Introduction

This report presents the changes in elevation recorded from four LiDAR surveys of Sudbourne beach within Aldeburgh Bay on the Suffolk coast. The extent of the area assessed runs from Slaughden along Orford Ness to just south of the Cobra Mist site and Lantern Marshes.

This report is produced as part of the Anglian Coastal Monitoring (ACM) project. The ACM project is a partnership programme of coastal surveys providing long term data for coastal monitoring and analysis. More information about the project can be found at: http://www.coastalmonitoring.org/anglia/ and at the East Anglia Coastal Group: http://www.eacg.org.uk/default_monitoring.asp.

Beach recycling

Throughout the period being assessed there has been recycling of shingle within the frontage. As shown in Figure 1 the origin of this shingle is a donor site on Sudbourne beach alongside the Cobra Mist site at Lantern Marshes. The shingle is transported and deposited between the sailing club and just south of the Martello Tower at Slaughden.

Figure 1: Extent of the frontage analysed and the locations of the transects where data is extracted from the LiDAR data to produce beach profiles.
Records of shingle recycling events and volumes are relatively uncertain. The beach was recycled only once for the permission period of 2002 to 2007 and this was in 2002 when 10,000 tonnes, equating to 5,000 cubic metres, was moved. This was the year before the first LiDAR survey in April 2003. Prior to 2002 there was ad hoc recycling works, thought to have been on a nearly annual basis. Subsequent to 2007 there have been a number of recycling events, either as emergency works or on a scheduled basis.

Data collection and analysis
This report assesses change measured by four airborne LiDAR surveys on the following dates:

- 15 April 2003
- 7 February 2008
- 17 December 2012
- 25 January 2015

In addition, data from our walked GNSS topographic transect surveys is used to show how the LiDAR data compare to the surveys collected on the ground every summer and winter since 1991. The difference models displayed in Figures 2 – 5 are overlaid on the January 2015 LiDAR surface.

All data are collected by the Environment Agency as part of the ACM project. For information on airborne LiDAR as a method of measuring ground elevation please read our LiDAR survey Information sheet. For information about ground topographic surveys of beach transects please read our Topographic Survey Information sheet. Both are available from the project website or by request to ACM@environment-agency.gov.uk

The output of the LiDAR survey is a point cloud of millions of data returns, each containing location information, signal intensity and an elevation. From this we create a Digital Surface Model (DSM), this is an unfiltered representation of the beach and ground surfaces. The LiDAR has a 1 m spatial resolution, this means an elevation measurement every metre on the ground. From this DSM a cross section or profile, along the same transect line that we survey on foot, is extracted. These beach cross sections are then compared to the annual topographic survey data. The DSMs themselves are compared by creating a difference model, which shows the change between two DSMs from two LiDAR survey datasets. Four difference models are presented in this report. To minimise any errors caused by systematic offset between the two LiDAR datasets, the data are normalised based on areas of no change such as concrete and tarmac surfaces, before any analysis is carried out.

The LiDAR datasets provide an observation of change over four surveys between 2003 and 2015. However the topographic surveys extend from 1991 through to present and are surveyed every summer and winter. Therefore these surveys provide a better picture of the trends and longer term changes of the beach profile. The profiles only provide an indicator of what is happening along the frontage, whereas the LiDAR survey provides data coverage of the whole beach. The difference models also clearly identify potential sediment movement alongshore, and areas of accumulation and erosion.

LiDAR elevation change
In the following plots increased elevation, such as the result of deposition and accumulation of sediment on the beach is coloured in blue, with the greatest changes shown in a darker shade. Areas of erosion or lowering elevation are shown in a graded scale of red through to green. When there is no significant change (~30 cm) the data is shaded grey.
Figure 2: LiDAR difference model showing elevation change between April 2003 and February 2008.

Figure 3: LiDAR difference model showing elevation change between April 2003 and January 2015.

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Figure 4: LiDAR difference model showing elevation change between February 2008 and December 2012.

Figure 5: LiDAR difference model showing elevation change between December 2012 and January 2015.
There has been an overall lowering of elevation or erosion of sediment at the deposition site from 2003 to 2015 (Figure 6). The 2003 – 2008 difference model shows a drop in the beach level, however there was a build up in sediment from 2008 – 2012 along the Slaughden neck to Aldeborough. Levels fell again leading into 2015 when compared to 2012, and overall there has been a loss of sediment. Transect SL015 is located at the north of the deposition area. Photos taken as part of the land topographic survey show the loss of shingle at this site and the difference in level from 2003 and 2015 that is seen in the difference model.

![Survey photos taken looking across (northwards) and up (landwards from the waterline) transect SL015 in 2003 (top) and 2015 (bottom).](image)

![Aerial photograph of the deposition site and location of transect SL015 in July 2015.](image)
Transect SL029 is to the south of the deposition area and is shown as a thumbnail insert in the change maps (Figures 2 – 5). The transect lies within a groyne field that serves to retain sediment and inhibit alongshore transport of sediment. The elevation change analysis shows the beach to be relatively stable here, as expected within the groyne field. There is an accumulation of sediment on the lower beach, with some loss on the upper section of the shingle ridge. Topographic ground surveys have observed some variability here with a sandy lower beach being exposed on occasion over the years. The difference model comparing 2012 to 2008, which showed a build up in sediment at the Slaughden deposition site, shows a loss of sediment at the frontage around SL029. While there is a built up in sediment in 2008 from 2003 and 2015 compared to 2012, when there is an observed loss at the deposition site at these times.

Further south there appears to be an area of erosion just south of the groyne field. From 2012 to 2015 there has been a significant loss of sediment in this area. South from here the beach running to the donor site, the origin site of the recycling material, has increased in elevation by over 1 m. This stretch of beach shows consistent growth in every difference model over the period from 2003 to 2015. However the topographic surveys of the transect line S046 actually shows erosion of the 35 m wide beach slope. The difference model here, based on the LiDAR coverage of an exposed beach, is comparing the upper beach section and shingle crest.

Transect SL117 is located south of the donor site and the embankment wall of the Lantern Marshes area. It is an area of vegetated shingle backed by a lagoon and marsh. The beach is shown to be consistently eroding in the difference models. The ground topographic surveys show that since 2015 the crest of the shingle ridge, lost in the winter of 2013-14, has built back up.
Figure 9: Aerial photograph of the donor beach in July 2015. The tracks along the designated access routes on and off the beach can be seen in the photograph.

Figure 10: Aerial photograph of the beach south of the donor site in July 2015 and showing the location of transect SL117. View across the transect looking north in August 2015 (top right) and August 2003 (top right).