. This view captures, the port, shipping, the beach with people and beach huts, the fortifications and the buildings along the seafront and stretching

further back into the city. In this image like many others, landmarks such as the lighthouse (also ID 479, also see Section 4.1.4), windmills (also ID 478) and churches (ID 433) can be used to locate positions and chart changes. Ships arriving at the port is a common theme (ID 466 and 498), as are touristic beach scenes (468) and fishing scenes (375). Oostende art works also capture battle scenes (ID 503).

4.1.4 Field Survey of Art Locations

Following scoring of the artworks a number of examples have been the subject of more detailed analysis involving a site visit. Where it was practical to gain access and relevant to the study, present day photographs were taken in the field to try, as far as possible, to match the views painted by the nineteenth and early twentieth century artists. It also provided the opportunity to assess the conditions of the shore to note changes that may have taken place over time. This ensured that thorough comparison could be made between the situation depicted in the artwork and the present-day situation (Figure 37 and 38).


Figure 37: ID467 Oostende Station 1846 (Courtesy of Stadsarchief – De Benne, Blankenberge), and a similar view today


Figure 38: ID479 The Lighthouse (Vue de L'ancien phare – unknown artist), and a similar view today from Google Maps (the lighthouse on the right blends into the neighbouring white building).

4.2 Photographs

Photographs are an invaluable resource to support coastal change studies because they represent true depictions of the landscape; there is not the need to rank them in the same way as artworks (where views may be susceptible to interpretation and variation). For photographs to be used to assess how they can support studies of coastal change the two key issues are the content (in terms of what the image tells us) and the quality of the image. Because of the dynamic nature of this coastline historic photographs can be a particularly valuable resource with many historic photos containing depictions of the shore and sea front with recognisable heritage features nearby, including buildings, quays and bridges. These can be compared to the modern situation and from this an accurate idea of the rate of erosion since the date of the photograph can be gained.

A total of 22 historic photos were assessed as part of the project, images include those from locations within the pilot area where historic paintings and archaeological sites were also known. The photographs were collected and then scored using the methodology outlined in SARCC Maritime Atlas: Methodology Report (MAT, 2022). The study and scoring of historic photographs highlights the potential for historic photos to provide information on coastal change. Sources and archives used included a range of national, regional and locally based resources that are available online.

4.2.1 Results of Scoring

This pilot area has a range of available historic photographs and postcards some of which depict the aftermath of storms.

22 photographs were entered into the project database, information on the scoring of all of these images has been included in the table below. Figure 39 shows the distribution of the images and the table has the detail of their subjects and scores.

Image ID	Title	Year	Purpose	Score Heritage View	Physical Image State	Total Score
1388	Ostende Digue Ostende Mariakerke		4	3	3	100
1330	Ostend beach. National Archief, copyright holder unknown	1950	4	2	3	77
1389	Ostende 1924_La mer	1924	4	2	3	77
1379	1953 Oostende flood	1953	4	2	3	77
1381	Mariakerke Dunes. Geneanet (CC BY-NC-SA 2.0)	1900	4	2	3	77
1383	Mariakerke the beach and the hotels. Geneanet (CC BY-NC-SA 2.0)		4	2	3	77
1385	Mariakerke beach sea and promenade c1950s. Geneanet (CC BY-NC-SA 2.0)		4	2	3	77
1384	Mariakerke beach low tide. Geneanet (CC BY-NC-SA 2.0)		4	2	3	77
1386	Mariakerke, gun observatory on the Promanade. OldThing.de	1916	4	2	3	77
1387	Mariakerke La Digue. Hippostcard.com	1951	4	2	3	77
1380	Mariakerke Bathing Machines and hotels low tide. Geneanet BY-NC-SA 2.0)		4	2	3	77
1408	Flooded city of Oostende		3	2	3	77
1406	Storm of 1953	1953	4	2	3	77
1409	Overtopping in Oostende		4	2	3	77
1279	Oostende First Trading Dock	1900	4	2	3	77
1446	Mariakerke the beach, promenade and the hotels. Geneanet (CC BY-NC-SA 2.0)		4	2	3	77

1449	German Bunkers. Beeldbank, model licence for free use Attribution: 4.0 international	1942	4	2	3	77
1451	Parish Church of Our Lady of the Ascension.	1914	4	2	3	77
1450	Parish Church of Our Lady of the Ascension 1900. JoJan CC BY-SA 3.0	1900	4	2	3	77
1390	Ostende_fine montage of views	1884	4	2	2	66
1382	Mariakerke Aerial view towards the beach	1935	4	1	3	55
1407	Sinterklaas storm 2013	2013	4	1	3	55

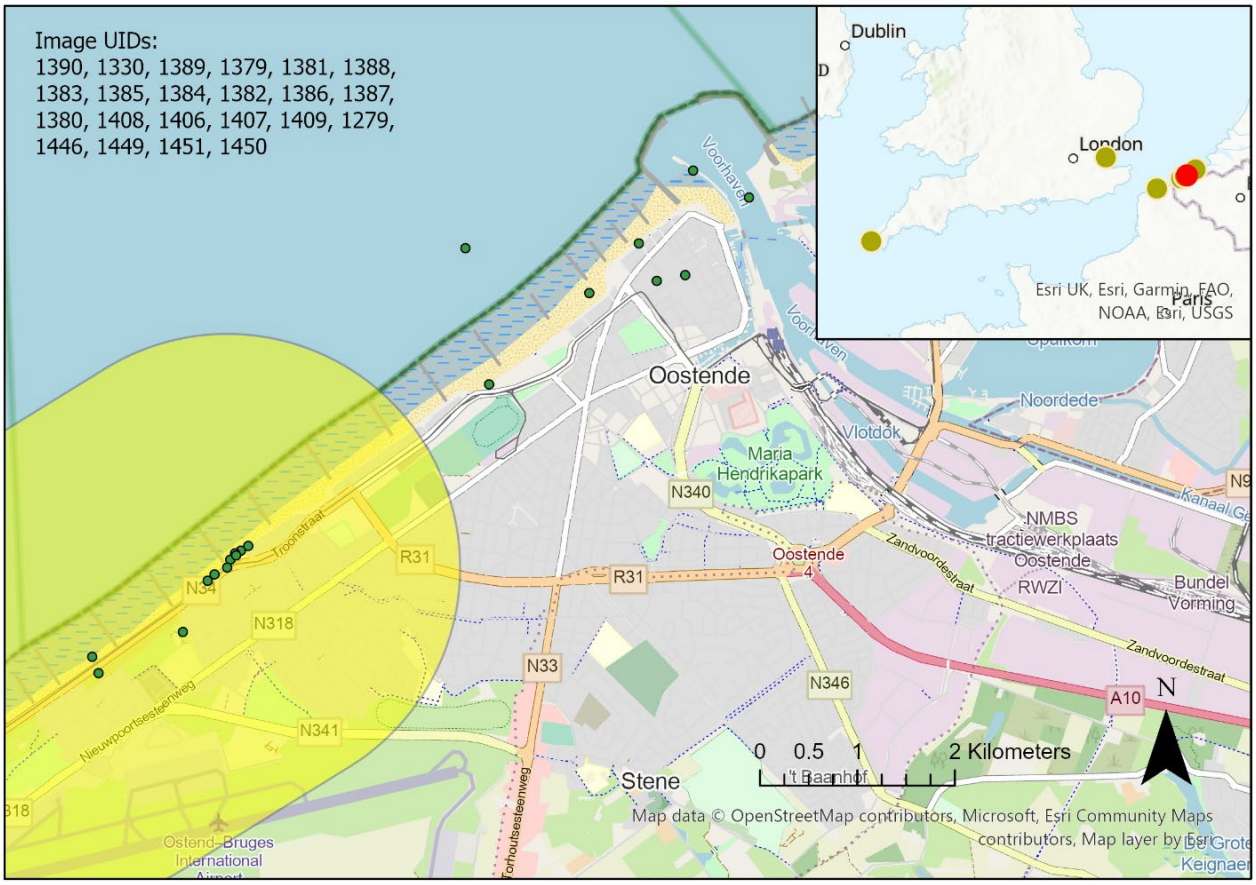

Figure 39: Distribution of high scoring historic photographs and postcards around the Oostende Pilot Area.

4.2.2 Discussion of Scoring Results

The majority of the top scoring images are touristic views that feature the beach and the seafront at Mariakerke. The top scoring image ID 1388, is a classic beach scene captured in the early 1900's with hotels in the background and dunes in the foreground. Two other images also feature the dunes (ID 1381 and 1382). Six images feature storms, flooding and waves crashing over the sea wall (ID 106-109, 1379 and 1389). Two of the images show WWI (ID 1386) and WWII (ID 1449) military installations built into the bunkers. The parish church of Our Lady of the Ascension is featured twice in the top scoring photographs (ID 1450-1), and also featured as a top scoring archaeological site. ID 1451 shows the damaged it sustained during WW1.

4.2.3 Field Survey of Photograph Locations

Following scoring of the photographs a number were the subject of more detailed analysis involving a site visit. Where it was practical to gain access and relevant to the study, present day photographs were taken in the field to try, as far as possible, to match the views. It also provided the opportunity to assess the conditions

of the shore and to note changes that may have taken place over time through comparison of the features shown in historic photographs and the present-day situation. Examples are included below (Figures 40 – 42), with further examples in Section 5.

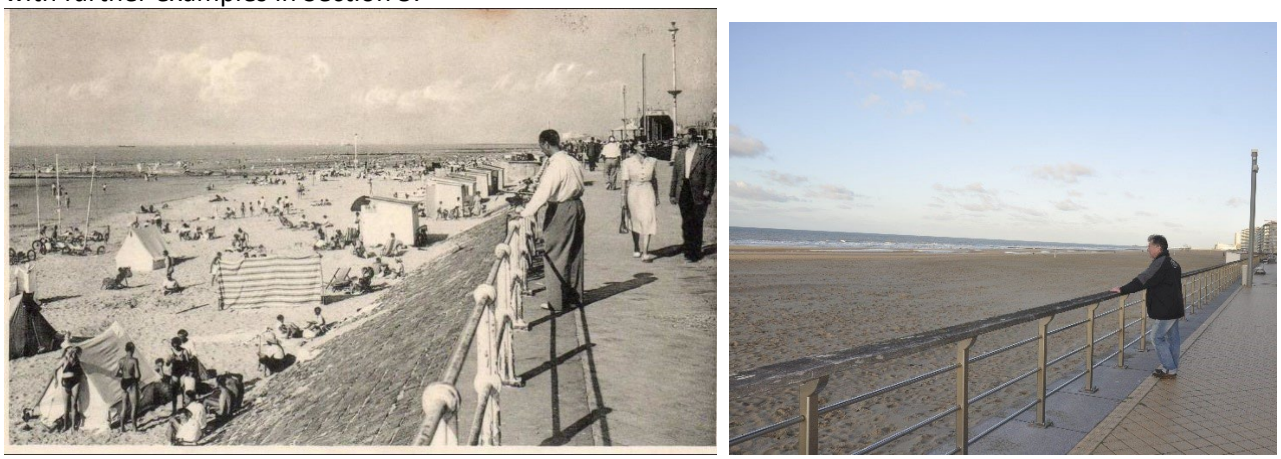

Figure 40: (left) Historic photograph [ID 1385] Mariakerke beach sea and promenade c1950s (Geneanet (CC BY-NC-SA 2.0)), with the comparative modern day image (right) (MAT 2021)

Figure 41: (left) Historic photograph [ID 1384] Mariakerke beach low tide (Geneanet (CC BY-NC-SA 2.0)), with the comparative modern day image (right) (MAT 2021)

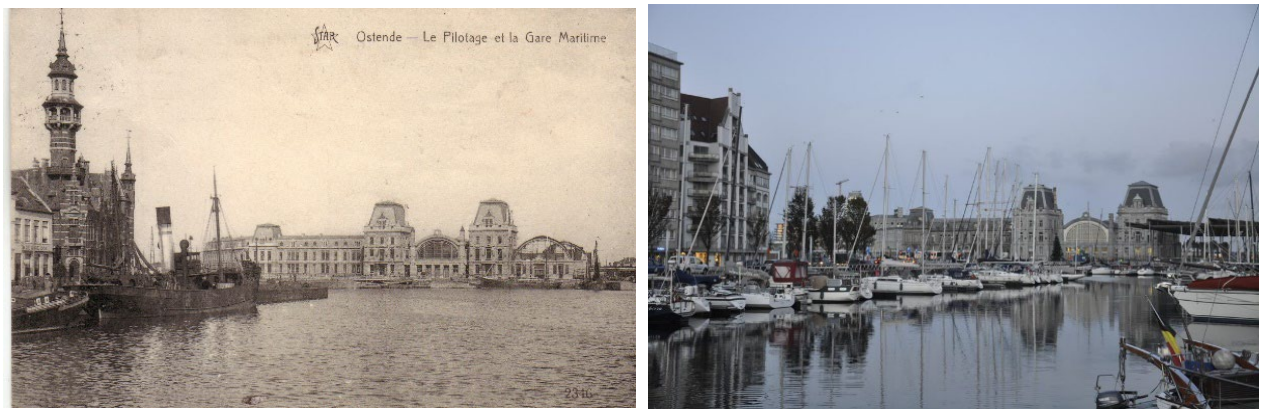

Figure 42: (left) Historic photograph [ID 1279]Oostende First Trading Dock in 1900, with the comparative modern day image (right) (MAT 2021)

5. Combined Application for Analysis of Coastal Change

The above sections have demonstrated the potential of each type of resource – archaeological, palaeoenvironmental, artistic, maps and charts and photographs – to be assessed and analysed to inform on the scale and pace of coastal change. When these resources are utilised together to look at particular areas or features this provides an exceptionally powerful set of data to be able to understand the long-durée of

the coastline. In addition to the frontage that is directly adjacent to the Pilot Area there are a number of other features on the nearby areas which help show and understand how the local shoreline has changed. These are explored further here.

5.1 Beach Frontage Adjacent to Pilot Area

Why selected for detailed study: The beach front at Mariakerke is the site of the SARCC pilot study for Oostende. This area has a very low-lying road with tramway and has no protection from the encroaching sand after bad weather as the protective dunes are behind the road, stormy weather can have a severe impact on this area.

Detail from scoring of available resources: A combination of resources can be linked to get a picture of the development of Oostende over time through looking at various features associated with the developing town, the coastline and dunes, and the port.

- Archaeology – the area adjacent to the pilot area contains a polder landscape, the dune strip is completely enclosed between the buildings of Raversijde-Bad and Mariakerke-Bad. The soils and vegetation can help tell the story of coastal change in this area. The top scoring entry is the Dune and Polder landscape between Oostende and Nieuwpoort (Site ID: 5100).
- Maps/ Charts – The map by Bleu of 1645 (ID 344) depicts the coastline very well showing considerable dune protection in the area adjacent to the pilot study area and all along this coastline. The importance of this protection in the study area is still evident in the chart from 1966 (ID: 336).
- Art – Art works that show how the coast was depicted can particularly be seen in the coastal scene from Nieuwpoort to Oostende in 1816 which appears to be before the road was constructed in front of the dunes (ID: 436). Another artistic image shows the mill at Mariakerke high amongst rolling dunes close to the sea front (ID: 478).
- Photographs – The top scoring photograph (1388) has a detailed view of Mariakerke beach which includes beach level, the adjacent road, and the sand dunes behind the road. Many of the photographs/postcards have a high score as they show the beach front with a clear indication of the struggle to keep on top of the eroding beach. Aerial views of the area indicate the vulnerability of the low-lying coastal town.

How the combined resources inform on coastal change: Archaeological and paleoenvironmental evidence can tell the story of the recent changes in the coastline and also can be used for dating back thousands of years (5100). Thin humic horizons in the soil profile indicate the presence of old vegetation surfaces that have been drowned. The coastal dune soils are transitional soils: they are dune sand soils, whether or not containing silt, resting on polder deposits. Removal of peat in Roman and Medieval times resulting in lowering of the land surface allowing the sea to come further inland was discussed in Section 2.3 along with an image of the remnants of peat excavation Figure 13.

The historic postcard Figure 17 in Section 2.4 which is from around c1900, shows Mariakerke with the beach level quite low to the roadway, while the dunes to the right of the road are quite high. The modern image Figure 16 from the same area shows replenishment of the beach using planted dunes to create a natural landscape along the seawall. This should allow a dune landscape enough space to develop through the natural dynamics of waves and wind so keeping the sand from encroaching onto the tramway and road. Apart from allowing encroachment of the sea, the blown sand is causing a nuisance in terms of disruption to the tram and road traffic, and is also costly because of constantly clearing the sand which cannot be put back onto the beach because it is contaminated.

Other images that contrast beach levels in the area of Mariakerke are Figure 40 within Section 4.2.3, and below where Figure 43 shows the considerable difference in the beach level between 1900 and today.

Figure 43 (left) Mariakerke Beach with hotels taken around 1900 (ID: 1024) (https://nl.geneanet.org/prentbriefkaarten/view/7699848#0 Geneanet, Creative Commons (BY-NC-SA 2.0)), shows the beach level to be very low. Modern image on the right from Nov 2021 shows the beach levels much higher, the buildings have been replaced post-war and sand levels are being replenished to prevent erosion.

The coastal scene from a painting by John Wilson (436) in Figure 44 is that of the area between Nieuwpoort and Oostende in 1816. The protective dunes along the coast at the back of the beach are depicted running along this stretch of coast, and evidence of partially buried wooden posts are in the foreground. The modern photograph from Google street map view shows that area today where a road and tramway now run in front of the dunes. A windmill within Figures 44 and 45 are believed to be the same structure.

Figure 44: (top) A coastal scene between Nieuwpoort and Oostende 1816 (436). John Wilson. National Gallery of Scotland. Creative commons CC-BY. https://www.nationalgalleries.org/art-and-artists/5596/coastal-scene-between-nieuport-and-ostend), note a windmill can be seen on the top of the dunes on the right side, (bottom), the street view image from the present shows the area now with the road in between the beach and the dunes.

Figure 45: The undated art image 'Mill at Mariakerke' shows what is thought to be the same windmill as in Figure 44, this time looking the opposite way along the coast (Blankenberge Archive, Courtesy of Stadsarchief – De Benne, Blankenberge).

When comparing the extensive dune protection seen on the Blaeu map of 1645 with the chart from 1966, it can be seen that dunes are still evidenced (Figure 46). The postcard below the maps from Middelkerke (ID: 1381) is showing people relaxing in the dunes at Middelkerke around the early 20th century which demonstrates that dunes were still substantially present at this time (Figure 47). The photograph also provides the topographic detail to add the third dimension which it is difficult to determine from map and chart projections.

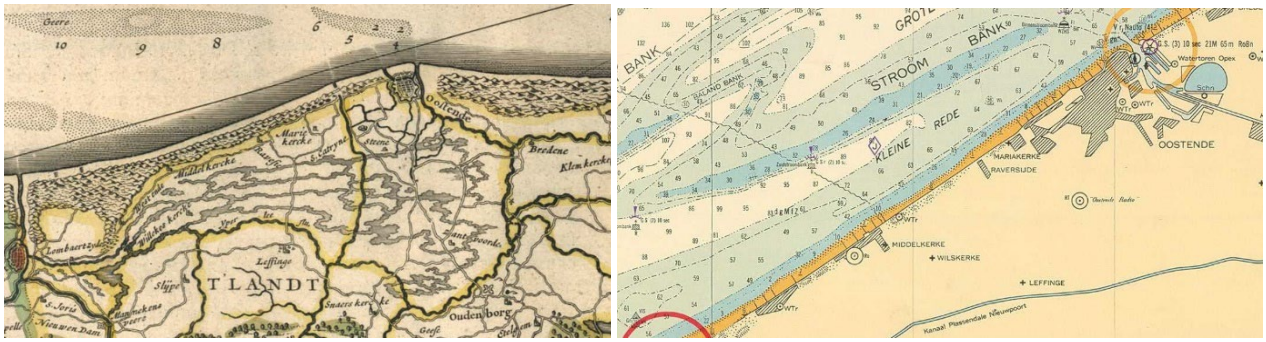

Figure 46. The map by Blaeu 1645 Flandriæ_Teutonicæ pars orientalior wikimedia commons (left), 1966 chart (right), Hydrographic Service of the Oostende Coast Creative commons non-commercial share alike (BY-NC-SA 4.0)

Figure 47. People relaxing amongst the dunes early 20th century.
Creative Commons (CC-BY-NC-SA 2.0) https://nl.geneanet.org/prentbriefkaarten/view/7699849#0

5.2 Coastal Dune System & Historic Structures

Why selected for detailed study: Dune features are hugely important to combatting the impacts of sea level rise as they dissipate wave energy and help protect habitats and land situated behind them. They are apparent on historic images and maps of the Oostende area which show that they have always featured heavily in this low-lying landscape. They can also help measure the scale and pace of coastal change through using historic structures associated with them such as the bunkers from both World Wars at Raversijde to measure the movement and levels of sediment.

Detail from scoring of available resources: A large number of the resources consulted included information on the dune systems and/ or historic structures associated with them, or located nearby.

- Archaeology – One of the high scoring entries is the Atlantic Wall along the coast from Raversijde to Mariakerke which is known as 'Domein Raversijde' with 'Memorial Prince Karel' (ID: 4913), it is a military site from both World Wars and an archaeological site that is protected by Royal Decree of 5/5/1959. Hard structures can be positively dated so have a role in assessing the movement of dunes or sea level from studying maps and images. Also present is the Parish Church of Our Lady of Assumption (ID: 5346) which is on the site used for a church building from the fourteenth century and the Fishermans cottage built in 1822. The location of some structures can be explored through their depictions on historic maps - such as the chapel that was present in Raversijde the tower of which was demolished in 1860.

- Maps/ Charts – over the centuries these have depicted the presence of dunes all along this part of the French and Belgium low lying coast. In some cases historic structures are associated with them which enables further dating evidence. Examples of dune systems are seen some of the maps below and the archaeology within them can help tell the story.

- Art – many artworks picture dunes, whether reproducing battles that have taken place along this coast, attractive coastal scenes, or tourist etchings. They give an indication of the height and extent of the dunes at the time of the artwork.

- Photographs – old photographs, whether from military activity such as the WWI and WWII German bunkers at Ravesijde, or from tourist postcards can be used to directly compare the form of dunes and structures to modern day.

How the combined resources inform on coastal change: The coastal dunes that have been a feature of this coastline for centuries are witnessed on historic maps and charts, some have had structures, and some still have historic structures built within them which feature on maps and historic coastal images. The importance of these protective dunes is evident on historic maps. The maps of 1645 and 1966 in Section 5.1 show dunes along the coast, they can also be seen on the map of 1562 in Section 5.3 (Figure 53) and are depicted all along the coast on maps of the siege of Oostende 1601-1677, Corenelli's map of 1697 (ID: 324), and the 1842 map of Oostende (ID: 377) (Figure 48).

Figure 48. (top): The siege of Oostende 1601-1607 (ID: 392) Courtesy of Stadsarchief – De Benne, Blankenberge. (middle): Coronelli's Map of 1697 (ID: 324). Courtesy of mzk museum http://www.vliz.be/hisgiskust/en/image-library?album=4905&pic=111861, (bottom): Oostende map of 1842 Courtesy of Stadsarchief – De Benne, Blankenberge

There was a chapel at Raversijde which was the last remnant of the Medieval village, the tower was demolished in 1860. The chapel is evident on the map of 'A plan of Oostende 1760' (ID: 424), Figure 49 shows part of that map showing the area of Raversijde where the chapel is clearly seen along with the extensive dune system protecting it from the sea. The Parish Church of our Lady of Assumption (ID: 5397) situated on Dorpsstraat is in a position used for a church from the 14th century, with the church having had several rebuilding phases. It is in an unspoilt belt of dunes and is better known as 'het Duinenkerkje' (The Dune Church), is also present on the map of 1760 below. The Church and its open location is shown in Figure 50 from 1914 during WW1, the modern view (Google street view Figure 51) shows the area much more built up to the east but still quite open to the west. The German occupying forces demolished the tower of the church because it served as a target for the British Fleet. The church was renovated in 1929. The last remaining fisherman's cottage built in 1822 can be seen just to the right of the church (small white building). There is an earlier image of the church c1900 still complete with its tower (Figure 50).

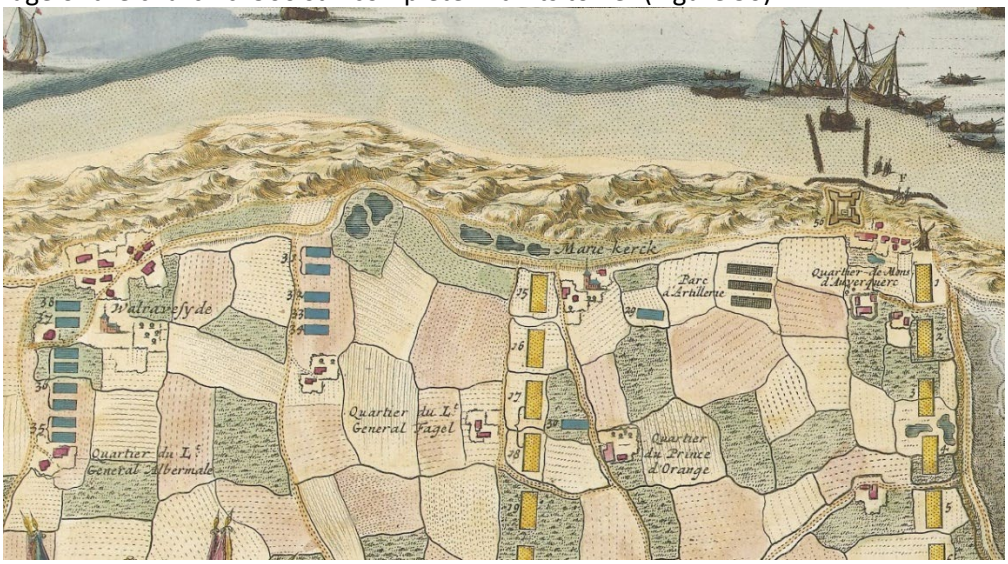

Figure 49. A plan of Oostende 1706. Jacobus Harrewijn. Rijksmuseum, CC0, via Wikimedia Commons CC0 1.0 Universal Public Domain Dedication

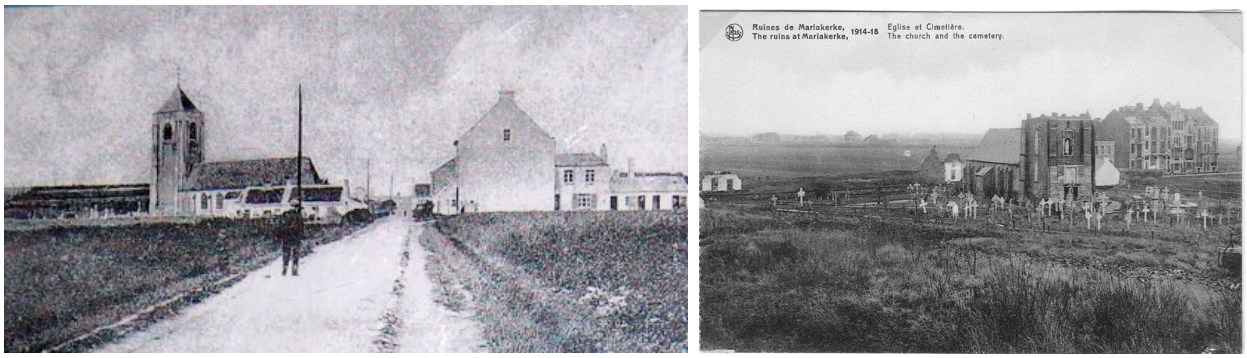

Figure 50: Left the Church of Our Lady of Ascension in c1900 (JoJan CC BY-SA-3.0) right is the church in 1914 with demolished tower. https://www.deplate.be/trefwoorden/dorpsstraat

Figure 51: Modern view showing the Church of Our Lady of Ascension, with it's renovated chapel (Google Maps Street View)

Along the roadway to the west of the pilot site are the remains of the military bunkers which were built into the dunes at Ravesijde during both World Wars. Knowing exactly when these structures were built provides a reliable dating tool for measurement of any changes occurring around the dunes in this area, and they will show up on charts and maps, therefore adding information regarding sea level and coastal change. Figure 52 shows how close these were to the paved road which was constructed in 1904 when the pedestrian dyke between Middlekerke and Mariakerke was converted into a permanent sea dyke. The tram tracks were originally close to the dunes but were moved to the sea side of the road. The image at Figure 18 in Section 2.4 shows a modern aerial view of the line of these structures forming the 'Atlantic Wall'. Comparisons with these photographs and military maps from WWll (as discussed in Section 3.1) can help to judge if these structures were in the same position in comparison to the road.

Figure 52. German bunker at the Atlantic Wall (1031). Beeldbank, model licence for free use Attribution: 4.0 international

5.3 Oostende Harbour and Lighthouse

Why selected for detailed study: The Harbour has continually developed over the centuries as first, great storms swallowed up the land and therefore changed the shape and location of the harbour. It was later developed as the relationship of the town and the waterside became more fixed, trade increased and the town grew. Comparing the different resources for the harbour can help understand how the sea level might have changed and how the harbour might have been adapted to keep pace with this.

Detail from scoring of available resources: A large number of the resources consulted included depictions of the harbour and historic structures associated with it.

- Archaeology – The lighthouse erected in 1771 on the west side of the harbour entrance can help to gauge changes in this area of the sea front. Although the lighthouse was destroyed in 1944 a memorial now stands at the same location.
- Maps/ Charts – The many maps and charts that scored highest showed features that included the waterways and inlets around the town and inland. The early map by Jacob Deventer (ID: 356) from 1562 shows the position of the town and the port before it moved further back from the sea as seen in later maps below (1601-1604) (ID: 389) and 1706 (ID: 424)). The late nineteenth century map anonymous engraving (ID: 241) gives a very detailed view of the harbour at that time, including the position and state of the various lighthouses.

- Art – Higher scoring art shows the beach front detail, the view of Oostende 1854 gives a good indication of the harbour entrance detail that can be compared with maps such as the 1842 map (ID: 377).
- Photographs - A photograph of the dock from the turn of the twentieth century compared with a modern image of the same location shows little change in sea level movement (Figure 56).

How the combined resources inform on coastal change: Studying maps over time reveal that changes have occurred around Oostende and its Harbour as it moved back from the coast giving some indication of changing sea level. The Jacob van Deventer map of 1562 (Figure 53) shows the town and harbour close to the open sea with the remains of the island of Testerep affording some protection. During the golden Age of prosperity in the sixteenth century the city moves to a new location, canals and dykes join Terserep, and the south of the city is tactically flooded. The map of 1601-1604 (Figure 53, right) depicts the heavily fortified city surrounded by waterways and Testerep split from the mainland by a waterway but with canals and dykes keeping contact.

Over the years, following major storms, the submergence of Testerep and coastline retreat, the town and harbour of Oostende gradually moved back from the coast as can be seen in the map of 1706 (ID: 424) (Figure 54). Later maps, such as one shown here from the late 19th century (Figure 55), shows that the coastline then remains stable.

Figure 53: (left) Oostende in 1562, (ID: 356) Jacob van Deventer, Public domain, via Wikimedia Commons Source https://upload.wikimedia.org/wikipedia/commons/9/96/Oostende_map_Jacob_van_Deventer.png and right shows the fortification of Oostende in the Siege of Oostende 1601-1604 Courtesy of Stadsarchief – De Benne, Blankenberge

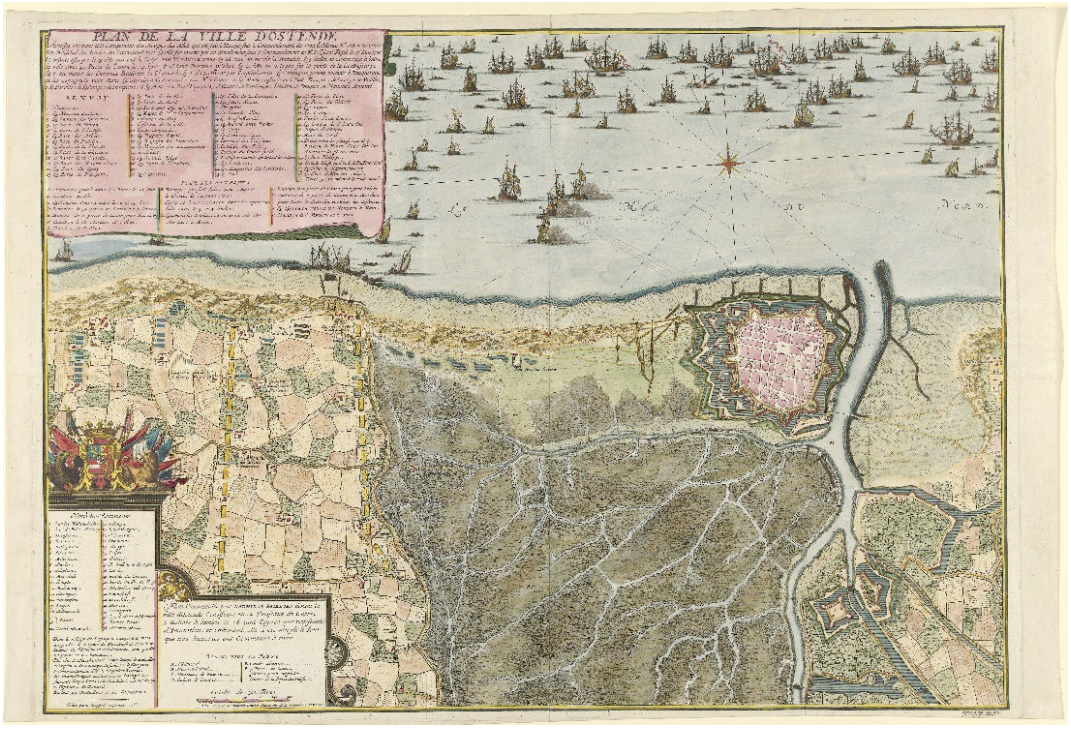

Figure 54: A plan of Oostende 1706. Jacobus Harrewijn. Rijksmuseum, CC0, via Wikimedia Commons CC0 1.0 Universal Public Domain Dedication

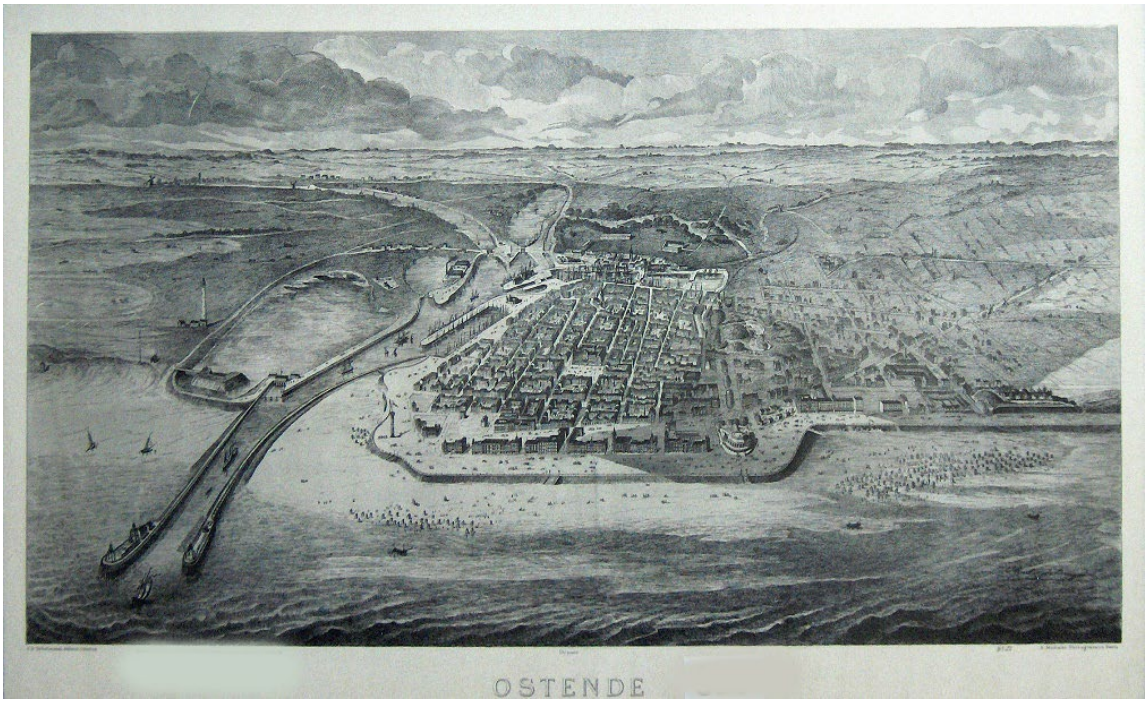

Figure 55. Ostend late 19 Century anonymous engraving. Georges Jansoone (JoJan), Public domain, via Wikimedia Commons

A postcard c1900 listed as 'Oostende first trading dock' compares well with the modern image taken from the same location in November 2021 (Figure 56). It shows Oostende railway station building in the distant centre (the same building as in the older image), and apart from the modern apartments now present on the left-hand side of the dock and modern vessels, the scene and waterway has changed little suggesting stability.

Figure 56. The First Trading Dock c1900 (copyright unknown https://www.deplate.be/content/postkaart-havengeul-27), shows the Sea level to be stable compared with modern image on the right (MAT).

The lighthouse at Oostende known as Lange Nelle today stands on the east side of the harbour and was built in 1947 and the entrance to the harbour is now extended and widened. Light beacons were recorded at Oostende since 1366 then a stone cylindrical lighthouse was built on the west side of the harbour in 1771, Figure 57 below shows the harbour entrance with the lighthouse c1854 the position of the lighthouse is shown on the map of 1842. A tourist tower and pavilion were built around it and can be seen in the 1854 map, but this was demolished in 1877 due to lack of public interest. In 1860 a new lighthouse was built on the eastern side of the harbour and the light was switched off on the western lighthouse as it could no longer be seen from the west due to increasing construction of the seawall. This new structure was destroyed during the First world War when the 1771 lighthouse came into use again for a number of years until a framework tower was erected on the eastern side in 1925. Another lighthouse was built here but destroyed in 1940. The 1771 lighthouse was demolished by order of the German occupiers in 1944.

The late 19th century engraving (Figure 57) shows the position of the 1771 (west) and the 1859 lighthouse (east), note the public pavilion around the old lighthouse is no longer present on this map. Once inside the harbour entrance the lead into the main harbour has remained stable (but has been widened) as can be seen from the Google maps image (Figure 58), the red pin indicates the position of the current lighthouse on the eastern side of the channel. A seaman's memorial erected in 1953 now stands in the location of the old lighthouse, the memorial at this location can continue to serve to gauge future changes.

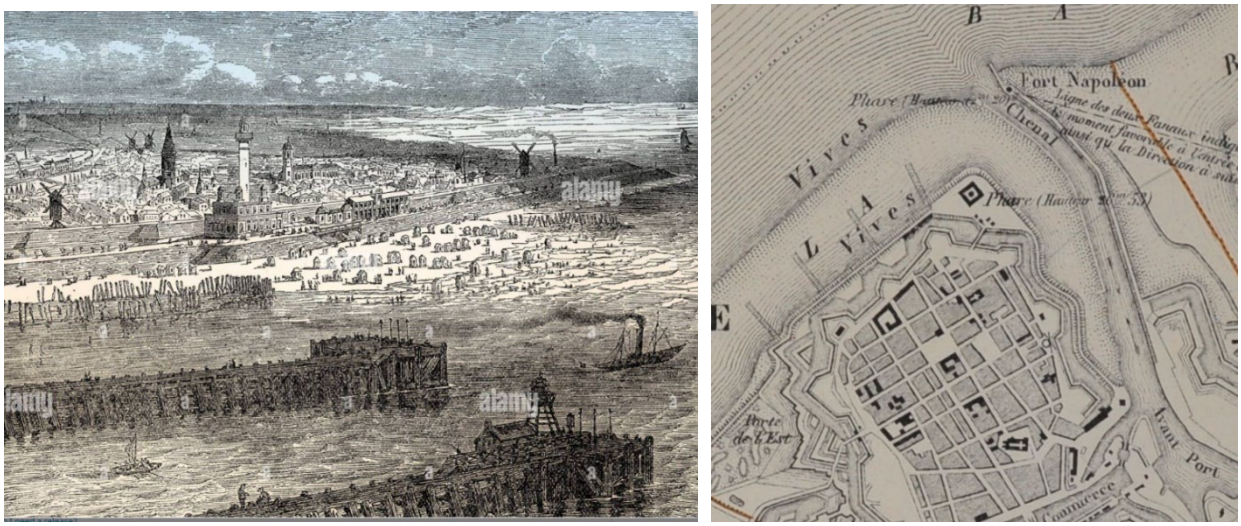

Figure 57: Image of Oostende lighthouse and harbour c1854, and its position on map of 1842. Public domain, Historical view of Ostend (https://www.alamy.com/historical-view-of-ostend-flanders-belgium) and image right Courtesy of Stadsarchief – De Benne, Blankenberge

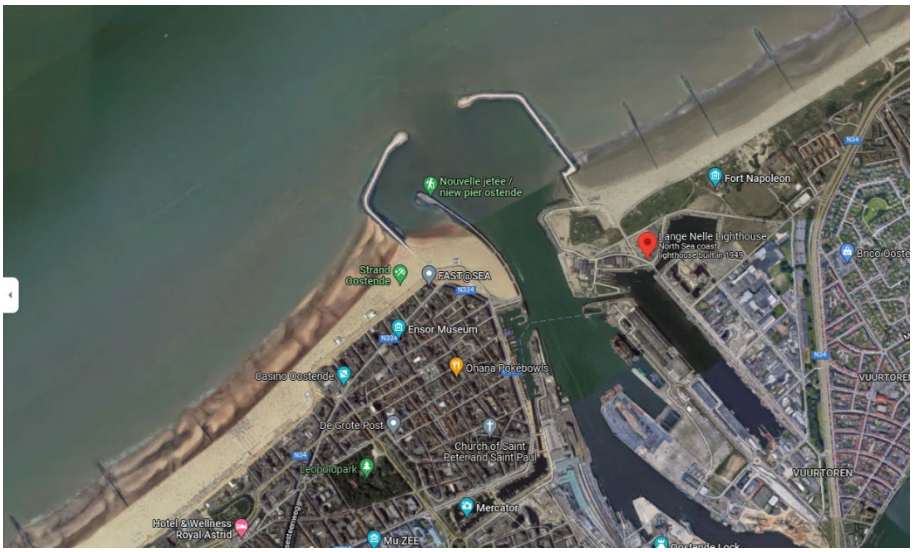

Figure 58: Google Map image of Oostende Harbour with position of the present Lange Nellie lighthouse at red pin (accessed 15/2/22)

In this nineteenth century artistic image from the Blankenberge archive below titled 'Promenade and the Dyke' (Figure 59), the entrance to the port and the lighthouse are in the background. It can be seen that the seawall is becoming substantial which eventually obscured the light to sea traffic approaching from the west so a new lighthouse was erected on the east side of the port.

Figure 59: Promenade and the Dyke, 19th century. Courtesy of Stadsarchief – De Benne, Blankenberge

6. Conclusions

The variety of available sources for the Oostende area and within the Pilot Study at Mariakerke has demonstrated the potential of the SARCC scoring approach that has been applied to identify those resources of particular importance for understanding the long-durée of the coast.

Historic maps particularly show the changes to the town of Oostende which once was on, and adjacent to, a precarious sand bar. Historic maps chart the development of the town as it grew in importance, becoming a heavily fortified city surrounded by water, and then was forced to moved its location back from the retreating coastal edge environment, and the port developed as the city grew in importance.

Archaeological and historical sites provide evidence from early historic periods through to the Second World War. Combining the available resources allows us to understand change from prehistory up to the present day. Comparing artistic images and photographs along with archaeology and maps can place structures that once existed, and those that are still present today, to understand if there has been movement in this low lying coastline. The protective dunes are evidenced on maps going back centuries, the German bunkers from both World Wars now within the dunes are a good indication of the stability of the dunes and will continue to be over time.

The combination of the various available sources of data have provided detail on the form and scale of change over time – particularly with the building of structures further out into and eventually across the dune frontage. This information is of importance to coastal scientists. Through a better understanding of how the Oostende area developed, and in particular how the frontage and dune system became what it is today, coastal managers will be better placed in planning for the future.

In many coastal locations detailed monitoring has taken place for less than twenty years. This pilot study helps explain the rate of change over past centuries as a result of sea level changes, human construction and the relationship of this with apparent periods of increased storm frequency. These data can supplement existing and future monitoring of trends and can support predictions for the future.

The NBS pilot study for this area at Mariakerke is specifically concerned with the planting of dunes and the stabilisation of them to help slow down the advancement and destructive force of the sea when there is a storm along this area of the coast. When installed it will be possible to use the presence of historic structures adjacent to the features to assist in the measurement of change over time.

7. References

Adriaan, M. J. De Kraker, 2006, Flood events in the southwestern Netherlands and coastal Belgium, 1400–1953. Hydrological Sciences–Journal–des Sciences Hydrologiques, 51(5) October 2006 Special issue: Historical Hydrology.

All Saints Flood, http://www.deltawerken.com/All-Saints-flood-(1570)/304.html, accessed November 2021.

Baeteman, C. (2013). History of research and state of the art of the Holocene depositional history of the Belgian coastal plain. In: Theon, E., Borger, J. G., De Kracker, A. M. J., Soens, T., Dries, T., Vervaet, L. and Weerts, H. J. T. (Eds). Landscapes or Seascapes? The history of the coastal environment in the North Sea area reconsidered. Brepols, Belgium, pp 11–30.

De Clercq, M., Vos, P., Missiaen, T. & Pieters, M. (2013). Archeologische en Geo-archeologische indicatoren. Internal report IWT SBO Project 120003 "SeArch".

Dunkirk Transgression (2021), Wikipedia. https://en.wikipedia.org/wiki/Dunkirk_transgression . Accessed November 2021

Ervynck, A., Baeteman, C., Demiddele, H., Hollevoet, Y., Pieters, M., Schelvis, J., Tys, D. and Van Strydonck, M. (1999). Human occupation because of a regression, or the cause of a transgression? A critical review of the interaction between geological events and human occupation in the Belgian coastal plain during the first millenium AD. Probleme der Küstenforschung im südlichen Nordseegebiet, 26, 97-121.

McInnes, R. 2014, The art of the Channel-Southern North Sea Region. Arch Manche Technical Report https://archmanche.maritimearchaeologytrust.org/uploads/images/Documents/Technical_Report_Section_One.pdf

McInnes, R. & Stubbings, H., 2010. 'Art as a Tool in Support of the Understanding of Coastal Change in East Anglia'. The Crown Estate. 92 pps.

McInnes, R. & Stubbings, H., 2011. 'A Coastal Historical Resources Guide for England'. The Crown Estate. 91 pps.

McInnes, R. & Benstead, S., 2013a. 'Art and Coastal Change in Wales'. The Crown Estate. London.

McInnes, R. & Benstead, S., 2013b. 'Art and Coastal Change in Scotland'. The Crown Estate. London.

McInnes, R. & Benstead, S., 2015. 'Art and Coastal Change in Northern Ireland'. The Crown Estate. London.
McInnes, R. & Benstead, S., 2013a. *'Art and Coastal Change in Wales'*. The Crown Estate. London.

McInnes, R. & Benstead, S., 2013b. *'Art and Coastal Change in Scotland'.* The Crown Estate. London.

McInnes, R. & Benstead, S., 2015. *'Art and Coastal Change in Northern Ireland'.* The Crown Estate. London.

Mathys, M. (2009). The Quaternary geological evolution of the Belgian Continental Shelf, southern North Sea (Unpublished doctoral dissertation). Ghent University, Ghent, Belgium.
Oostende, 2021, Wikipedia, https://en.wikipedia.org/wiki/Ostend, accessed November 2021.

Ostend, 2021, *Encyclopaedia Britannica*, https://www.britannica.com/place/Ostend, accessed November 2021.

Pieters M, Baeteman C, Bastiaens J, Bollen A, Clogg P, Cooremans B, De Bie M, De Buyser F, Decorte G, Deforce K, De Groote A, Demerre I, Demiddele H; Ervynck A, Gevaert G, Goddeeris T, Lentacker A, Schietecatte L, Vandenbruaene M, Van Neer W, Van Strydonck M, Verhaeghe F, Vince A, Watzeels S, Zeebroek I (2013), The archaeological research in Raversijde (Ostend) in the period 1992–2005. Flint artefacts, a Roman dike, a 14th-century coin depot, a 15th-century sector of a fishing settlement and traces of an early 17th-century and an early 18th-century siege of Ostend, *Relicta Monographs* 8, Brussels.

Pieters M., Missiaen T., De Clercq M., Demerre I., Van Haelst S. (2020) Belgium: Prehistoric and Protohistoric Archaeology in the Intertidal and Subtidal Zones of the North Sea. In: Bailey G., Galanidou N., Peeters H., Jöns H., Mennenga M. (eds) The Archaeology of Europe's Drowned Landscapes. Coastal Research Library, vol 35. Springer, Cham. https://doi.org/10.1007/978-3-030-37367-2_9

Pieters M (1993) Archeologisch onderzoek te Raversijde. Interim Verslag 1992. Archeologie in Vlaanderen II:247–264

Testerep, 2021, Wikipedia, https://nl.wikipedia.org/wiki/Testerep, accessed November 2021.

The Inundation of Walcheren, 2021, Holland Land of Water, https://www.hollandlandofwater.com/inundatie-walcheren-1944/ , accessed November 2021.

Thoen, H. (1978). De Belgische kustvlakte in de Romeinse tijd. Bijdrage tot de studie van de landelijke bewoningsgeschiedenis. Brussels: Paleis der Academiën.

Tys, D. (2013). The medieval embankment of coastal Flanders in context. In: Theon, E., Borger, J. G., De Kracker, A. M. J., Soens, T., Dries, T., Vervaet, L. and Weerts, H. J. T. (Eds). Landscapes or Seascapes? The history of the coastal environment in the North Sea area reconsidered. Brepols, Belgium, pp 199–240.

Tys D and Pieters, M (2009). Understanding a medieval fishing settlement along the southern Northern Sea: Walraversijde, c. 1200–1630 In: Sicking L and Abreu-Ferreira D (Eds.) Beyond the catch: fisheries of the North Atlantic, the North Sea and the Baltic, 900–1850, Brill, pages 91–122.

Walraversijde, 2021, Wikipedia, https://en.wikipedia.org/wiki/Walraversijde, accessed November 2021.

World War One Belguim, Ostend, 2015, https://histclo.com/essay/war/ww1/cou/eur/bel/city/w1cb-ost.html, accessed November 2021.