Medmerry

Summary of monitoring
August 2013 to April 2018

TR 89
April 2018
Cover photograph: Exposed relict land surface on the eastern arm, Medmerry. P. Mylroie, April 2018
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MEDMERRY

Summary of monitoring, August 2013 to April 2018

1. Introduction

The Channel Coastal Observatory (CCO) was commissioned by the Environment Agency to conduct topographic, bathymetric and hydrodynamic monitoring of the breach site at Medmerry between August 2013 and March 2017. Further funding was granted to continue the topographic and bathymetric surveys to April 2018.

Prior to the scheme, the Medmerry frontage comprised a narrow shingle barrier beach extending northwest-southeast for approximately 3km between Selsey and Bracklesham, West Sussex. The Environment Agency maintained the flood defence function of the barrier beach through recycling and repolishing. To provide a more cost-effective and sustainable long-term solution to manage flood risk to people and property in the hinterland, 7km of inland flood defence embankments were constructed, and the barrier beach breached. This also allowed 184 hectares of intertidal habitat to be created (considered as compensatory habitat under the Conservation of Habitats and Species Regulations 2010) to offset the predicted losses of salt marsh and mudflat in the Solent over the next 20 years, resulting from coastal squeeze.

This report summarises the four and a half years of monitoring and data analysis undertaken by the CCO between August 2013 and April 2018, and the key geomorphological and volumetric changes that have been observed.
2 Data collection

2.1 Topographic surveys

Surveys were carried out using a combination of Leica C10 terrestrial laser scanner and Trimble Real Time Kinematic Global Positioning System (RTK GPS) receivers. Each data has an accuracy of +/- 20mm horizontally and 30mm vertically. The laser scanner has an effective operating range of up to 300m line of sight; The laser does not record elevations through water or where there is a sheen of water on wet sediment and such areas are captured with RTK GPS extending seawards to the Mean Low Water Springs contour (-1.8 OD). The processed data is made into Digital Terrain Models from which volumes can be calculated.

A pre-breach full baseline topographic survey was completed in August 2013, covering a 3km stretch between the undefended section east of Bunn’s defences, Selsey and the western rock armour structure, Bracklesham, with repeat surveys in March 2014, October 2015, October 2016 and October 2017. The intention is to repeat this baseline survey on an annual basis to monitor the larger scale change to the frontage up- and downdrift of the breach site. Lidar data, collected in June 2012, were combined with the datasets to provide pre-breach topographic detail landward of the barrier beach.

For the surveys conducted between August 2013 and January 2016 topographic surveys extended approximately 500m either side of the breach channel, from the landward extent of the barrier beach to the MLWS contour (or, for post-storm surveys as far seaward as could be achieved safely). Following the major morphological changes resulting from the 2013/14 storms, the western boundary of the routine survey area was extended to the rock armour structure at Bracklesham from April 2016 to present.

For the first 9 months following the breach, surveys were carried out monthly. Since June 2014, surveys are undertaken approximately every three months. To date, 28 surveys have been undertaken, as detailed in Table 1.

2.2 Bathymetric surveys

Five single beam hydrographic surveys have been completed, in January and June 2014, July 2015, August 2016 and March 2018, in order to assess elevation changes in the inter-tidal and sub-tidal areas just offshore of the breach site. Survey lines extended 300m offshore with a line spacing of 25m along a 1km stretch of frontage spanning either side of the breach. A higher level of detail was collected over a 300m section centred on the breach channel, with a line spacing of 12m and shore-parallel cross check lines of 20m. Some bathymetry within the main breach channel itself was also captured. A swath bathymetry survey of the East Solent was completed in June 2013 as part of the Southeast Regional Coastal Monitoring Programme, which provided an Order 1a standard bathymetric baseline, against which the single beam surveys could be compared.

2.3 Hydrodynamics

An Aquadopp Acoustic Doppler Current Profiler (ADCP) was deployed in the main breach channel, close to the confluence of the drainage channels, in order to measure current flows through the breach.
Unfortunately, within a week of deployment, the highly-mobile eastern arm of the barrier buried the instrument. It was eventually retrieved on 15 July 2014 (Figure 1), then checked and re-deployed at 50° 44.646’ N 000° 49.295’W on 15 August 2014. Final instrument recovery was on 16 September 2014, giving a full month of hydrodynamic measurements.

No further hydrodynamic monitoring at the site has been conducted.

Maximum velocities were observed around mid-tide, with shorter but faster flows on the ebb tide (Figure 2).

Boundary wave conditions are measured by a Directional Waverider buoy deployed in approx. 10m CD water depth off Bracklesham, operated by the Channel Coastal Observatory, for the Southeast Regional Coastal Monitoring Programme.

It is important to note that during the winter of 2013-2014 the southern coast of England was exposed to an unusual and prolonged period of intense severe storms. In an average year, there are usually 3 or 4 storms which have some impact on the barrier beach at Medmerry; a "storm" is defined as having wave heights above that which would be expected, on average, once a year i.e. the 1 year return period (Bradbury and Mason, 2014). The storm calendar, as shown in Figure 3, shows the occurrence of storm events.
Figure 3: Storm calendar, Bracklesham (Storm threshold Hs 3.43m)
3 Methods of data analysis

For the purpose of analysis, the site has been split into 3 overlapping areas:

- Breach – the frontage between the western bay of the Bunn frontage and approximately 500m west of the breach channel; coverage for surveys between September 2013 and January 2016.
- Rock armour to rock armour – 1.7 km of shoreline between the western bay of the Bunn frontage and the western rock armour structure. The quarterly surveys were extended to cover this area from April 2016.
- Baseline - 3km frontage between the eastern end of Selsey West beach and the rock armour structure, at Bracklesham; these surveys are conducted once per year.

The extent of the topographic surveys are presented in Figure 4.

![Figure 4: Extent of the different topographic survey coverages](image)

3.1 Morphological change

A digital terrain model (DTM) has been produced for each survey, to assess and quantify the evolution and scale of morphological change. The locations of and terms used to describe the key features identified are given in Figure 5.

![Figure 5: Locations and terms of key morphological features](image)
3.2 Volume changes at the breach site

The beach volume above Mean Low Water Springs (MLWS -1.8 OD) was calculated for each topographic survey and above -5 OD for the bathymetric surveys. Using the DTMs, difference plots between successive surveys were generated. The area common to both surveys varies and the boundary box used for each difference model is shown on the individual plots. The difference models indicate areas of net erosion (red) or accretion (blue).

The accuracies of each measurement system must be taken into account when drawing conclusions from the difference models. In the case of topographic difference models Difference plots show changes >±0.25m, should be indicative of areas of measurable change. The volume changes between successive surveys, and between the post-breach and most recent surveys are provided in Section 4.4.
4. Results

4.1 Breach area

A time series of survey-to-survey DTM and volume change is given in Appendix A, with the 2 most recent surveys shown presented (Figure 6), together with a difference model showing change from post-breach to the most recent survey in April 2018 (Figure 7).

Within 3 months of the breach, the surveys undertaken between December 2013 and March 2014 indicated the significant impact the winter storms had on the breach site. The width of the barrier beach decreased dramatically during the 2013/14 winter storms from 45m in December 2013 to 30m wide in January 2014.

Between the post-breach and most recent surveys, the eastern and western barrier beaches have rolled back up to 150m through overwashing in response to wave and storm conditions that have occurred during the 55 month period, causing a lowering and flattening of the barrier on sides of the breach. This has resulted in exposure of the former land surface, historic groynes, field boundaries and former defence structures, and significant realignment of the shoreline. The continued unhindered progression of overwash fans is notably evident on the landward flanks of the western arm. Over the winter 2017/2018 the eastern arm has completely rolled back, exposing the former land surface as well as in-filling the eastern drainage channel.
The hinge of the western arm receded westwards by approximately 150m between breaching and June 2014, a further 500m between October 2015 and April 2016, and 200m in the last two years to April 2018. The resistant, compacted mud foreshore fronting the western hinge and elbow and the eastern arm are evident and appear to influence the rate of roll-back at these locations, resulting in slight embayment of the eastern and western arms, and changing the alignment of the shoreline.

Following the breach, the compacted mud surface (land previously beneath the spit) has been significantly exposed and eroded, and is clearly visible on the foreshore fronting the arm of the eastern barrier and the elbow of the western barrier. This material appears to be more resistant to erosion than the foreshore.

Over the past two years (April 2016 to April 2018), the eastern arm has migrated back significantly, exposing relict fields from before the breach. This compacted mud is eroding at different rates along this frontage.
Following the winter 2015, the eastern barrier beach has continued to roll-back unabated until reaching the eastern drainage channel in early 2018, infilling the channel and altering how the borrow pit drains into the main breach channel.

The orientation of the breach channel has continued to modify in response to the growth of the distal ends of the spits. A northwest-southeast oriented ditch near the western arm has also constrained the movement of the western finger.

The distal end of the eastern finger has prograded by 124m in a northeasterly direction, and then connected with the northern bank of the confluence of the drainage channels. An island of shingle has been isolated from the main eastern finger, due to changes in flow of the eastern drainage channel and position of the confluence with the main breach channel. The western arm has pivoted from the hinge, and the “elbow” has rolled back 100m, whilst the distal end of the western finger has prograded approximately 300m in a northwesterly direction. This continues to change with every survey undertaken.
The first post-breach survey shows the breach channel and the section of barrier beach that was removed. Both the eastern and western breach arms, following 55 months of site evolution, have prograded significantly northwards, maintaining and defining the breach channel, and influencing the location, orientation and confluence of other drainage channels. This is particularly evident to the east where the drainage channel has been in filled by gravel that used to make up the eastern arm, blocking drainage from the borrow pit behind Bunn Leisure.

Figure 6: Geomorphological change of the breach between Survey 2 and Survey 28
Figure 7: Change in elevation of the breach between Survey 2 and Survey 28

The difference plot shows the development and roll-back of the arm to the western side and the disappearance of the arm to the east as the eastern drainage channel has infilled and is now blocked. The western distal feature has extended significantly north and curving to the northwest.
4.2 Rock armour to rock armour

The results of the baseline survey in October 2015 and the breach survey January 2016 demonstrated that considerable morphological change was occurring along the wider beach (Figure 8). Accordingly, the breach survey area was extended westwards to the rock armour structure at Bracklesham with effect from April 2016. Further DTMs and volumetric change are given in Appendix B.

Over the 55 month period between the pre-breach and April 2018 survey, there has been a net loss of -318,457 m$^3$ of material (Figure 8). The highest rates of erosion are found at the mouth of the breach, extending approximately 600m to the eastern rock armour structure and the western embayment of the Bunn frontage, and approximately 1km along the western arm from the breach channel.

The continued progression of overwash fans is notably evident on the landward flanks of the western arm; the overwash fans are no longer visible on the eastern arm as the barrier has rolled back over an east-west bank and ditch, and continued to migrate northwards into the eastern drainage channel. As of April 2018 this drainage channel had also been infilled blocking drainage from the borrow pit.
Figure 8: Change in elevation for extended breach survey (rock armour to rock armour), between Survey 1 and Survey 28
4.3 Baseline survey

The baseline survey from survey 1 (post-breach) to survey 26 (October 2017) shows a net loss of 290,962 m$^3$ (Figure 10); comparisons between the baseline surveys are given in Appendix C.

The highest rates of erosion are found at the mouth of the breach, extending approximately 500m along the eastern arm to the eastern rock armour structure and the western embayment of the Bunn frontage. Significant erosion has occurred approximately 1km along the western arm from the breach channel. The landward roll-back of the arm has changed the alignment of the shoreline, with the elbow and hinge retreating less markedly.

The significant areas of accretion indicate where the barrier beach arms either side of the breach have rolled back forming highly mobile arms and spit features. The Bunn frontage and eastern-most bay have incurred minor levels of foreshore steepening, indicated by zones of accretion on the seaward face of the beach, with minor erosion at the toe.
Figure 9: Change in elevation for baseline between Survey 1 and Survey 26
### 4.4 Volumetric changes

Volume changes between surveys, and are detailed in Table 1.

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<th>Date To</th>
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Baseline (western rock armour to eastern end of Selsey West Beach) (3 km shoreline)

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**Table 1:** Volume changes between surveys calculated from difference plots
4.5 Bathymetric change

Five single beam bathymetry surveys have been completed, in January and July 2014, July 2015, August 2016 and March 2018. Comparisons between the single beam bathymetry surveys are given in Appendix D.

![Figure 10: Collecting single beam data in the mouth of the breach, July 2014](image)

Analysis of the bathymetry datasets indicated that there has been minimal change in depths in the survey area over the monitoring period, as shown in Table 2. Between January 2014 and July 2016 relatively minor changes were largely limited to the inter-tidal foreshore for the frontage that extended between the eastern survey area boundary and approximately 200m west of the breach channel (offshore of the western barrier hinge). Some shoaling at the mouth and southwest of the breach channel is apparent and corresponds with measurements from topographic survey data. Between summer 2016 and March 2018 the significant change is one of erosion observed in the mouth to the breach extending up to 200m to the west of the breach channel.

<table>
<thead>
<tr>
<th>Bathymetric Surveys</th>
<th>Date</th>
<th>Volume Change (m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey 8 to Survey 13</td>
<td>10/01/2014</td>
<td>24,539</td>
</tr>
<tr>
<td>Survey 13 to Survey 17</td>
<td>31/07/2014</td>
<td>-16,113</td>
</tr>
<tr>
<td>Survey 17 to Survey 21</td>
<td>02/07/2015</td>
<td>1,692</td>
</tr>
<tr>
<td>Survey 21 to Survey 28</td>
<td>18/08/2016</td>
<td>-16,682</td>
</tr>
</tbody>
</table>

*Table 2: Volume changes between single beam bathymetric surveys*
5 Reference

Appendix A: Time series of breach surveys
The pre-breach to most-recent survey comparison shows the location and orientation of the breach channel, and the significant roll-back of the barrier arms when compared to the fixed position of the eastern rock armoured terminus of the flood embankment. The resistant compacted mud foreshore fronting the western hinge and elbow and the appearance of compacted mud seaward of the eastern arm.

Figure A1: Geomorphological change between Survey 1 and Survey 28
The difference plot clearly shows the former position of the barrier and the current position of the barrier beach arms, resulting from extensive and continual roll-back through overwashing in response to wave and storm conditions that have occurred during the 55 month period. The continued unhindered progression of overwash fans is notably evident on the landward flanks of the western arm; the overwash fans are less distinct on the eastern arm as barrier has rolled back and has migrated into the eastern drainage channel. The orientation of the breach channel has continued to be modified in response to the growth of the distal ends of the spits. Land previously beneath the footprint of the spit has continued to be exposed and eroded significantly.

**Figure A2**: Change in elevation between Survey 1 and Survey 28
The first post-breach survey shows the breach channel and the section of barrier beach that was removed. The arms have not evolved notably although a proto-finger extension is apparent on the eastern arm, extending westwards but limited by the engineered breach channel.

**Figure A3:** Geomorphological change between Survey 1 and Survey 2
The area of erosion indicates the section of barrier beach removed and location of the breach channel. The area of accretion landward of the eastern arm and the seaward flank of the western beach is due to the plant still present on the site re-profiling and moving material.

Figure A4: Change in elevation between Survey 1 and Survey 2

5aSU01 Medmerry: Pre-breach (27/08/2013) to Survey 2 (12/09/2013)
The proto-finger on the distal end of the eastern arm has developed into a hook feature extending west then northwest by 20m before curving northwards by 20m. The western arm has also developed a less distinct finger-like projection, extending 40m to the northeast.

Figure A5: Geomorphological change between Survey 2 and Survey 3
A loss of material from predominantly the eastern arm where the vegetated area of land behind the barrier beach began eroding due to inundation at high tide twice a day. Accretion is evident in the breach channel itself.

20,600m$^3$ Erosion

5aSU01 Medmerry: Survey 2 (12/09/2013) to Survey 3 (24/09/2013)

Figure A6: Change in elevation between Survey 2 and Survey 3
The hook of the eastern arm curved sharply to the north, extending by 60m. The distal end of the western arm prograded in an arc initially to the east then northwards.

Figure A7: Geomorphological change between Survey 3 and Survey 4
Erosion of the seaward flanks of both the western and eastern arms and foreshore. Accretion at the distal ends of both finger features and down the eastern edge of the main breach channel.

Figure A8: Change in elevation between Survey 3 and Survey 4

3,600m$^3$ Erosion
The curve of the eastern arm is less pronounced having rolled back 20m, with the distal end oriented more to the northwest. The hinge has migrated eastward approx. 50m. The barrier beach has eroded on the seaward face, however the hinge has remained largely fixed. The western arm has rolled northwestwards approx. 20m.

Figure A9:Geomorphological change between Survey 4 and Survey 5
Both the western and eastern arms have continued to significantly roll-back, with accretion of 2m landward of eroding barrier beach, and lowering of the foreshore. Erosion is also evident on the eastern face of the main breach channel.

Figure A10: Change in elevation between Survey 4 and Survey 5
Relatively stable with very little change to either arms, and minor erosion to the seaward face of the barrier beach.

**Figure A11**: Geomorphological change between Survey 5 and Survey 6
Relatively stable with minor accretion to the western arm, and minor erosion to the seaward face of the barrier beach and either side of the main breach channel.

Figure A12: Change in elevation between Survey 5 and Survey 6
The distal end of the eastern arm curves slightly back to the north. There is little change to the position and orientation of the western arm. Due to the wave conditions experienced since breaching, the crest levels of the breach arms have been lowered but in general the alignment and position of the barrier arms have not significantly changed, in relation to the seaward end of the eastern rock armour.

Figure A13: Geomorphological change between Survey 6 and Survey 7
Relatively stable again with little change to the barrier beach and patchy erosion and accretion to the arms. Some higher rates of erosion to the mouth of the breach channel.

5aSU01 Medmerry: Survey 6 (28/11/2013) to Survey 7 (10/12/2013)

Figure A14: Change in elevation between Survey 6 and Survey 7
The crest of the eastern barrier beach has rolled back 25m. To the west the hinge migrated approx. 50m westwards and the arm has rolled 40m northwestwards. The curve is less pronounced with the distal end extending 50m in a northeasterly direction. The hinge on the eastern barrier has also migrated westward approx. 50m. The eastern arm has extended 50m, the curve is less pronounced and oriented more to the northwest. The eastern channel formed a “dog leg” northwest southeast bend into the main channel.

Figure A15: Geomorphological change between Survey 7 and Survey 8
The extension of the eastern arm is clearly visible in the difference plot. The crest of the eastern and westerns barrier beaches have rolled back up to 25m therefore showing high levels of erosion along the whole frontage. There is some accretion in the mouth of the breach and to the distal end of the western arm.

**Figure A16**: Change in elevation between Survey 7 and Survey 8
The eastern arm retreated a further 40m to the east, the distal end curving back to the northeast. The hinge position remained largely static. The western arm extended 20m curving to the northwest. The barrier beach to the west of the breach retreated approximately 20m.

*Figure A17: Geomorphological change between Survey 8 and Survey 9*
There are high levels of erosion to the seaward side of the western arm particularly around the hinge. The distal end of the eastern arm also shows considerable erosion. There is patchy accretion across the whole site, landward of the barrier beach on the western arm and in the centre of the barrier beach and around the mouth of the breach channel to the east.

Figure A18: Change in elevation between Survey 8 and Survey 9
The eastern arm prograded in a northwesterly direction by 35m. The eastern barrier beach also rolled back a further 25m, the rate of retreat constrained by an east-west ditch. There was little change to the position or orientation of western arm.

Figure A19: Geomorphological change between Survey 9 and Survey 10
Considerable roll-back of both arms and hinge sections, as indicated by the parallel areas of erosion and accretion to landward. Some accretion is evident in the breach channel mouth, whilst the eastern and central foreshore area shows patches of minor erosion, with an area of minor accretion further to the west.

Figure A20: Change in elevation between Survey 9 and Survey 10
The eastern arm prograded 30m in a northwesterly direction. Minor change to position and orientation of western arm.

Figure A21: Geomorphological change between Survey 10 and Survey 11
Minor erosion of the seaward flank of the western arm and foreshore and the eastern finger feature, with patches of minor accretion of the eastern and central foreshore area.

Figure A22: Change in elevation between Survey 10 and Survey 11
The eastern arm extended 15m in a northeasterly direction. Minor change to position and orientation of western arm.

Figure A23: Geomorphological change between Survey 11 and Survey 12
Some minor erosion to the western arm towards the defences. Minor accretion around the hinge. There is little change to the barrier beach to the east however there are patches of significant erosion to the banks of the main breach channel and along the eastern tributary channel.

Figure A24: Change in elevation between Survey 11 and Survey 12
Relatively stable with only minor change to position and orientation of either arm.

Figure A25: Geomorphological change between Survey 12 and Survey 13
Changes mainly evident on the banks of the breach channel, with only minor changes to arms or finger features.

Figure A26: Change in elevation between Survey 12 and Survey 13

5aSU01 Medmerry: Survey 12 (12/06/2014) to Survey 13 (31/07/2014)
The eastern arm retreated 60m to the east with the arc in a more northerly direction. The hinge position remained static. The eastern end of the eastern barrier beach (near to the rock armour structure) rolled back 10m. The western arm prograded 30m with the distal end curving to the northwest. The barrier beach rolled back 10m.

Figure A27: Geomorphological change between Survey 13 and Survey 14
Large volume loss to the eastern arm and barrier beach on both sides of the breach. Accretion to the shoal area at the breach mouth and around the eastern channel confluence with the main channel.

Figure A28: Change in elevation between Survey 13 and Survey 14
The eastern arm extended 25m to the northwest the distal end curving to the northeast. The western arm prograded 20m arcing to the north then back in a westerly direction.

**Figure A29**: Geomorphological change between Survey 14 and Survey 15
Erosion of both the eastern and western barrier beaches as well as patchy erosion seaward of the mouth of the breach channel. Areas of accretion at the distal end of the eastern arm and midway on the western bank of the breach channel.

**Figure A30**: Change in elevation between Survey 14 and Survey 15

5aSU01 Medmerry: Survey 14 (29/10/2014) to Survey 15 (20/01/2014)
The eastern arm has continued to extend to the northwest, with the curve at the distal end reduced. The western arm has continued to curve in a westerly direction.

*Figure A31: Geomorphological change between Survey 15 and Survey 16*
The western arm has rolled back with overwash fans developed landward of the remaining western barrier beach. The overwash fans are less evident on the eastern arm.
The distal end of the eastern arm has continued to extend 50m to the northwest. The hinge of the western arm has eroded north and west with the finger continuing to accrete northwards and curve in a westerly direction.

*Figure A33*: Geomorphological change between Survey 16 and Survey 17
The western arm has rolled back, the hinge and elbow eroded significantly, and the finger continuing to extend and curve to the northwest. The distal end of the eastern arm has accreted significantly. The eastern bank of the breach channel has accreted.

Figure A34: Change in elevation between Survey 16 and Survey 17
There has been little change to the western arm. Although remaining connected the ridge of the eastern finger lowered along the central section to form a short finger and an island at the distal end. This appears to have resulted in changes to breach channel flows, resulting in shoaling of the foreshore in the vicinity of the breach channel mouth, and formation of foreshore tributary channels.
The extent of the lowering and erosion of the ridge on the eastern finger is notable, along with the accretion at the distal end. The arm, hinge and elbow of the western barrier have continued to erode, although no significant roll-back has occurred. Erosion of the western bank of breach channel has continued. The eastern barrier has migrated northwards and is constrained by an east-west bank and ditch, reducing rate of roll-back. Foreshore tributary channels from the breach channel continue to influence beach levels.

**Figure A36**: Change in elevation between Survey 17 and Survey 18
Substantial roll-back has occurred to both barrier arms over this winter period. The western flank of the distal end of the eastern finger has lowered and flattened extending to and controlling the position of the breach channel, whereas the northern flank has extended northwards, significantly affecting the position and orientation of the eastward drainage channel. The eastern elbow has migrated north, exposing compact mud, previously beneath the footprint of the barrier. The western hinge has rolled back and widened, with the distal end widening and extending significantly to the northwest. The breach channel has shallowed sufficiently to enable more comprehensive survey coverage than previously possible.

Figure A37: Geomorphological change between Survey 18 and Survey 19
Significant roll-back and distinct overwash fans have occurred on both breach arms. No longer constrained by the east-west bank and ditch, the roll-back of the eastern arm has continued unabated, broadening and flattening towards the eastern drainage channel. The hinge and finger of the western barrier, and the western flank of the eastern finger have widened. The position and orientation of the main breach and eastern drainage channel confluence continue to change in response to behaviour of the eastern finger.

Figure A38: Change in elevation between Survey 18 and Survey 19
The eastern arm has continued to roll-back significantly, in part migrating into the eastern drainage channel, and exposing further compacted mud formerly beneath the spit. The rate of roll-back of the eastern arm has been reduced where it is still migrating over the east-west bank, resulting in lowering of the ridge crest, forming a fractured although still continuous, arm and finger. The hinge of the western arm has eroded and rolled back to the northwest, exposing considerable length of compacted mud. Two distinct foreshore tributaries of the main breach channel have formed.

**Figure A39: Geomorphological change between Survey 19 and Survey 20**
Substantial roll-back of both arms have continued, with extensive overwash fans evident. There has been significant erosion to the western hinge and finger, which has extended to the northwest, controlled in part by a drainage bank. The erosion of the compacted mud areas at both the elbows is significant. The northern tip of the eastern finger has extended and connected with the northern bank of the main drainage channel. Changes in channel confluence have since isolated this material from the distal finger.

Figure A40: Change in elevation between Survey 19 and Survey 20
The eastern arm has continued to roll-back, migrating into the eastern drainage channel, and exposing further compacted mud formerly beneath the spit. The main breach channel now exits the site in a southerly direction. The hinge of the western arm has remained unchanged.

Figure A41: Geomorphological change between Survey 20 and Survey 21
Some erosion is evident to the western foreshore where the breach channel has altered course.
The eastern arm has continued to roll back exposing more compacted mud. The distal end of the eastern arm has flattened. There has been little change to the western arm with some erosion of the gravel seaward of the hinge.

Figure A43: Geomorphological change between Survey 21 and Survey 22
There has been some erosion to the distal end of the eastern arm as well as to the elbow of the western arm. Some accretion is evident to the mouth of the main breach channel.
The eastern arm has continued to migrate to the tributery channel. The exposed compacted mud in front of the eastern arm has started to erode. There has also been some erosion to the western finger and a significant build up of gravel seaward of the western elbow.
The erosion to the western finger is significant in the difference plot as is the accretion of material at the mouth of the breach. The continued migration towards the tributary channel of the eastern arm is clearly shown as is minor roll back of the western arm and hinge.

**Figure A46:** Change in elevation between Survey 22 and Survey 23
The eastern arm has continued to migrate to the tributary channel. The exposed mud in front of the eastern arm has also continued to erode. There has been some erosion to the western arm exposing more compacted mud and the build up of gravel seaward of the western elbow has rolled back and attached to the western elbow.

**Figure A47:** Geomorphological change between Survey 23 and Survey 24
The roll back of both eastern and western arms is visible in the difference plot as is the migration of the gravel seaward of the western hinge back towards the hinge of the western arm. Erosion of the mud in front of the eastern arm can also be seen.

Figure A48: Change in elevation between Survey 23 and Survey 24
The eastern arm has continued to migrate to the tributery channel. The exposed mud in front of the eastern arm has also continued to erode. There has been some erosion to the western arm exposing more compacted mud and the build up of gravel seaward of the western elbow has rolled back in its entirety and attached to the western elbow.

Figure A49: Geomorphological change between Survey 24 and Survey 25
The roll back of both eastern and western arms is visible in the difference plot as is the migration of the gravel landward of the western hinge back towards the hinge of the western arm. Erosion of the mud in front of the eastern arm can also be seen.

Figure A50: Change in elevation between Survey 24 and Survey 25
The eastern arm has continued to migrate to the tributery channel. The exposed mud in front of the eastern arm has also continued to erode. There has been a build up of sediment on the western elbow which has rolled back. The mouth of the breach now divides into two distinct channels with an island of gravel between them.

Figure A51: Geomorphological change between Survey 25 and Survey 26
The roll back of both eastern and western arms is visible in the difference plot as is the migration of the gravel landward of the western hinge back towards the hinge of the western arm. Erosion of the mud in front of the eastern arm can also be seen. The development of the channels at the mouth of the breach can also be seen.

Figure A52: Change in elevation between Survey 25 and Survey 26
The eastern arm has migrated and filled the tributary channel. The exposed mud in front of the eastern arm has also continued to erode. The western arm and elbow have eroded revealing more mud. The main breach channel is much narrower with continuous movement of gravel around the confluence of the tributary channels. The mouth of the breach is now much wider and shallower. The eastern arm has lowered and breached in the centre, leaving two isolated sections.

Figure A53: Geomorphological change between Survey 26 and Survey 27
The roll back of both eastern and western arms is visible in the difference plot as is the migration of the gravel landward of the western hinge back towards the hinge of the western arm. Erosion of the mud in front of the eastern arm can also be seen as well as the infilling of the tributary channel. The flattening of the breach mouth is also visible.

Figure A54: Change in elevation between Survey 26 and Survey 27
The eastern arm has migrated and infilled and blocked the eastern drainage channel. The exposed mud in front of the eastern arm has also continued to erode. The western arm and elbow have eroded revealing more mud. The main breach channel now dog legs due to the change in drainage from the east. The main breach channel is much deeper opening out to a sand flat at low water. The eastern arm breach has widened and continued to shall, with clear “hooking” at the end of the small features.

Figure A55: Geomorphological change between Survey 27 and Survey 28
The roll back of both eastern and western arms is visible in the difference plot. Erosion of the mud in front of the eastern arm is also evident.

Figure A56: Change in elevation between Survey 27 and Survey 28
Appendix B: Time series of extended breach surveys (rock armour to rock armour)
Figure B1: Change in elevation between Survey 1 and Survey 10

137,200 m³ Erosion
Figure B2: Change in elevation between Survey 10 and Survey 18
Figure B3: Change in elevation between Survey 18 and Survey 20
Figure B4: Change in elevation between Survey 20 and Survey 21

8,000m$^3$ Accretion
Figure B5: Change in elevation between Survey 21 and Survey 22
Figure B6: Change in elevation between Survey 22 and Survey 23

4,900m$^3$ Accretion

5aSU01 Medmerry: Baseline Survey 22 (28/10/2016) to Rock Armour Survey 23 (11/01/2017)
Figure B7: Change in elevation between Survey 23 and Survey 24
Figure B8: Change in elevation between Survey 24 and Survey 25
Figure B9: Change in elevation between Survey 25 and Survey 26
Figure B10: Change in elevation between Survey 26 and Survey 27
Figure B11: Change in elevation between Survey 27 and Survey 28

21,200 m$^3$ Erosion
Appendix C: Time series of baseline surveys
Figure C1: Change in elevation between Survey 1 and Survey 10

126,900 m$^3$ Erosion

5aSU01 Medmerry: Baseline Survey 1 (27/08/2013) to Survey 10 (07/03/2014)
Figure C2: Change in elevation between Survey 10 and Survey 18

57,700m³ Erosion
Figure C3: Change in elevation between Survey 18 and Survey 22

74,400m³ Erosion
Figure C4: Change in elevation between Survey 22 and Survey 26
Appendix D: Bathymetry
Figure D1: Change in elevation between Survey 8 and Survey 13

5aSU01 Medmerry: Survey 8 (10/01/2014) to Survey 13 (31/07/2014) Single Beam Hydro
Figure D2: Change in elevation between Survey 13 and Survey 17

16,100 m³ Erosion

5aSU01 Medmerry: Survey 13 (31/07/2014) to Survey 17 (02/07/2015) Single Beam Hydro
Figure D3: Change in elevation between Survey 17 and Survey 21
Figure D4: Change in elevation between Survey 21 and Survey 28