Clacton and Holland-on-Sea Beach Monitoring Report

13 December 2017

Tendring District Council

Mott MacDonald
Mott MacDonald House
8-10 Sydenham Road
Croydon CR0 2EE
United Kingdom

T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
mottmac.com

Tendring District Council
Town Hall,
Station Road,
Clacton-on-Sea,
Essex,
CO15 1SE

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Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
V1	13/12/17	E Smyth	V Deakin	Z Hutchison	Draft Beach Monitoring Report for comment.
V2	16/08/18	E Smyth	H Taylor	Z Hutchison	Final revision, updated appendices

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Contents

Executive summary

A monitoring survey of the recently constructed beach along the Clacton and Holland-on-Sea coastline, which forms part of the coastal protection scheme constructed in 2014-15 was carried out by representatives of Mott MacDonald on behalf of Tendring District Council between the 25th to 26th July 2017.

The Clacton and Holland-on-Sea frontage is located along the south-eastern coastline of Essex and the scheme's coastal defences comprise of 22 fishtail groynes, 1 terminal groyne and recharged beach material.

The beach monitoring programme of the Clacton and Holland-on-Sea Coastal Protection Scheme is composed of several survey techniques. These consisted of a drone elevation survey, beach profile surveys and fixed aspect photos.

Data collected from the survey has been assessed and indicates that the fishtail groynes are retaining beach material well and are establishing the predicted bay formations along the frontage. Furthermore, though the beach has experienced erosion, no overall trigger levels for beach levels and crest width were reached and accretion has occurred within all bays and usually on the more northerly groyne. This suggests the frontage has experienced a typically south westerly wave direction since construction.

The recommended approach is to continue with monitoring the beach bi-annually to observe the future evolution of the frontage.

1 Introduction

1.1 Background Information

As part of The Beach Management Plan (BMP) 2015 for the Clacton and Holland-on-Sea Coast Protection Scheme, a beach monitoring programme of the frontage is to be undertaken bi-annually. The Clacton and Holland-on-Sea Coastal Protection Scheme includes 22 fishtail rock groynes, 1 terminal rock groyne and a sand/shingle mix recharge along the entire frontage.

1.2 Location

The frontage at Clacton and Holland-on-Sea is located on a south-easterly facing section of the Essex coast and is exposed to the North Sea. The beach frontage is a sand/shingle mix material and is backed by London Clay cliffs, which are currently protected from erosion by fishtail groynes, recharged beach material, a seawall, and the promenade.

The beach monitoring programme for the Clacton and Holland-on-Sea frontage covers from the Gunfleet Boating Club in the north-eastern end to the first concrete groyne (Groyne 41) to the southwest of Clacton Pier, as is presented in Figure 1.

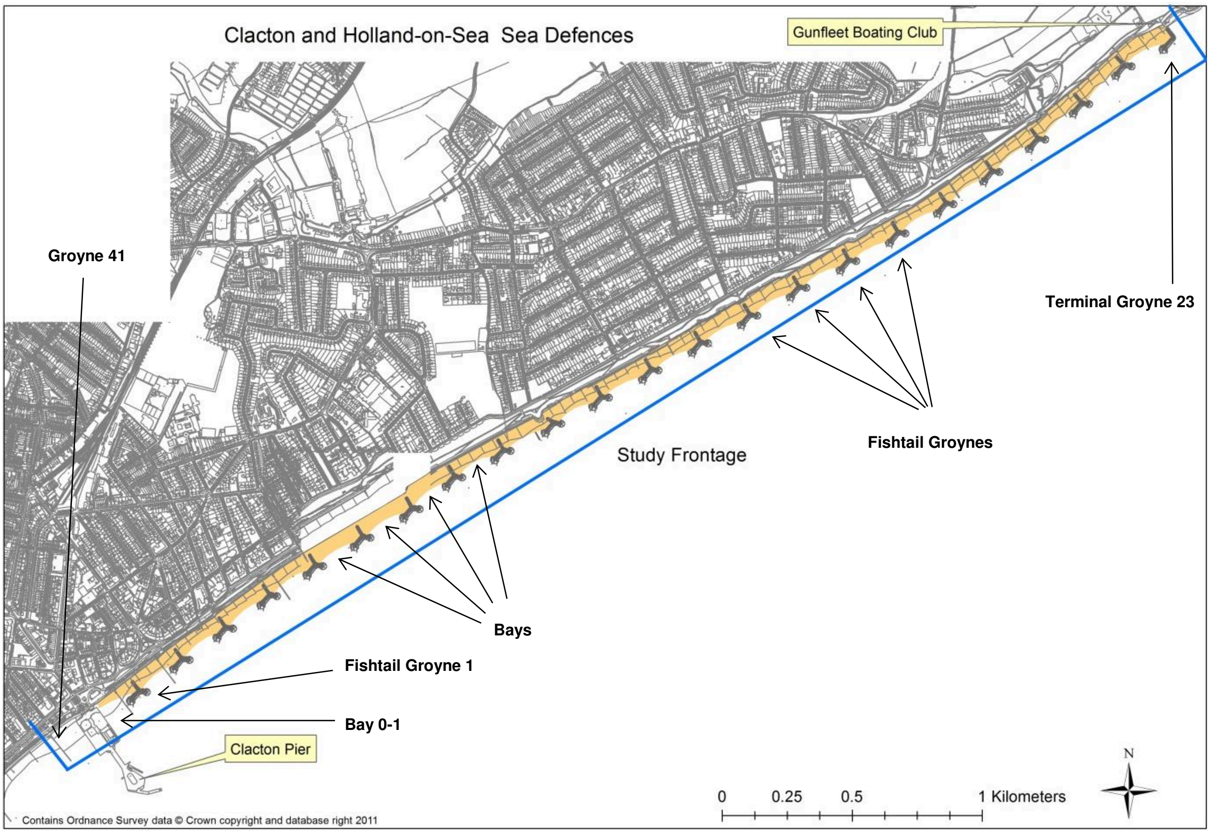


Figure 1 Clacton and Holland-on-Sea frontage covered in the BMP. (Crown Copyright, License Number LA079707 2003)

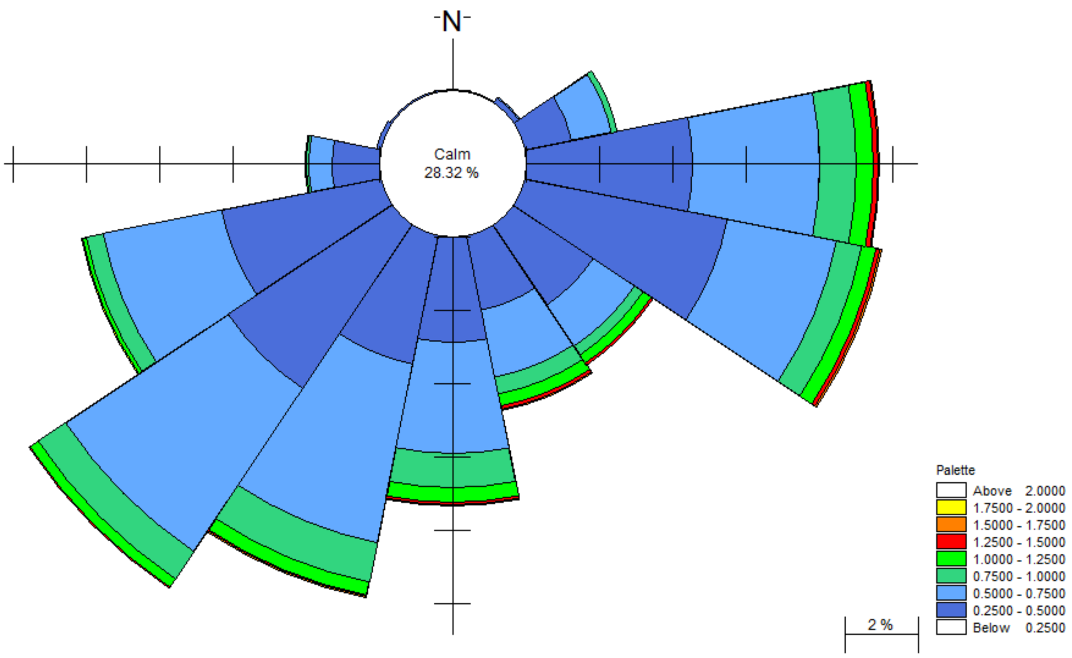
1.3 Weather Conditions

Due to no monitoring stations set up along the frontage or offshore, continuous weather conditions since construction have not been recorded. However, the general weather condition experienced along the Clacton and Holland-on-Sea frontage is discussed in 1.3.1 to 1.3.3 and extreme weather events experienced in the last six months in section 1.3.4.

1.3.1 Wave Conditions

The region generally experiences a southwest and east/east-southeast wave direction, which has been established using Cefas wave buoy located at 51˚ 46.020" N 001˚ 08.840"E in place from October 2006 to October 2009. The wave data was transformed into a 10-year wave data set using the LITPACK model (Mott MacDonald, 2013a), see figure 2. Due to the larger fetch direction across the North Sea higher waves approach the coastline from the east / east-south east direction. The wave direction along the Clacton and Holland-on-Sea frontage varies from the offshore wave conditions. A large proportion of the offshore waves approach from the northeast or south-southwest. The variation between offshore and nearshore wave direction is the result of the large sandbanks which result in the diffraction and breaking of the waves (Mott MacDonald, 2013b).

Figure 2: 10-year wave rose from the Clacton AWAC buoy.



1.3.2 Water Levels

The Clacton and Holland-on-Sea coastline is situated within a macrotidal area and therefore water levels can vary greatly throughout the year. Astronomical tidal levels and surges also affect the water levels. At Clacton and Holland-on-Sea, Chart Datum is equivalent to -2.29m below Ordnance Datum. The tidal range in this area is 2.3m and 4m at neap and spring tides respectively (Mott MacDonald, 2013b).

1.3.3 Wind Conditions

The predominant wind conditions along the frontage are influenced by south westerlies that blow across the Outer Thames Estuary creating the south-westerly wave direction and the east / south easterlies winds that are generated over the North Sea, resulting in the east/east-southeast wave directions (Mott MacDonald, 2015). Due to the sheltering effect of East Anglia north or north-easterlies wind conditions can produce weaker north /north easterly wave conditions (Semedo *et al*., 2014).

1.3.4 Storm Conditions

In January, the village of Jaywick was evacuated on the evening 13th January due to predicted gale-force winds, high tides, and sleet, likely to cause flooding (Culbertson, 2017). However, this storm condition did not cause a breech at Jaywick and the coastline only received minimum damages under the circumstances (Rawlinson, 2017).

2 Data Analysis

2.1 Introduction

The beach monitoring programme for the Clacton and Holland-on-Sea Coastal Protection Scheme is composed of several survey techniques required to collect data of the evolution of the frontage. These are presented in more detail in the Mott MacDonald Clacton and Holland on Sea Coast Protection Scheme Beach Management Plan, 2015. The techniques undertaken for this report were a drone elevation survey, beach profile surveys and fixed aspect photos.

A drone was flown along the 5km stretch of the Clacton and Holland-on-Sea frontage from Clacton pier to Gunfleet Boating club in the north. This recorded the elevation of the beach from the promenade to the Mean Low Water Mark (MLWM). When undertaking the beach profile surveys, the method of beach levelling was used. Each profile was taken perpendicular from the shoreline as a straight line transect. Within each bay, one profile was taken in the midpoint of the bay between the two groynes structures and others adjacent to both the groyne structure (see Figure 3). Therefore, three beach profiles were taken per bay. Additional profiles were taken between groyne 41 (see Figure 1) and Clacton Pier for comparison between the constructed beach and the beach not within the scheme. In conjunction with the beach profiles fixed aspect photos were taken. These were taken at a fixed position at the same height with one angled perpendicular to the promenade and two at 45˚ either side of the beach profile.

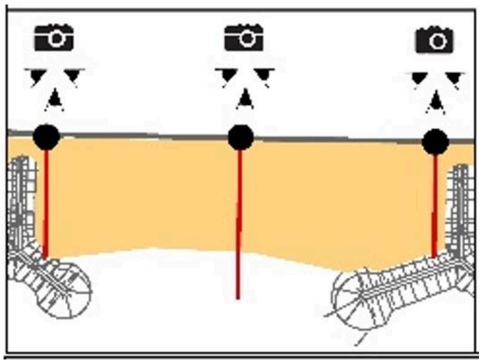


Figure 3: Beach profile locations

The findings from these surveys are discussed in the following sections below, along with the sediment budget processes for the area. The recommendations for future monitoring and maintenance have been concluded from these findings and are outlined in section 3.1.

2.2 Sediment Budget at Clacton and Holland-on-Sea

The Clacton and Holland-on-Sea frontage is exposed to two dominant wave directions from the east-southeast and southwest. Sediment movement along the frontage is complicated by this bi-directional wave environment and the effect of offshore sandbanks on approaching waves. During the last century, there was a significant decrease in the supply of sediment as a result from the cliffs in the region being protected, thus reducing the material produced through cliff erosion (Mott MacDonald, 2013b). In 2014-15 under the Coastal Protection Scheme, a recharge event was undertaken to restore beach levels along the Clacton and Holland-on-Sea frontage.

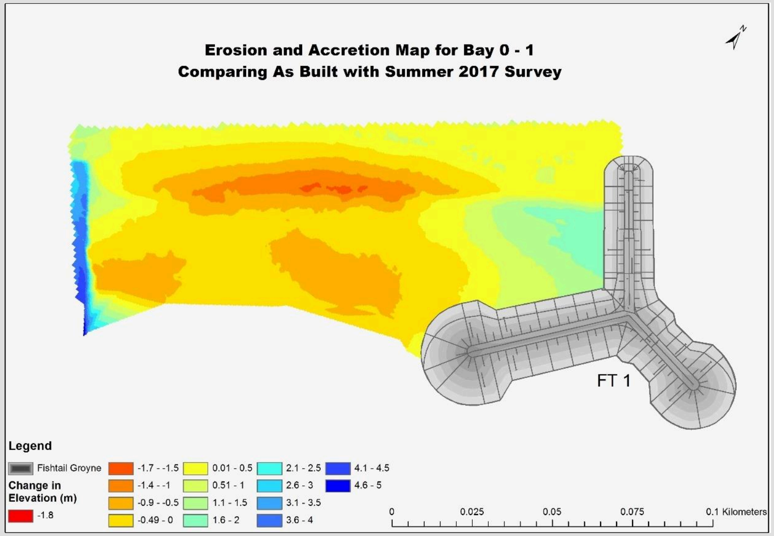
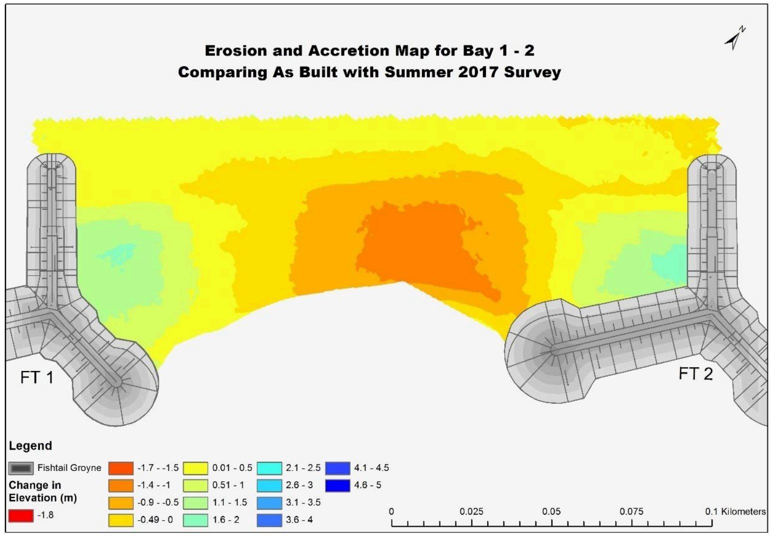
Prior to the construction of the Clacton and Holland on Sea Coast Protection Scheme the longshore sediment movement was identified as very weak along the frontage, although a north-east to south-west movement of sediment was generally seen along this part of the coastline (HR Wallingford, 2002). This is still considered to be the case along the frontage and will continue to be assessed through further beach monitoring reports. Previous specific modelling, undertaken by Mott MacDonald, around the Clacton and Holland-on-Sea frontage has highlighted the variability of longshore sediment transport that exists. The bi-directional wave dominance means that both northerly and southerly transport of sediment occurs around the frontage. Thus, sediment movement is temporally variable; if a year experiences a particularly large amount of high energy waves approaching from the south west, dominant northerly movement of sediment may occur during that year (Mott MacDonald, 2015).

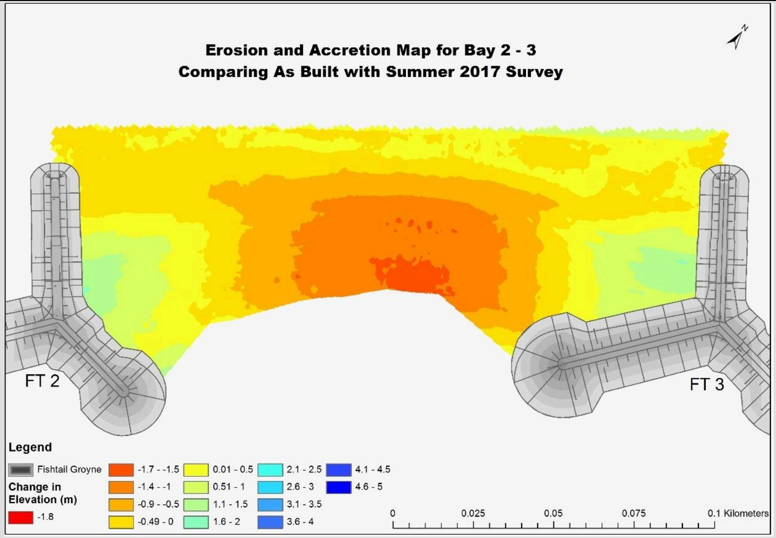
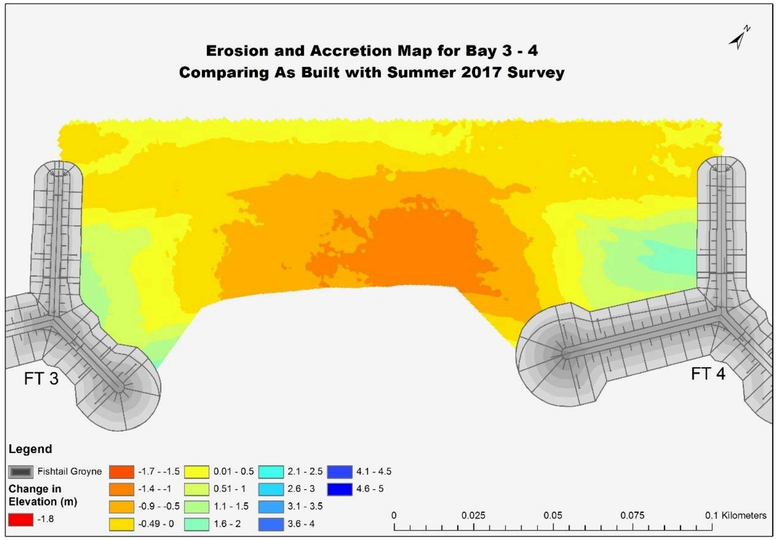
2.3 Accretion and Erosion Processes

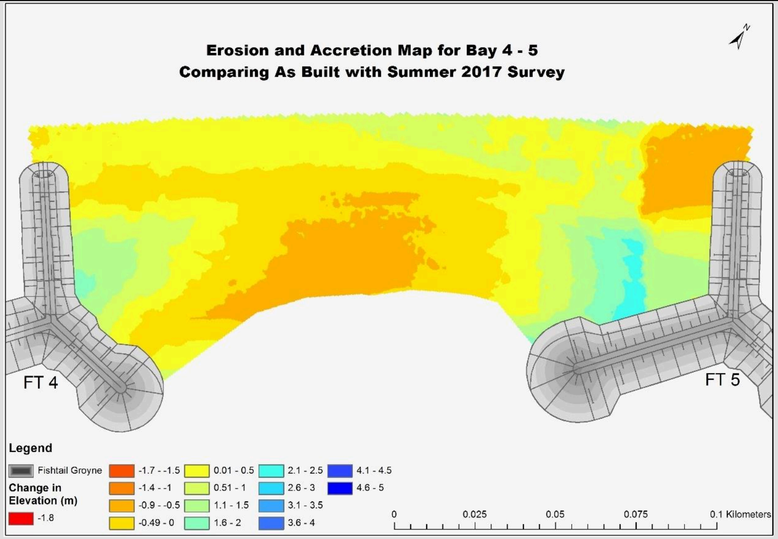
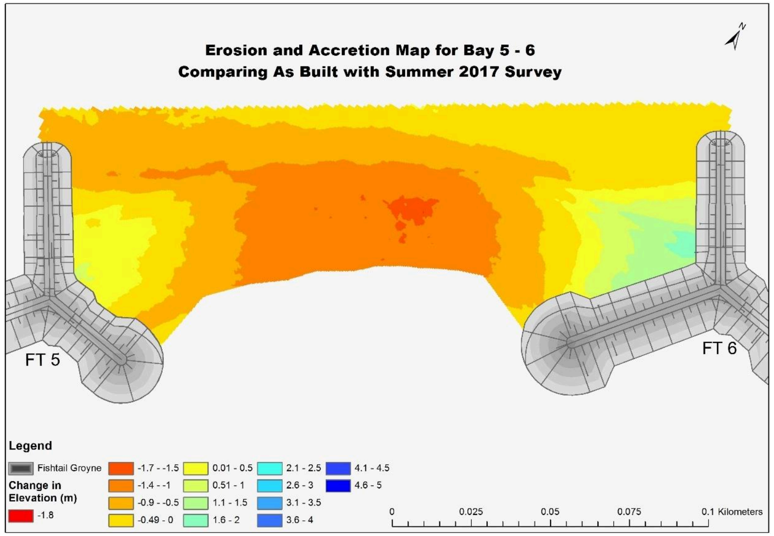
A drone was flow over the frontage from Groyne 41 (Figure 1) in the south to Gunfleet Boating Club in the north to record the elevation of the beach from the promenade to the MLWM. The outputs from the drone survey were compared against the As Built elevation of the frontage, post construction. This comparison highlights the areas along the frontage which have experienced accretion and areas that have experienced erosion since construction. In Table 1 accretion and erosion maps outlines the dominant processes for each bay from 2014-15 to 2017.

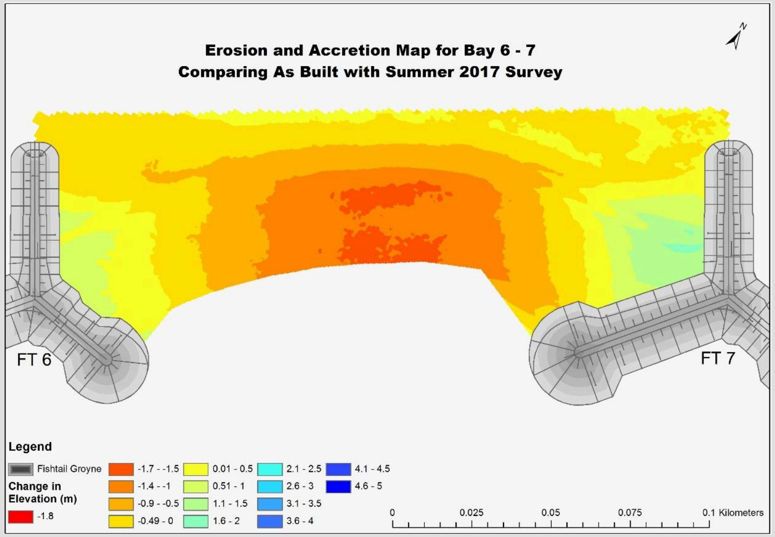
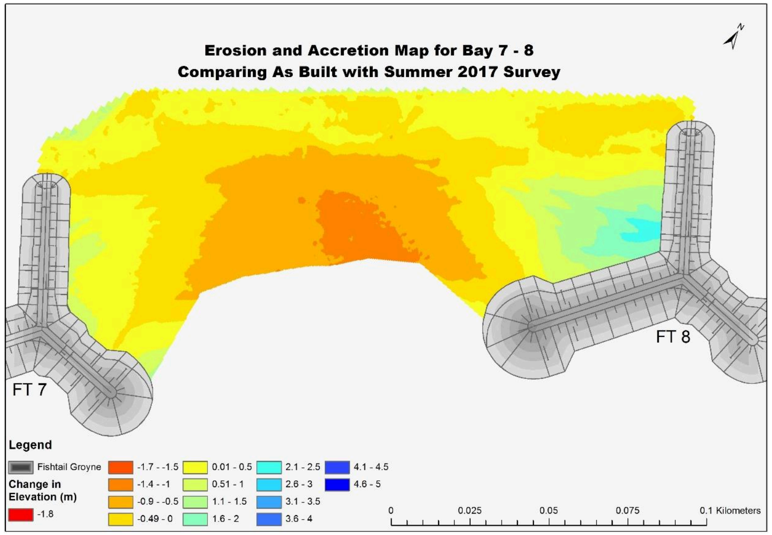
In general, the comparison maps show that the greatest erosion has been experienced in the centre of the bays, between the two fishtail groynes. There have also been high levels (over 1.8m) of erosion experienced at the top of the beach. Under As Built conditions a relatively straight berm was constructed, which provides reason why significant levels of erosion occurred higher up the beach, as embayment shapes are formed. For the bay shapes to form, wave defraction has occurred between the two fishtail groynes, though erosion has generally occurred closer to the more northly rock groynes. This indicates that the frontage has likely experienced a more south westerly wave direction since construction. Furthermore, the general trend has been accretion of sediment being trapped behind the landward side of both rock groynes arm and their shore connected arm, with more accretion occurring on the more northerly rock groyne, within each bay. This is likely to be due to material transported by longshore drift becoming trapped behind the shore connected arm of the northerly rock groyne. Adding to the assumption that in the last six months southerly wave conditions have been prominent.

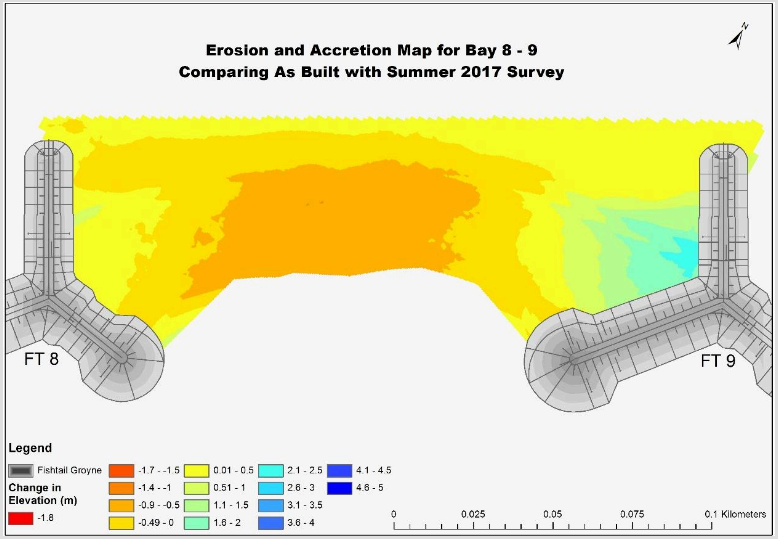
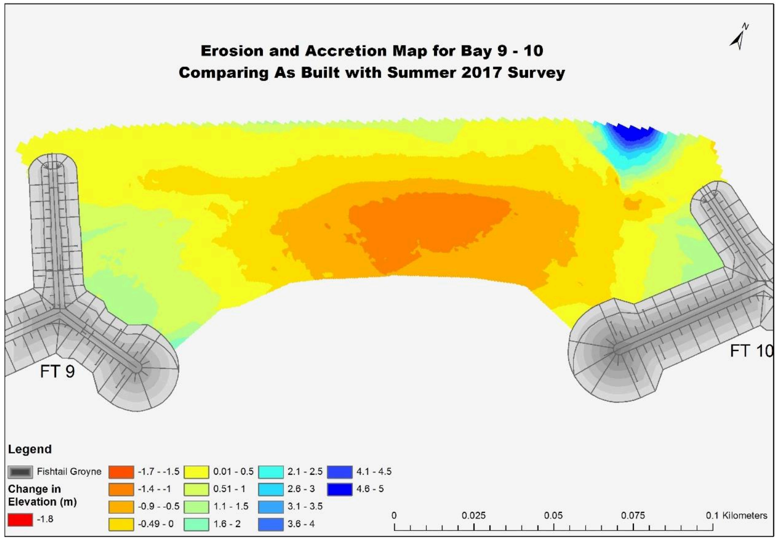
Table 1: Accretion and erosion maps for each bay along the Clacton and Holland-on-Sea frontage.

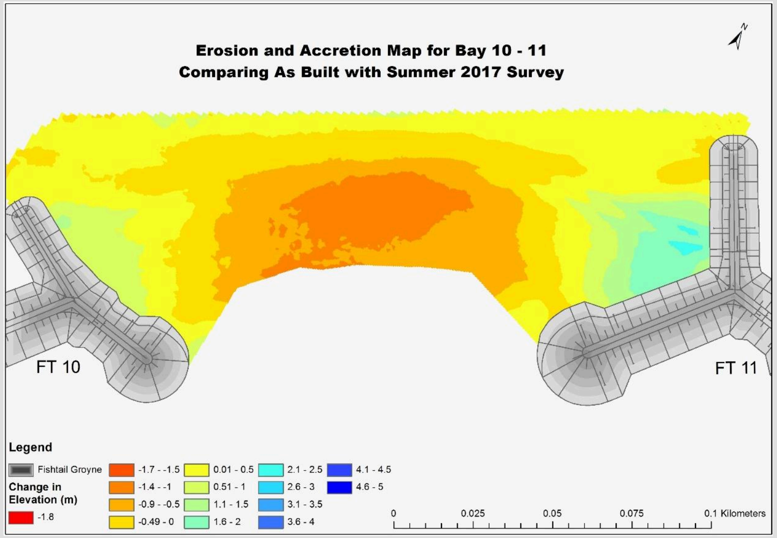
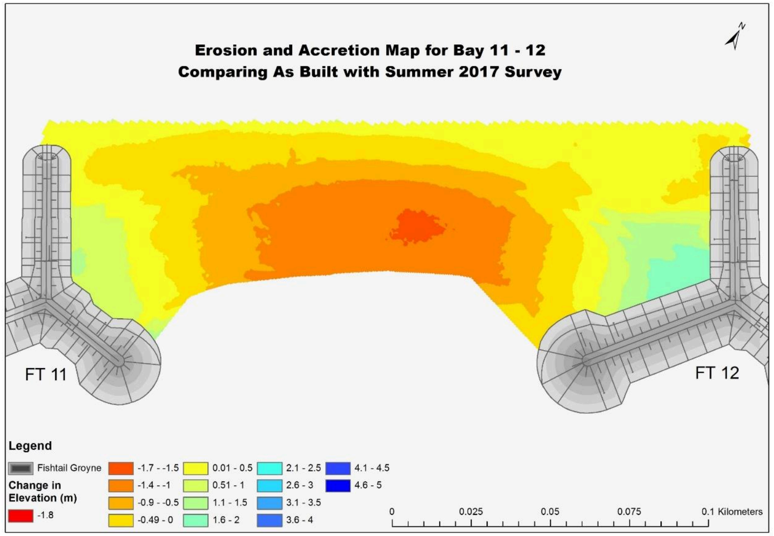
Bays	Accretion and Erosion Maps	Description of the key changes in the bay
1		- Highest erosion at berm, over 1.8m decrease in beach elevation. - Accretion highest behind the FT1 at 1.6m-2m increase in elevation. - As this bay has only one rock groyne erosion is occurring in the middle and to the south (close to the pier) and thus a typical bay shape has not formed.
2		- Highest erosion at centre of bay, by 1m-1.4m decrease in beach elevation. - Accretion highest behind FT2 at 1.6m-2m increase in elevation. - FT 2 has a larger area of accretion adjacent to it than FT1.

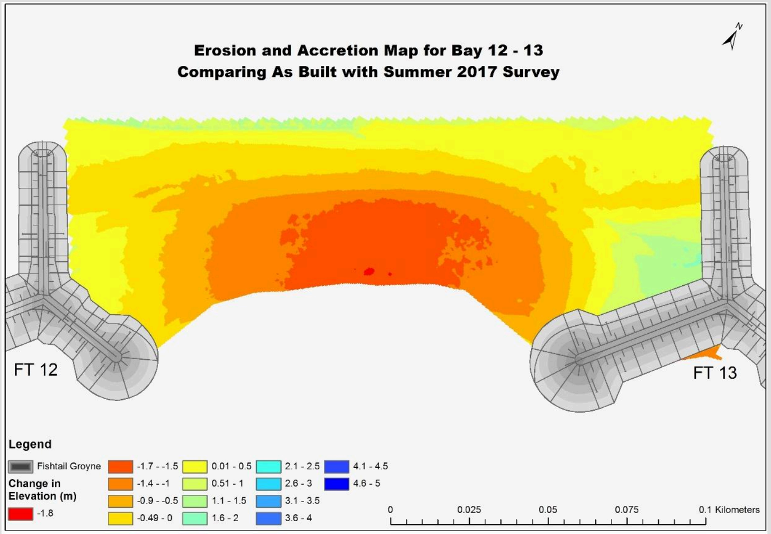
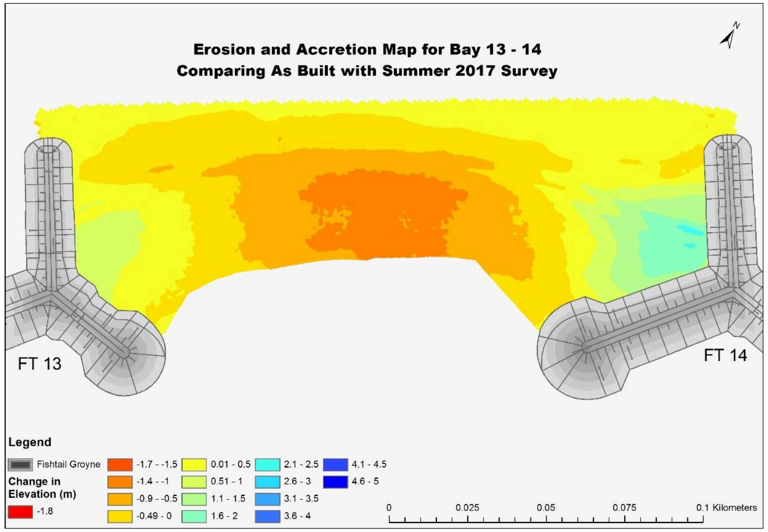
Bays	Accretion and Erosion Maps	Description of the key changes in the bay
3		- Highest erosion at centre of bay, by 1.5-1.7m decrease in beach elevation. - Accretion highest behind FT2 at 1.1m-1.5m increase in elevation. - FT 3 has a larger area of accretion adjacent to it than FT 2.
4		- Highest erosion at centre of bay, by 1m-1.4m decrease in beach elevation. - Accretion highest behind FT4 at 1.6m-2m increase in elevation. - FT 4 has a larger area of accretion adjacent to it than FT 3.

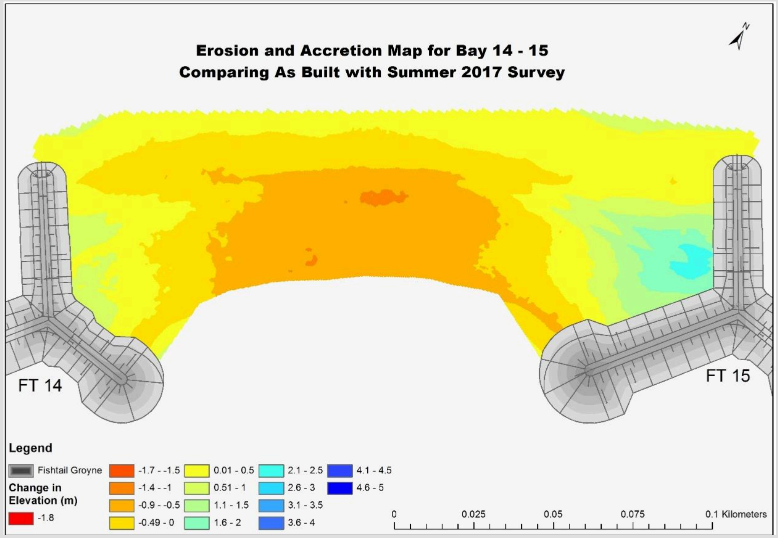
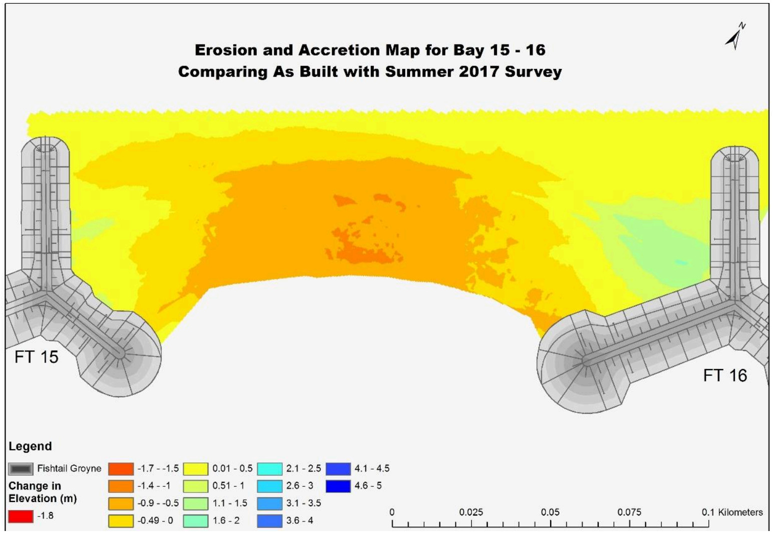
Bays	Accretion and Erosion Maps	Description of the key changes in the bay
5		- Highest erosion at centre of bay and around the top of the shore connected arm of FT5, by 0.5m-0.9m decrease in beach elevation. - Erosion has occurred closer to FT 4, this could be due to the outfall close to FT 4 causing increased scour in this area. - Accretion highest behind FT5 at 2.1m-2.5m increase in elevation. - FT 5 has a larger area of accretion adjacent to it than FT 4. - The cause of erosion at the top of the shore connected arm of FT5, is unknown and should be monitored in future surveys.
6		- Highest erosion at centre of bay and higher up the beach, by 1.5m-1.7m decrease in beach elevation. - There is also significant erosion high up the beach around the top of the shore connected arm of FT5. The reason for this is unknown, but should be monitored in future surveys - Accretion highest behind FT6 at 1.6m-2m increase in elevation. - FT 6 has a larger area of accretion adjacent to it than FT 5.

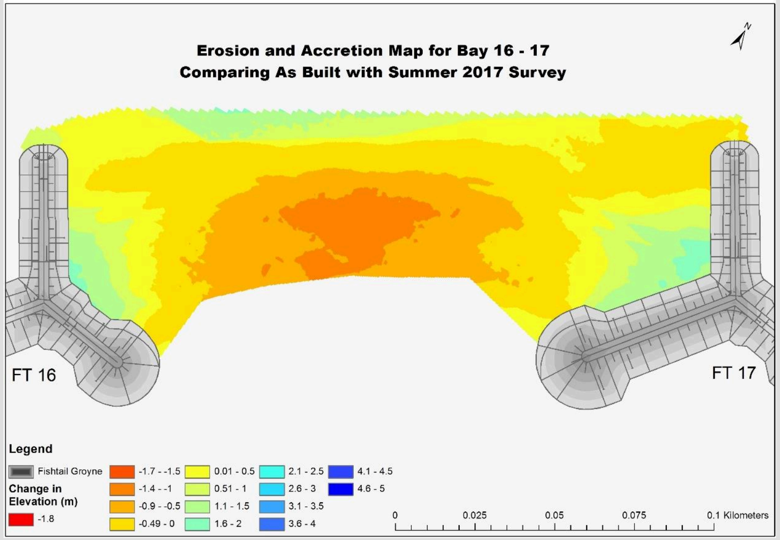
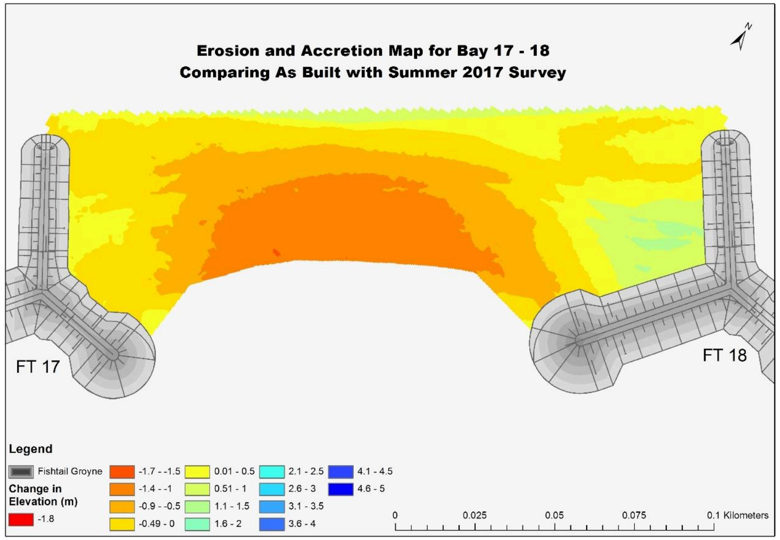
<table>
<tr><th>Bays</th><th>Accretion and Erosion Maps</th><th>Description of the key changes in the bay</th></tr>
<tr><td>7</td><td>
</td><td>- Highest erosion at centre of bay, by 1.5m-1.7m decrease in beach elevation.
- Accretion highest behind FT7 at 1.6m-2m increase in elevation, but with a more general high of 1.1m-1.5m.
- FT 7 has a larger area of accretion adjacent to it than FT 6.</td></tr>
<tr><td>8</td><td>
</td><td>- Highest erosion at centre of bay, by 1.5m-1.7m decrease in beach elevation.
- There is a larger area of erosion near to FT7 and this is likely due to the promenade being set back within this bay and the beach adjusting to this.
- Accretion highest behind FT8 at 2.1m-2.5m increase in elevation, but with a more general high of 1.1m-1.5m.
- FT 8 has a larger area of accretion adjacent to it than FT 7.</td></tr>
</table>

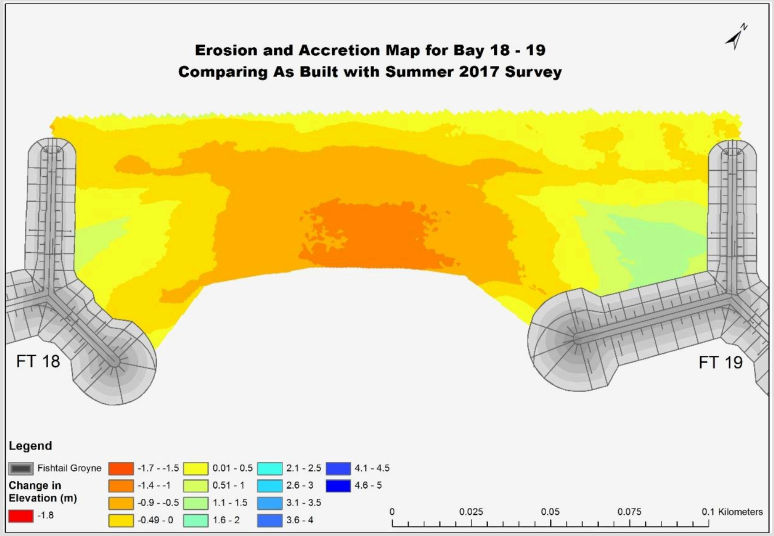
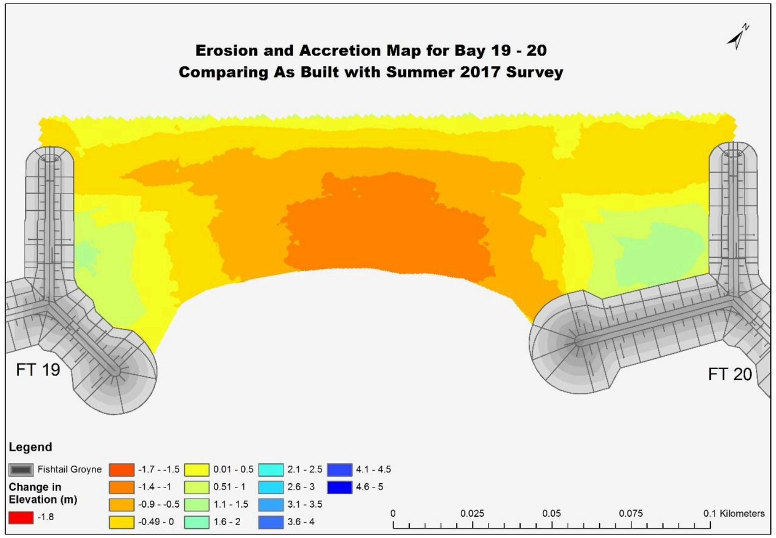
Bays	Accretion and Erosion Maps	Description of the key changes in the bay
9		- Highest erosion at centre of bay, by 0.5m-0.9m decrease in beach elevation. - However, erosion has occurred slightly closer to FT 8 unlike all the other bays along the frontage. This is likely due to the slight change in orientation at this point along the frontage. - Accretion highest behind FT9 at 2.1m-2.5m increase in elevation. - FT 9 has a larger area of accretion adjacent to it than FT 8.
10		- Highest erosion at centre of bay, by 1m-1.4m decrease in beach elevation. - Accretion highest behind FT9 at 1.1m-1.5m increase in elevation, but with a more general high of 0.51m-1m. - An area of high accretion can be seen near to the top of FT 10, but this is from a projecting manmade headland rather than the beach processes. - Unlike the majority of bays along the frontage the largest area of accretion is behind the more southerly groyne FT9. This is likely due to the fact FT10 has a smaller shore connected arm and at a different orientation to the other groynes along the frontage and thus being less effective at trapping sediment.

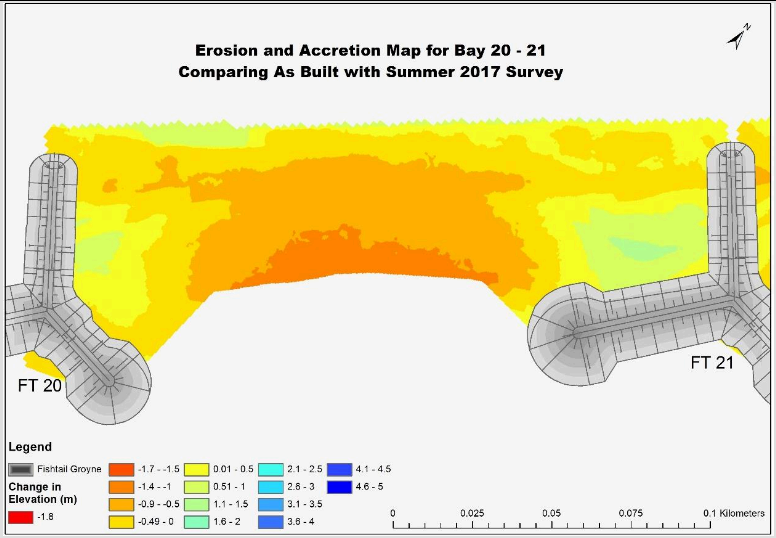
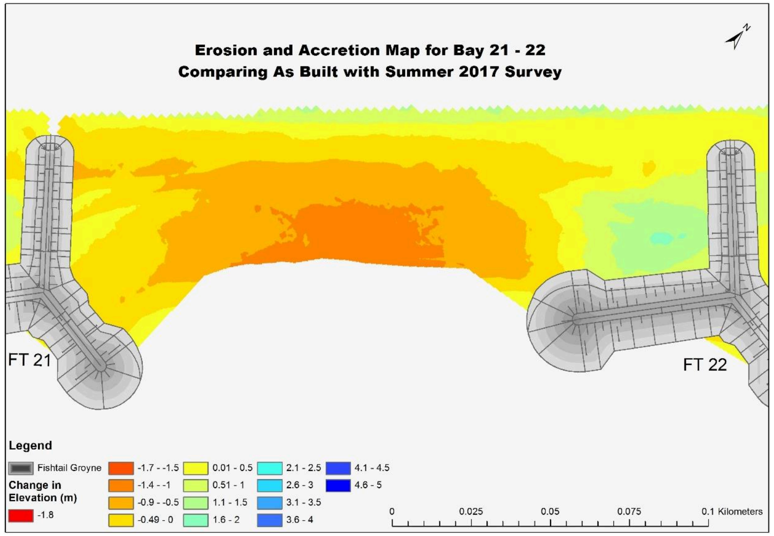
<table>
<tr><th>Bays</th><th>Accretion and Erosion Maps</th><th>Description of the key changes in the bay</th></tr>
<tr><td>11</td><td>
</td><td>- Highest erosion at centre of bay, by 1m-1.4m decrease in beach elevation.
- However, erosion is slightly skewed towards to FT 10, which is likely due to FT10 having a smaller shore connected arm and at a different orientation to the other groynes along the frontage and thus being less effective at trapping sediment.
- Accretion highest behind FT11 at 2.1m-2.5m increase in elevation, but with a more general high of 1.6m-2m.</td></tr>
<tr><td>12</td><td>
</td><td>- Highest erosion at centre of bay, by 1.5m-1.7m decrease in beach elevation.
- Accretion highest behind FT12 at 1.6m-2m increase in elevation.
- FT 12 has a larger area of accretion adjacent to it than FT 11.</td></tr>
</table>

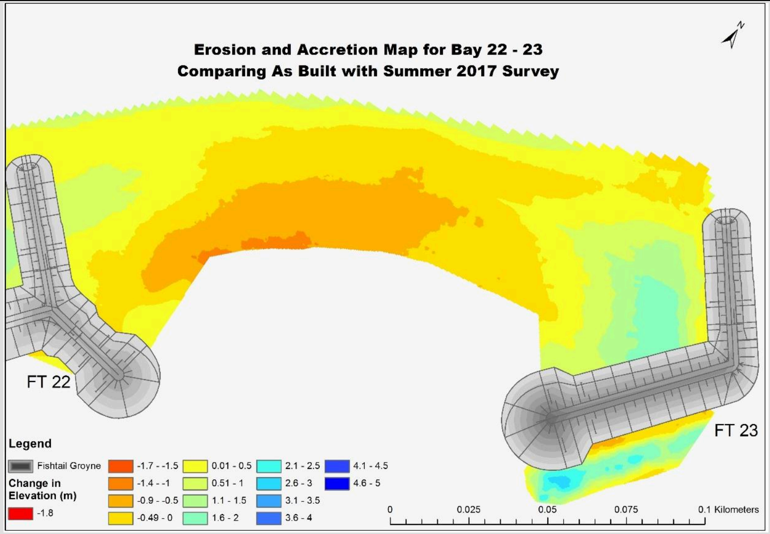
Bays	Accretion and Erosion Maps	Description of the key changes in the bay
13		- The highest level of erosion is experienced right at the centre of the bay with over 1.8m decrease in elevation, though a more general 1.7-1.5m decrease in elevation has occurred at the centre of bay overall. - Accretion highest behind FT13 at 1.1m-1.5m increase in elevation. - FT 13 has a larger area of accretion adjacent to it than FT 12.
14		- Highest erosion at centre of bay, by 1m-1.4m decrease in beach elevation. - Accretion highest behind FT14 at 2.1m-2.5m increase in elevation, but with a more general high of 1.6-2m - FT 14 has a larger area of accretion adjacent to it than FT 13.

Bays	Accretion and Erosion Maps	Description of the key changes in the bay
15		- The highest level of erosion is experienced at the centre of the berm by 1.4-1m decrease in elevation, though a more general 0.5-0.9m decrease in elevation has occurred at the centre of bay overall. - Accretion highest behind FT15 at 2.1m-2.5m increase in elevation. - FT 15 has a larger area of accretion adjacent to it than FT 14.
16		- The highest level of erosion is experienced right at the centre of the bay by 1.4-1m decrease in elevation, though a more general 0.5-0.9m decrease in elevation has occurred at the centre of bay overall. - Accretion highest behind FT16 at 1.1m-1.5m increase in elevation. - FT 16 has a larger area of accretion adjacent to it than FT 15.

Bays	Accretion and Erosion Maps	Description of the key changes in the bay
17		- Highest erosion at centre of bay, by 1.4m-1m decrease in beach elevation. - Accretion highest behind FT17 at 2.1m-2.5m increase in elevation. - FT 17 has a larger area of accretion adjacent to it than FT 16.
18		- Highest erosion at centre of bay, by 1.4m-1m decrease in beach elevation. - Accretion highest behind FT18 at 1.1m-1.5m increase in elevation. - FT 18 has a larger area of accretion adjacent to it than FT 17.

Bays	Accretion and Erosion Maps	Description of the key changes in the bay
19		- Highest erosion at centre of bay, by 1.4m-1m decrease in beach elevation. - Accretion highest behind FT19 at 1.1m-1.5m increase in elevation. - FT 19 has a larger area of accretion adjacent to it than FT 18.
20		- Highest erosion at centre of bay, by 1.4m-1m decrease in beach elevation. - Accretion highest behind FT20 at 1.1m-1.5m increase in elevation. - FT 20 has a larger area of accretion adjacent to it than FT 19.

Bays	Accretion and Erosion Maps	Description of the key changes in the bay
21		- Highest erosion at centre of bay, by 1.4m-1m decrease in beach elevation. - Accretion highest behind FT21 at 1.1m-1.5m increase in elevation. - FT 21 has a larger area of accretion adjacent to it than FT 20.
22		- Highest erosion at centre of bay, by 1.4m-1m decrease in beach elevation. - Unlike other bays along the frontage FT21 has virtually no accretion around the shore connected arm. This is likely due to the slight change in orientation at this point along the frontage. - Accretion highest behind FT22 at 1.6m-2m increase in elevation, but a with a more general high of 1.5m-1.1m. - FT 22 has a larger area of accretion adjacent to it and FT 21, which has minimal accretion.

Bays	Accretion and Erosion Maps	Description of the key changes in the bay
23		- Highest erosion is skewed to the south of the bay, at 1.4m-1m decrease in beach elevation. - Accretion highest behind FT 23 at 1.6m-2m increase in elevation. In comparison FT 22 has experienced only 1.1m-1.5m increase in elevation in a relatively smaller area. This difference in accretion between the groynes is likely due to the extended arm of FT23 coupled with material transported by longshore drift in an northly direction. - The skewed erosion to the south and the higher levels of accretion in the north of this bay indicated that the extended arm of the rock groyne has increased wave defraction.

Source: <Insert Notes or Source>

From the accretion and erosion maps within Table 1 it is evident that curved bays have formed between all fishtail groynes. In general accretion has occurred within the more northly part of the bays, indicating that waves have approached the frontage from a south westerly direction and resulting in a dominate northerly movement of sediment. These findings show the coastal processes have behaved in a way that was predicted, by trapping sediment behind the groyne, utilising longshore drift and eroding to form bay shaped features.

2.4 Dip and Crest Trigger Levels

The management of the Clacton and Holland-on-Sea beach is based on two trigger levels from the Beach Management Plan 2015. These levels are related to the berm width and the beach level (crest height) at the seawall, at the fishtail groynes and at the rock burial areas down to the MLWM. Both parameters were obtained during the monitoring of the frontage using the beach profiles. Profiles taken in the middle of the bays extended from the promenade or seawall to the MLWS tide level. Profiles adjacent to the structures were required to be approximately 10m from the structures and extended until the fishtail rock groyne arms were reached. Locations of beach profiles surveyed can be seen in Figure 4.

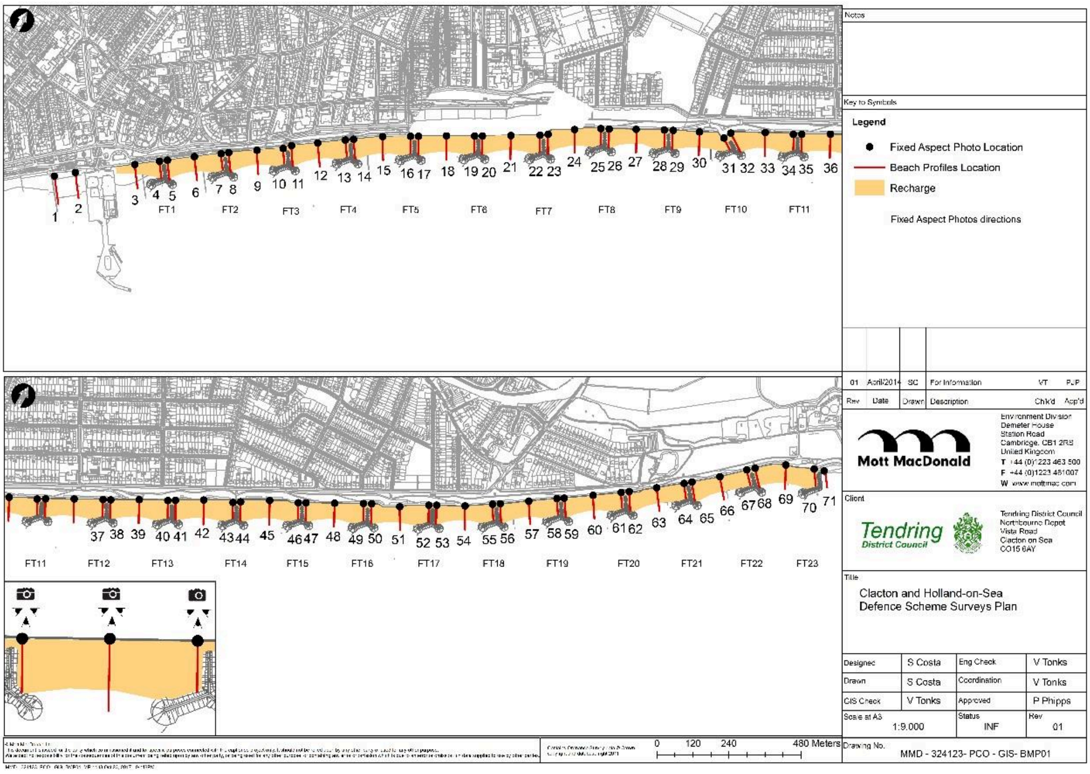


Figure 4 Beach profile survey locations at Clacton-on-Sea

In the Clacton and Holland on Sea Coast Protection Scheme (Mott MacDonald, 2015) it is important to note that it has been assumed the seawall will fail if the beach level drops to **+1mOD** along the frontage. This distance from the promenade to the top of the beach may vary along the frontage depending on the condition and type of seawall; however, in order to simplify the management of the beach, a constant worst case failure level along the scheme has been assumed. It was assumed that the fishtail groynes and rock revetments will fail if the beach level drops 2.0m from the original recharge level (see Table 2.). The two rock burial areas (Bay 8-9 and Bay 13-14) are merely a store of excess material from the construction works that have no structural or defensive function. Thus a 'failure level' of approximately 0.5m sand coverage over the buried rock is used, to prevent the stored rock from being exposed. This level is approximately a 1.0m drop below the recharge level.

The beach profile survey located in the middle of each bay defines the trigger levels related to the seawall stability. The beach profiles adjacent to the structure indicate the stability of the fishtail groynes. Trigger levels have been graded using a traffic light system. Amber means that beach levels have dropped enough that beach recycling needs to be undertaken. If the trigger levels are Red then recharge of the bay needs to be carried out. Table 2 outlines the trigger values for each type of frontage.

Table 2: Trigger levels for either beach recycling or beach recharge events.

Beach Location	Original Recharge Level in 2014-15	Amber Trigger Level	Red Trigger Level
Seawall in bays without buried rock	**+3.5mOD**	**+2.0mOD**	**+1.0mOD**
Rock Revetments and Fishtail Groynes	**+3.5mOD** (at crest)	**1.0m** below original recharge (**+2.5mOD** at beach crest)	**2.0m** below original recharge (**+1.5mOD** at beach crest)
Bays with buried rock	**+3.5mOD**	**+3.0mOD**	**+2.5mOD**

Source: Mott MacDonald, 2015

Amber trigger levels are also measured using the width of the berm and height of the crest. The berm width along the frontage is recommended to be 18m, however, some retreat is expected in order to reach the equilibrium beach curve. Yet if the berm's retreat is larger than 5m and crest height falls by 1.5m to +2.0mOD at the seawall and/or by 1.0m at the groyne or revetment structures, and/or by 0.5m over the rock burial areas then beach material should be re-profiled.

A Red trigger level is measured if the crest height falls by 2.5m to +1.0mOD at the seawall and/or by 2.0m at the groynes or revetment structures, and/or by 1.0m over the rock burial areas. Under these conditions a recharge scheme in the bay is likely to be required.

In Table 3 the dip and crest measurement recorded from the survey are assessed to determine if the trigger levels, outline previously in this section, have been reached.

Table 3: Comparison of dip and crest measurements from As Built to when surveyed, and whether a trigger level has been reached (see Figure 3 for profile locations.).

Profile (Bay)	Seawall/ Prom Level (m)	Survey Dip (m)	Elevation of the beach (OD)	Trigger for Beach Levels	As Built Crest (m)	Surveyed Crest (m)	Crest Width Change (m)	Trigger for Crest Width	Overall Trigger
1 (South of pier)	-	1.02	-	-	-	20.5	-	-	-
2 (South of pier)	-	0.97	-	-	-	27		-	-
3 (Bay 1)	5.57	1.77	3.8	Not Triggered	19	9.5	-9.5	Amber	Not Triggered
4	5.57	1.73	3.84	Not Triggered	22.5	33.5	+11	Not Triggered	Not Triggered

Profile (Bay)	Seawall/ Prom Level (m)	Survey Dip (m)	Elevation of the beach (OD)	Trigger for Beach Levels	As Built Crest (m)	Surveyed Crest (m)	Crest Width Change (m)	Trigger for Crest Width	Overall Trigger
(Bay 1)									
5 (Bay 2)	5.57	1.85	3.72	Not Triggered	20	32	+12	Not Triggered	Not Triggered
6 (Bay 2)	5.57	1.77	3.8	Not Triggered	22.5	16	-6.5	Amber	Not Triggered
7 (Bay 2)	5.57	1.87	3.7	Not Triggered	22.5	34	+11.5	Not Triggered	Not Triggered
8 (Bay 3)	5.57	1.77	3.8	Not Triggered	22.5	31	+8.5	Not Triggered	Not Triggered
9 (Bay 3)	5.57	1.83	3.74	Not Triggered	22.5	16.5	-6	Amber	Not Triggered
10 (Bay 3)	5.57	1.75	3.82	Not Triggered	22.5	29	+6.5	Not Triggered	Not Triggered
11 (Bay 4)	5.57	1.61	3.96	Not Triggered	21	28.5	+7.5	Not Triggered	Not Triggered
12 (Bay 4)	5.57	1.73	3.84	Not Triggered	22.5	15	-7.5	Amber	Not Triggered
13 (Bay 4)	5.57	1.8	3.77	Not Triggered	20	36.5	+16.5	Not Triggered	Not Triggered
14 (Bay 5)	5.57	1.81	3.76	Not Triggered	21	33.5	+12.5	Not Triggered	Not Triggered
15 (Bay 5)	5.57	1.75	3.82	Not Triggered	21	18.5	-2.5	Not Triggered	Not Triggered
16 (Bay 5)	5.57	2.02	3.55	Not Triggered	20	34.5	+14.5	Not Triggered	Not Triggered
17 (Bay 6)	5.57	1.85	3.72	Not Triggered	20	32	+12	Not Triggered	Not Triggered
18 (Bay 6)	5.57	1.81	3.76	Not Triggered	21	17.5	-3.5	Not Triggered	Not Triggered
19 (Bay 6)	5.57	1.7	3.87	Not Triggered	20.5	33.5	+13	Not Triggered	Not Triggered
20 (Bay 7)	5.57	1.79	3.78	Not Triggered	19	29	+10	Not Triggered	Not Triggered
21 (Bay 7)	5.57	1.6	3.97	Not Triggered	-	13	-	-	-
22 (Bay 7)	5.57	2.3	3.27	Amber	17.5	32	+14.5	Not Triggered	Not Triggered
23 (Bay 8)	5.57	1.94	3.63	Not Triggered	18	22.5	+4.5	Not Triggered	Not Triggered
24 (Bay 8)	4.5	0.63	3.87	Not Triggered	17.5	19.5	+2	Not Triggered	Not Triggered
25 (Bay 8)	4.5	0.77	3.73	Not Triggered	17.5	35.5	+18	Not Triggered	Not Triggered
26 (Bay 9)	4.5	0.71	3.79	Not Triggered	18.5	29	+10.5	Not Triggered	Not Triggered
27 (Bay 9)	4.5	0.77	3.73	Not Triggered	17.5	14	-3.5	Not Triggered	Not Triggered
28 (Bay 9)	4.5	0.77	3.73	Not Triggered	17.5	36.5	+19	Not Triggered	Not Triggered

Profile (Bay)	Seawall/ Prom Level (m)	Survey Dip (m)	Elevation of the beach (OD)	Trigger for Beach Levels	As Built Crest (m)	Surveyed Crest (m)	Crest Width Change (m)	Trigger for Crest Width	Overall Trigger
29 (Bay 10)	4.5	0.78	3.72	Not Triggered	19.5	29.5	+10	Not Triggered	Not Triggered
30 (Bay 10)	4.5	0.56	3.94	Not Triggered	20	15.5	-4.5	Not Triggered	Not Triggered
31 (Bay 10)	n/a	-	-	Not Triggered	20	27	+7	Not Triggered	Not Triggered
32 (Bay 11)	n/a	-	-	Not Triggered	20	40	+20	Not Triggered	Not Triggered
33 (Bay 11)	4.5	0.8	3.7	Not Triggered	18	14	-4	Not Triggered	Not Triggered
34 (Bay 11)	4.5	0.8	3.7	Not Triggered	15.5	36	+20.5	Not Triggered	Not Triggered
35 (Bay 12)	4.5	0.8	3.7	Not Triggered	15.5	32	+14.5	Not Triggered	Not Triggered
36 (Bay 12)	5.4	1.27	4.13	Not Triggered	17.5	15	-2.5	Not Triggered	Not Triggered
37 (Bay 12)	5.4	1.47	3.93	Not Triggered	18	36	+18	Not Triggered	Not Triggered
38 (Bay 13)	5.4	0.7	4.7	Not Triggered	20	29.5	+9.5	Not Triggered	Not Triggered
39 (Bay 13)	4.5	0.5	4	Not Triggered	17.5	13.5	-4	Not Triggered	Not Triggered
40 (Bay 13)	4.5	0.47	4.03	Not Triggered	18	29.5	+11.5	Not Triggered	Not Triggered
41 (Bay 14)	4.5	0.46	4.04	Not Triggered	20	31	+11	Not Triggered	Not Triggered
42 (Bay 14)	4.5	0.12	4.38	Not Triggered	20	16.5	-3.5	Not Triggered	Not Triggered
43 (Bay 14)	4.5	0.33	4.17	Not Triggered	17.5	32	+14.5	Not Triggered	Not Triggered
44 (Bay 15)	4.5	0.4	4.1	Not Triggered	19	28.5	+9.5	Not Triggered	Not Triggered
45 (Bay 15)	4.5	0.38	4.12	Not Triggered	20	15.5	-4.5	Not Triggered	Not Triggered
46 (Bay 15)	4.5	0.29	4.21	Not Triggered	14.5	32	+17.5	Not Triggered	Not Triggered
47 (Bay 16)	4.5	0.26	4.24	Not Triggered	19	29.5	+10.5	Not Triggered	Not Triggered
48 (Bay 16)	4.5	-	-	-	18	15.5	-2.5	Not Triggered	Not Triggered
49 (Bay 16)	4.5	-	-	-	18.5	38.5	+20	Not Triggered	Not Triggered
50 (Bay 17)	4.5	-	-	-	17.5	33.5	+16	Not Triggered	Not Triggered
51 (Bay 17)	4.5	0.78	3.72	Not Triggered	14	10	-4	Not Triggered	Not Triggered
52 (Bay 17)	4.5	0.7	3.8	Not Triggered	20	33.5	+13.5	Not Triggered	Not Triggered

Profile (Bay)	Seawall/ Prom Level (m)	Survey Dip (m)	Elevation of the beach (OD)	Trigger for Beach Levels	As Built Crest (m)	Surveyed Crest (m)	Crest Width Change (m)	Trigger for Crest Width	Overall Trigger
53 (Bay 18)	4.5	0.87	3.63	Not Triggered	20	31	+11	Not Triggered	Not Triggered
54 (Bay 18)	4.5	0.71	3.79	Not Triggered	15.5	13	-2.5	Not Triggered	Not Triggered
55 (Bay 18)	4.5	0.72	3.78	Not Triggered	17.5	33.5	+16	Not Triggered	Not Triggered
56 (Bay 19)	4.5	0.67	3.83	Not Triggered	15.5	25.5	+10	Not Triggered	Not Triggered
57 (Bay 19)	4.5	0.38	4.12	Not Triggered	17.5	16.5	-1	Not Triggered	Not Triggered
58 (Bay 19)	4.5	0.73	3.77	Not Triggered	18.5	36	+17.5	Not Triggered	Not Triggered
59 (Bay 20)	4.5	0.6	3.9	Not Triggered	18.5	28.5	+10	Not Triggered	Not Triggered
60 (Bay 20)	4.5	0.32	4.18	Not Triggered	18.5	16.5	-2	Not Triggered	Not Triggered
61 (Bay 20)	4.5	0.6	3.9	Not Triggered	18.5	32	+13.5	Not Triggered	Not Triggered
62 (Bay 21)	4.5	0.63	3.87	Not Triggered	17.5	16.5	-1	Not Triggered	Not Triggered
63 (Bay 21)	4.5	0.65	3.85	Not Triggered	18	15.5	-2.5	Not Triggered	Not Triggered
64 (Bay 21)	4.5	0.66	3.84	Not Triggered	19	32	+c13	Not Triggered	Not Triggered
65 (Bay 22)	4.5	0.5	4	Not Triggered	19	27	+8	Not Triggered	Not Triggered
66 (Bay 22)	4.5	0.57	3.93	Not Triggered	16	13.5	-2.5	Not Triggered	Not Triggered
67 (Bay 22)	4.5	0.48	4.02	Not Triggered	17.5	33.5	+16	Not Triggered	Not Triggered
68 (Bay 23)	4.5	0.42	4.08	Not Triggered	10	25.5	+15.5	Not Triggered	Not Triggered
69 (Bay 23)	4.5	0.08	4.42	Not Triggered	14.5	16.5	+2.5	Not Triggered	Not Triggered
70 (Bay 23)	4.5	-	-	-	10	36	+26	Not Triggered	Not Triggered
71 (north of terminal groyne)	4.5	-	-	-		-		Not Triggered	Not Triggered

From Table 3 it is evident that no trigger levels for beach levels have been reached since As Built conditions. However, a few profiles indicate that an amber trigger level has been reached for crest width. Profile 3 saw over 9.5m decrease in crest width from As Built Conditions, though this is likely due to this location not being between two fishtail groynes, but adjacent to the pier. Thus, beach material is more easily lost from this location as the pier is not a solid barrier and allows sediment movement underneath it. Further, the crest width of Profiles 6, 9 and 12 have decreased between 6m to 7.5m from As Built conditions. These profiles are within the middle of the bay, between two fishtail groynes. It is possible that there has been a larger reduction in crest width here due to the pier diffracting the predominant south westerly waves. Thus, reducing wave energy, and reducing the material transporting in longshore drift, seen in section 2.3. However, though these beach profiles have reached an amber trigger level for their crest width, their beach levels have not been triggered, hence these locations have not reached an overall amber trigger level to warrant any beach management activities.

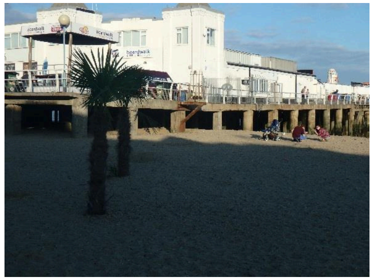
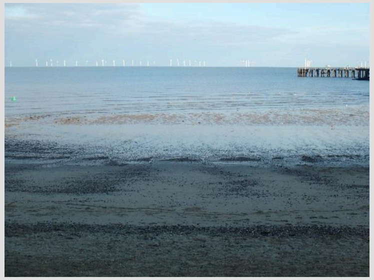
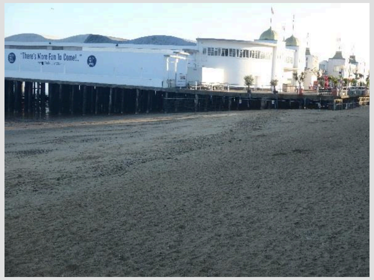
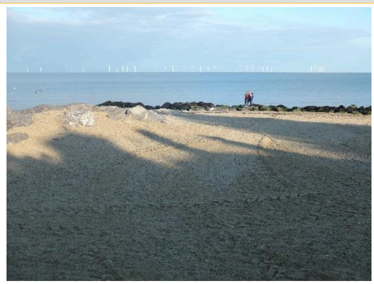
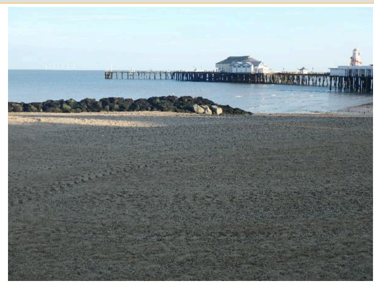
2.5 Photographic Record

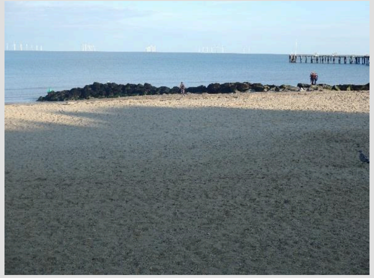
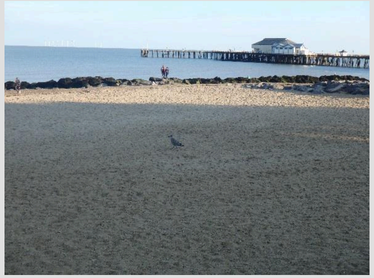
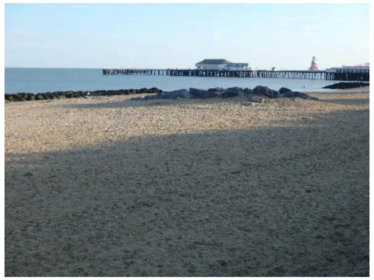
Fixed aspects photographs were taken for each beach profile at low tide. These photos included either side of the fishtail rock groynes and the condition of the beach between adjacent groynes. The photographs were taken from a fixed position looking perpendicular to the promenade, and two looking in each direction at an approximate angle of 45˚ (See Figure 4).

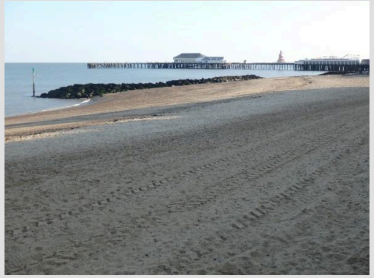
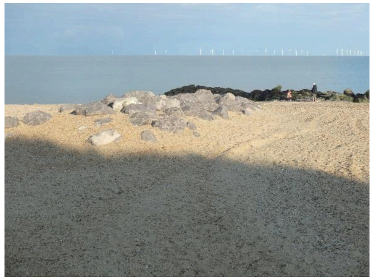
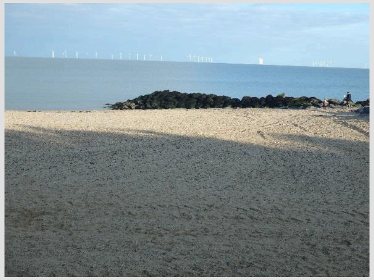
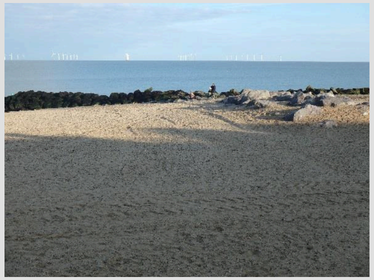
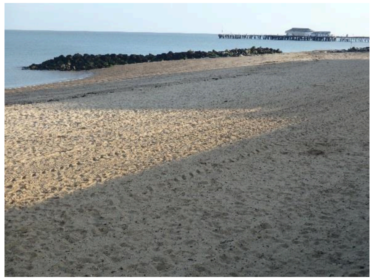
From the photographs, the general trend for profiles adjacent to the rock groynes show a very wide beach with a lot of beach material. This indicates that accretion has occurred and sediment is being trapped behind the rock groyne. The gradient of the beaches along these profiles are generally flat, suggesting the material is relatively stable. In comparison, profiles taken in the middle of the two rock groynes generally have narrower and steeper gradient beaches. From the photographs it is evident that a defined beach scalp is forming at the edge of the berm’s crest at most of these middle profiles. Furthermore, an overall trend at these profiles is the formation of a defined curved beach between the two rock groynes, indicating wave defraction and erosion processes are occurring, forming a bay.

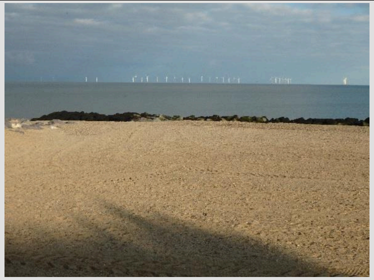
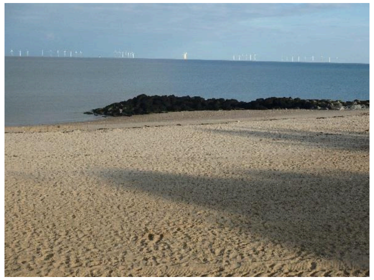
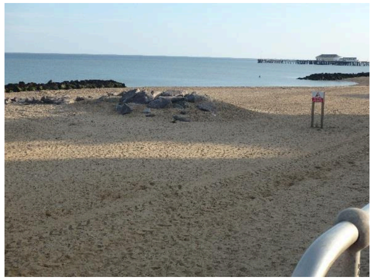
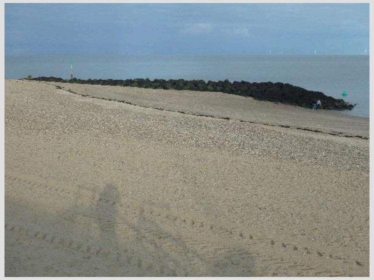
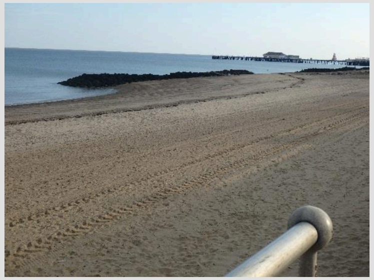
Table 4 displays these photos for each of the beach profiles and provides a description of sediment processes that can be observed, if the processes differ from the general trend experienced at this frontage.

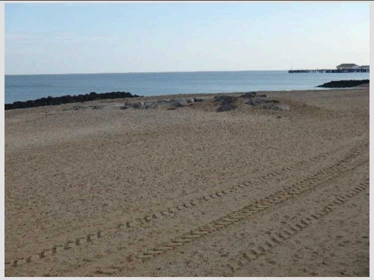
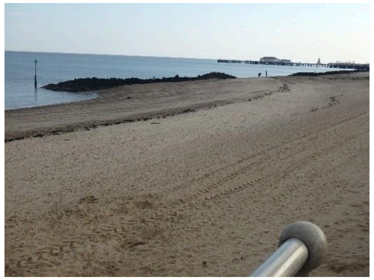
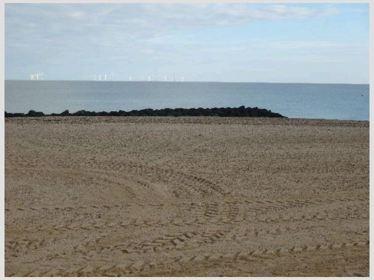
Table 4: Profiles from 1 - 71 along the Clacton-on-Sea frontage. Photographs taken at a 45° north, 45° south and perpendicular of the promenade.

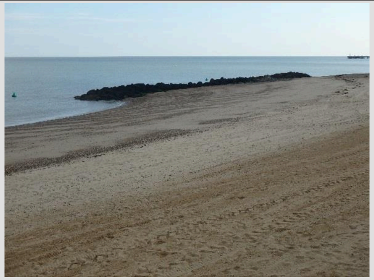
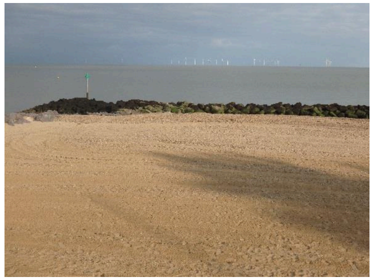
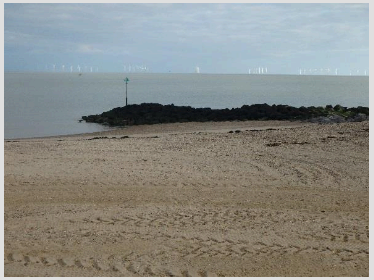
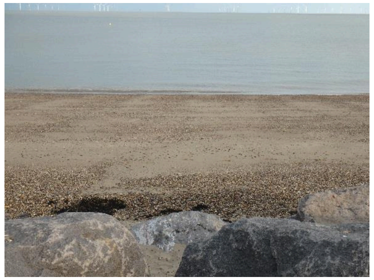
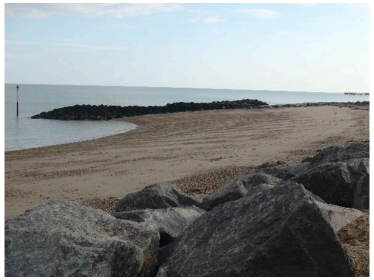
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
1				The beach is very wide, with the slope from the berm down to the foreshore at low tide being quite level. This is a well-established beach and it is evident that the beach material is stable higher up the beach.
2				The beach is very wide, with the slope from the berm down to the foreshore again very level at low tide. From the adjacent images, it is evident that material has been trapped higher up the beach and remaining stable.
3				The beach width varies along this profile, with the beach being wider closer to the rock groyne and narrow towards the pier, indicating this profile has experienced longshore drift in a northward direction. Closer to the pier the gradient from the berm to the foreshore is steeper than at the rock groyne. A more defined berm and beach scalp has formed closer to the rock groyne, indicating that erosive processes for a bay formation has occurred.
4				

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
5				
6				
7				
8				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.

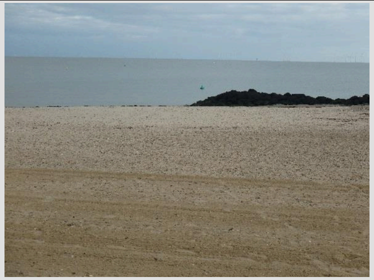
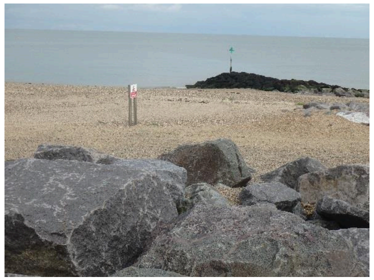
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
9				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.
10				
11				
12				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.

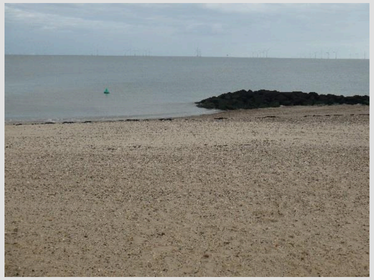
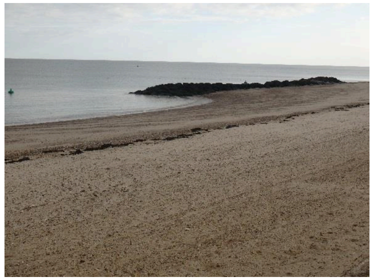
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
13				
14				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
15				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.
16				

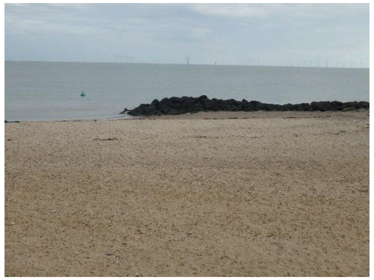
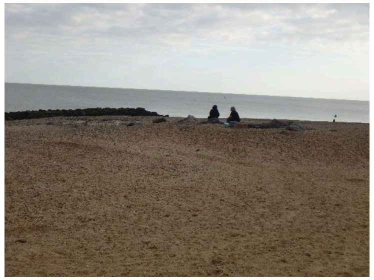
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
17				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
18				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.
19				
20				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.

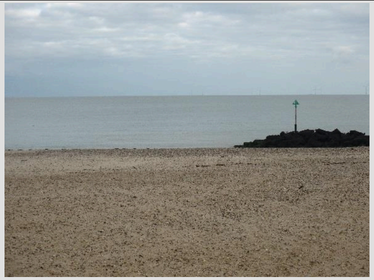
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
21				
22				
23				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
24				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.

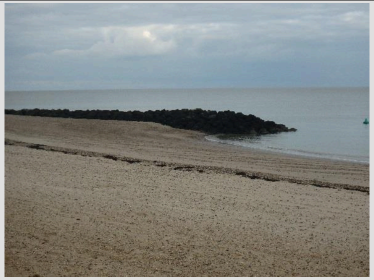
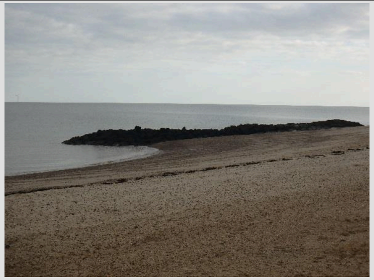
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
25				.
26				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
27				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.
28				

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
29				
30				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.
31				
32				

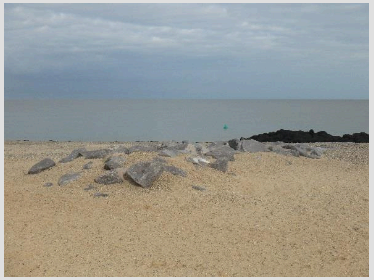
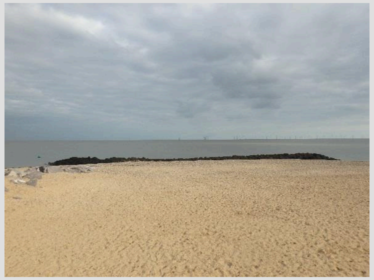
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
33				
34				
35				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
36				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.

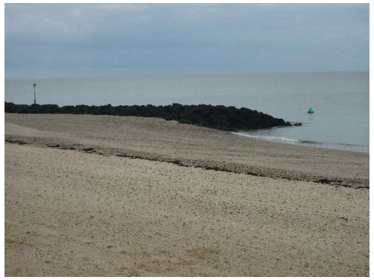
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
37				
38				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
39				
40				

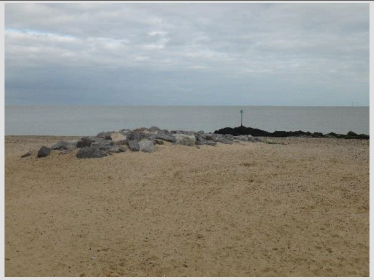
Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
41				
42				
43				
44				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
45				
46				
47				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
48				

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
49				
50				
51				
52				

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
53				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
54				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.
55				
56				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
57				
58				
59				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
60				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
61				
62				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
63				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.
64				

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
65				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.
66				Noticeably there is more sediment around the end of the rock groyne to the north than the one in the south. This suggest the coastline has experienced longshore drift in a northwards direction here.
67				
68				The end of the groyne (protruding into the sea) has little sediment around it, suggesting erosion due to wave defraction has occurred.

Profile	45˚ north to promenade	Perpendicular to promenade	45˚ south to promenade	Description
69				Unlike other bays, there is a significant amount of erosion at either end of the rock groynes. This is likely due to the slight change in orientation at this point along the frontage and the extended arm of the rock groyne affecting wave defraction.
70				The beach is very wide with a good amount of beach material. However, unlike other profiles taken on the south side of the groyne, there is very little sediment around the end of the groyne (protruding out to sea). This is likely due to the slight change in orientation at this point along the frontage and the extended arm of the rock groyne affecting wave defraction.
71				The beach is very wide, with the slope from the berm down to the foreshore at low tide being quite level. The beach appears to be relatively stable, though no accretion processes appear to have occurred here.

Source: Mott MacDonald, 2017

3 Summary

3.1 Recommendations

The site surveys that have been carried out as part of the Clacton and Holland-on-Sea Coast Protection Scheme beach monitoring programme clearly indicate that the fishtail groynes are retaining beach material well and are establishing the predicted bay formations for the frontage.

The beach profiles that were undertaken shows that overall beach levels and crest width have not reached trigger levels to warrant any beach management activities. Though the first three bays along the frontage, seem to be influenced by the pier diffracting wave energy. This has not resulted in an overall trigger level being reached, but should be continued to be monitored in the future.

Further the accretion and erosion maps, along with the fixed aspects photographs highlight that bay formation has occurred since As Built conditions, and that in the last six months there has been a dominant south westerly wave direction resulting in in a northerly movement of longshore drift.

Therefore, from these findings the recommended approach is to continue with bi-annual surveys of dip and crest measurements and drone surveys, to continue monitoring the future evolution of the frontage.

4 Refences

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Rawlinson, K. (2017). *Storms and floods force evacuation of thousands on east coast*. [online] Available at: https://www.theguardian.com/uk-news/2017/jan/14/storms-and-floods-force-evacuation-of-thousands-on-east-coast [Accessed 17th August 2017].

Appendices

A. Bay Layout Plan

Legend

Fishtail Groyne

Reference Drawings - N/A

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Contains Ordnance Survey data © Crown copyright and database right 2015.

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	20/07/2018	ES	Fishtail Groynes 1 to 5	HT	ZH

MOTT MACDONALD
Mott MacDonald House
8-10 Sydenham Road
Croydon, CR0 2EE
United Kingdom
T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W mottmac.com

Client
Tendring District Council,
Town Hall,
Station Road,
Clacton-on-Sea,
Essex

Tendring District Council

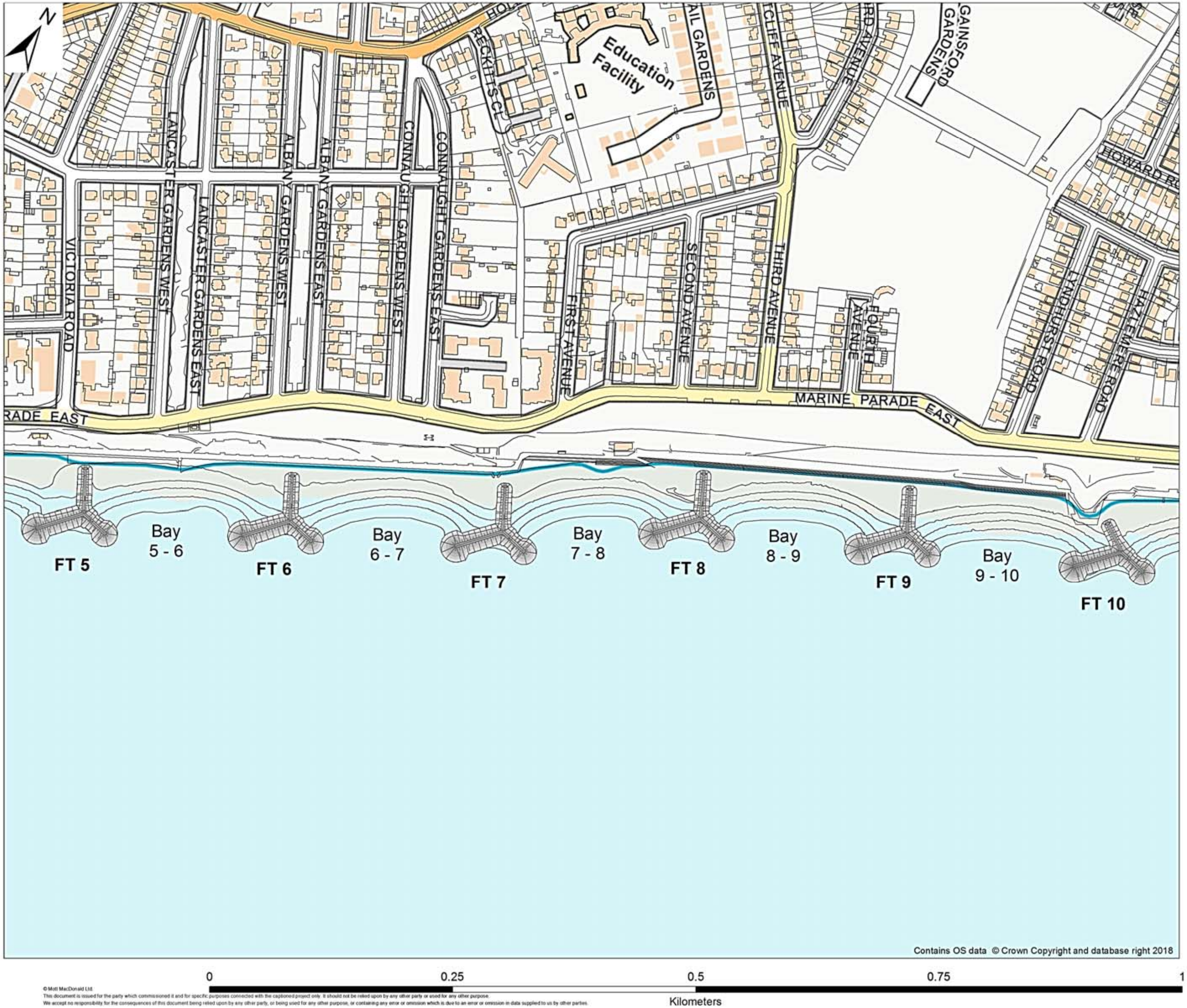
Title
Clacton-on-Sea Beach Management Plan

Plan layout 1 of 5.

Designed	E Smyth	Eng Check	H Taylor
Drawn	E Smyth	Coordination	H Taylor
GIS Check	V Deakin	Approved	Z Hutchison

Scale at A1	Status	Rev	Security
1:1,800	INF	1.0	STD

Drawing Number
384750-MMD-BMP-001-GIS-2018



Legend

Fishtail Groyne

Reference Drawings - N/A

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	20/07/2018	ES	Fishtail Groynes 1 to 5	HT	ZH

MOTT MACDONALD
Mott MacDonald House
8-10 Sydenham Road
Croydon, CR0 2EE
United Kingdom
T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W mottmac.com

Client
Tendring District Council,
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Title
Clacton-on-Sea Beach Management Plan

Plan layout 2 of 5.

Designed	E Smyth	Eng Check	H Taylor
Drawn	E Smyth	Coordination	H Taylor
GIS Check	V Deakin	Approved	Z Hutchison

Scale at A1	Status	Rev	Security
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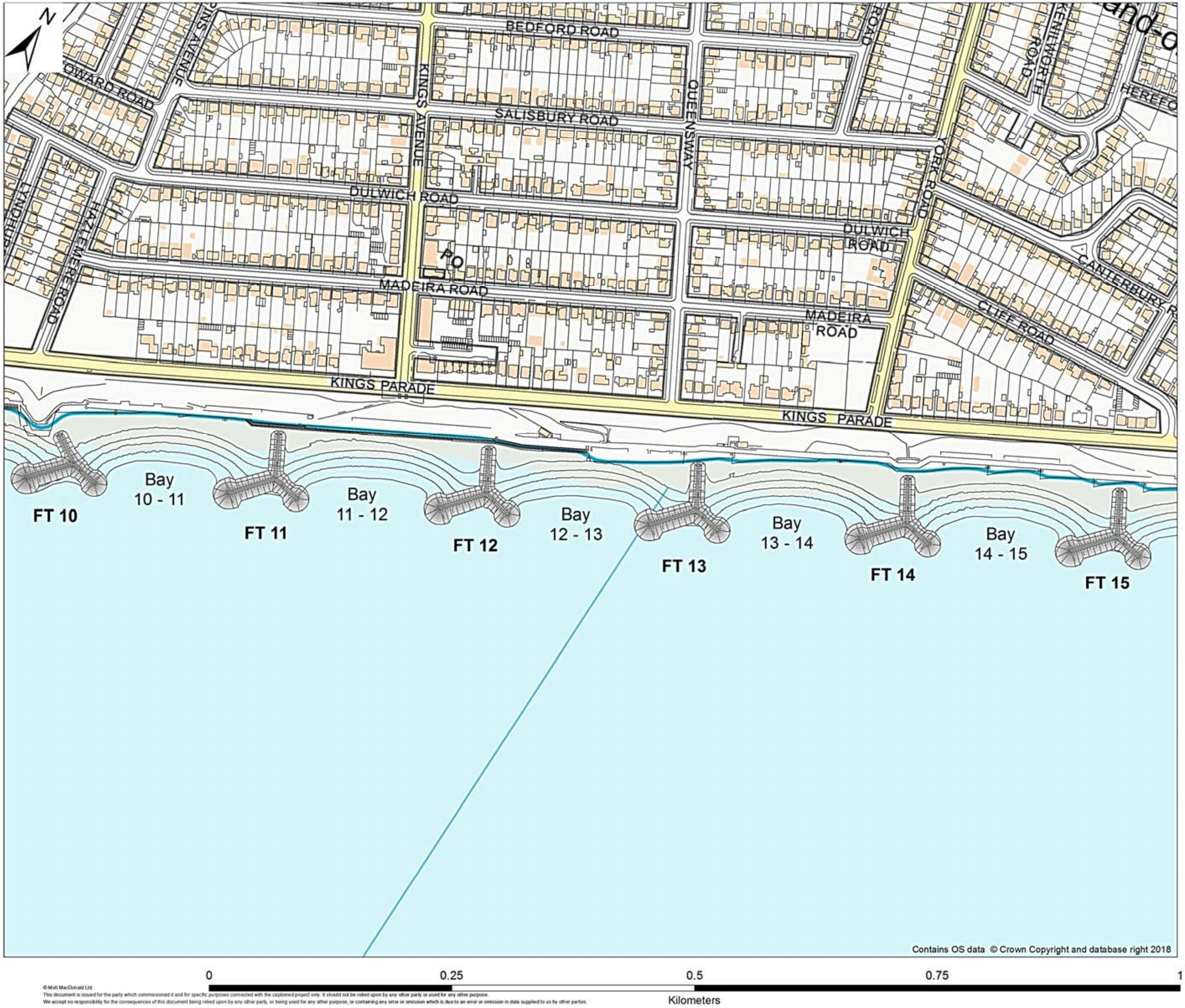

Legend

Fishtail Groyne

Reference Drawings - N/A

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	20/07/2018	ES	Fishtail Groynes 1 to 5	HT	ZH

MOTT MACDONALD
Mott MacDonald House
8-10 Sydenham Road
Croydon, CR0 2EE
United Kingdom
T +44 (0)20 8774 2000
F +44 (0)20 8681 5706
W mottmac.com

Client
Tendring District Council,
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Tendring District Council

Title
Clacton-on-Sea Beach Management Plan

Plan layout 3 of 5.

Designed	E Smyth	Eng Check	H Taylor
Drawn	E Smyth	Coordination	H Taylor
GIS Check	V Deakin	Approved	Z Hutchison

Scale at A1	Status	Rev	Security
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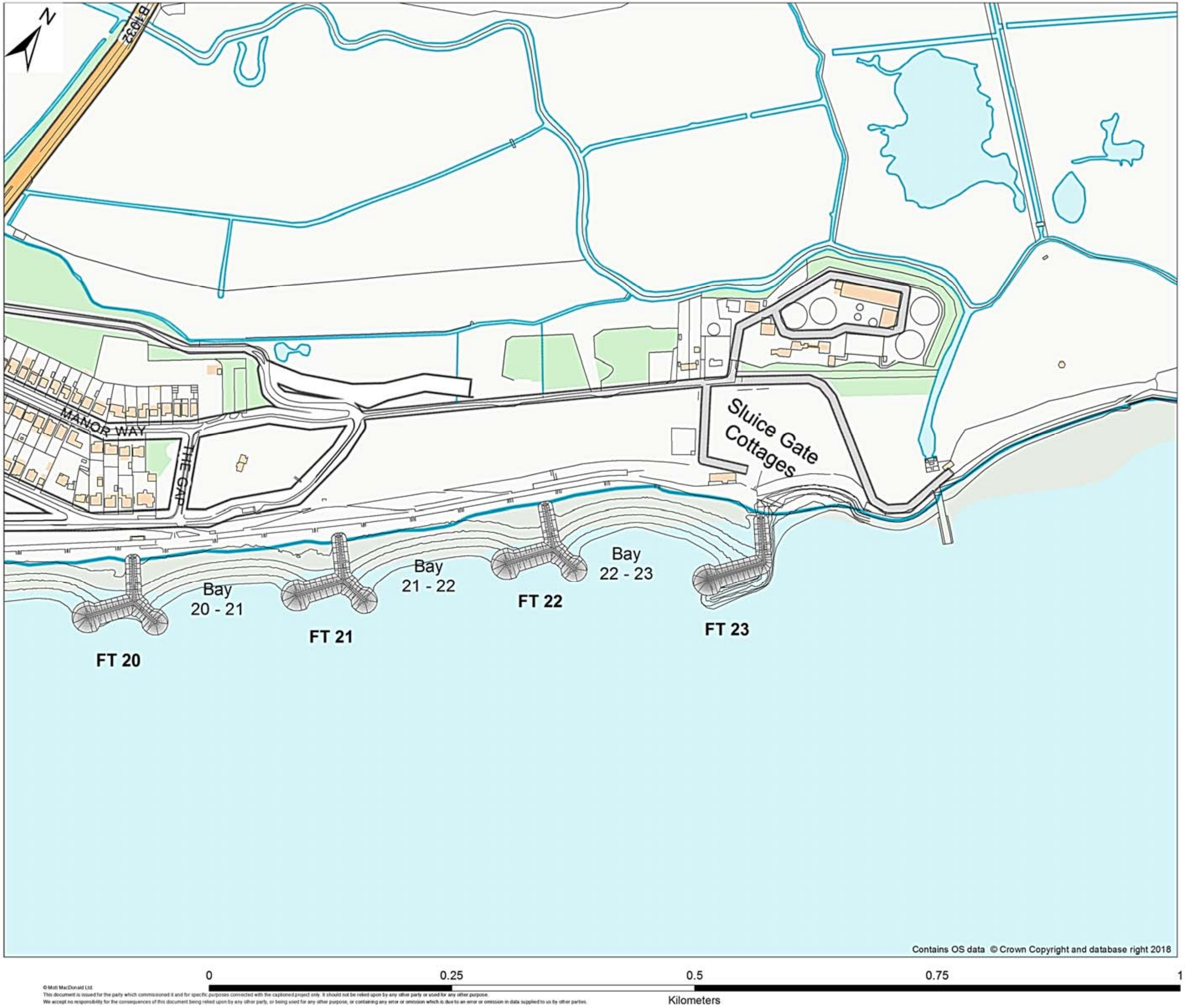

Legend

Fishtail Groyne

Reference Drawings - N/A

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Tendring District Council,
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Title
Clacton-on-Sea Beach Management Plan

Plan layout 5 of 5.

Designed	E Smyth	Eng Check	H Taylor
Drawn	E Smyth	Coordination	H Taylor
GIS Check	V Deakin	Approved	Z Hutchison

Scale at A1	Status	Rev	Security
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Drawing Number
384750-MMD-BMP-005-GIS-2018

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