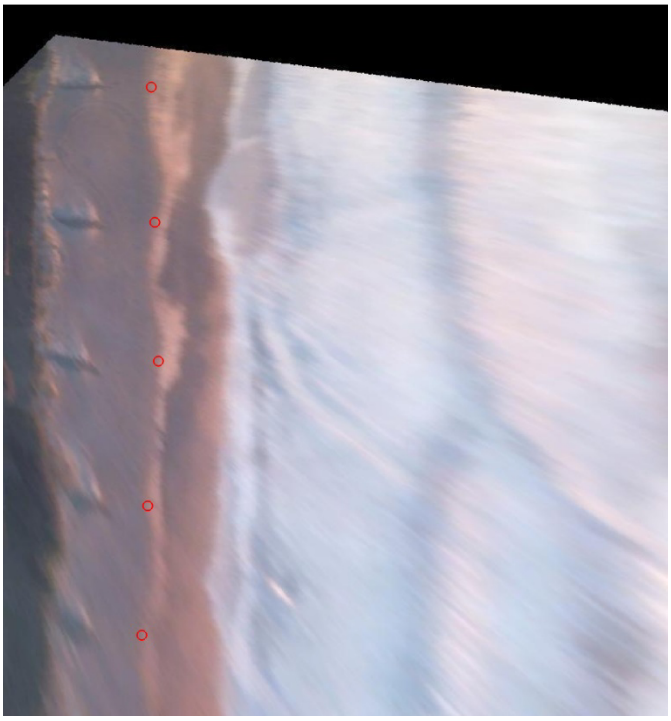
Wooli Coast-Cams Image Analysis

March 2012 – March 2013



Prepared for:

Coastal Communities Protection Alliance-Wooli Inc.

eCoast Ltd
Marine Consulting and Research
PO Box 151
Raglan
New Zealand

Telephone: +64 21 423 224
Email: enquiries@ecoast.co.nz

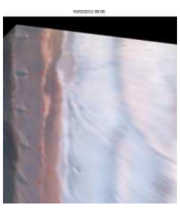
Wooli Coast-Cams Image Analysis

Report Status

Version	Date	Status	Approved By:
V 1	8 April 2013	Draft	EA
V 2	15 April 2013	Rev. 1	STM
V 3	21 May 2013	Rev. 2	STM
V 4	2 July 2013	Rev.3	STM

It is the responsibility of the reader to verify the currency of the version number of this report.

Shaw Mead *BSc, MSc (Hons), PhD*
Ed Atkin *BSc, MSc (Hons)*



Cover page: Digitizing the high-tide location for the southern coast-cam at Wooli.

The information, including the intellectual property, contained in this report is confidential and proprietary to eCoast Limited. It may be used by the persons to whom it is provided for the stated purpose for which it is provided, and must not be imparted to any third person without the prior written approval of eCoast. eCoast Limited reserves all legal rights and remedies in relation to any infringement of its rights in respect of its confidential information.
© eCoast Limited 2013

Executive Summary

Introduction

The attached document from Dr. Shaw Mead of eCoast is the first annual report on results produced by the automated camera system monitoring Wooli beach, which considers daily and monthly beach changes for the southern part of Wooli Village beach.

CCPA set up the system as an initial step in addressing a lack of detailed data about Wooli beach and the processes that shape it. The photographs and analysis from this and future years will provide information that can contribute to an evidence-based long term beach management and protection strategy for Wooli (see Note 1 below).

Objectives

The primary objective in this first year was to measure changes in “beach position”.

This was done by monitoring the high tide mark on a daily and monthly basis for the area of the beach being photographed.

Examples of other valuable objectives for which the system can be used (subject to available funding) are:

- Measuring the impact of particular storms and recovery time from them.
- Identifying trends from La Nina and El Nino weather cycles.
- Contributing to an overall model of Wooli bay in conjunction with information from beach surveys, offshore data gathering, and other available data.
- Gaining an understanding of nearshore bar/trough formations.
- Calibration of wave and morphological (Note 2) models.
- Increasing our understanding of processes within the whole embayment

Results

The camera system's headline results from this first year are:

- The expected pattern of winter-erosion and summer-accretion was confirmed by all three cameras although the rates of change varied markedly by area (refer eCoast report p17, para2).
- The pictures from early March 2013 indicated that the overall beach position was more eroded than a year earlier primarily as a result of the storms in January and February (P17, para3). However, the beach has the ability to recover just as fast as it can be eroded. This is shown by the large fluctuations in daily beach position (Note 3 below)
- There is good agreement in beach position between the data from the camera system and that from the beach surveys (p18, paragraph 2)
- In its first year the camera system was operational for approximately 85% of the time. The power problems which caused outages have been fixed and a daily monitoring process has been implemented to avoid loss of data due to delays in recognising and fixing problems. Maintenance difficulties will need addressing in year 2.

Notes

1. The camera system is a part of the monitoring process aimed at supporting a beach management and protection strategy. It provides hourly high resolution data for a defined part of the beach (see Figure 1.1). This data can then be put into the context of the whole beach by combining it with results from the 3-monthly beach surveys of the whole beach. This monitoring plan includes developing an understanding of how the beach 'works' (e.g. what are the extents of retreat and advance, and what conditions drive these processes?) and the tools to apply to future projections of beach evolution, to consider the design and impact of particular beach management and protection strategies (e.g. dune planting, renourishment, sand retention structures, etc.; what has been the impact of the training walls on Wooli Beach?), and other

factors that together will underpin a long-term beach management and protection strategy.

2. Coastal (geo)morphology is the scientific study of coastlines and the processes that shape them. It aims to understand why beaches currently look the way they do and to predict future changes through a combination of field observations, physical experiments, and computer modelling.

3. The beach position (high tide location) varies on average 3.2 m each day (either seawards – advance or shore-wards – retreat) (Table 3.1, page 6). Maximum daily retreat is similar to maximum daily advance, 21.5 m and 18.4 m, respectively (Table 3.1, page 6). While there are a number of variables that affect the location of the high tide mark it is a useful proxy for the width of the beach. These variations are seen as 'noise' in the data without significant impact on the overall trends.

Contents

List of Figures

1 Introduction

This report describes the findings of the analysis of one year of coast-cam image data collection between March 2012 and March 2013. The coast-cam system is comprised of 3 high-resolution cameras atop the Wooli water tower and is detailed in Mead (2012). The primary purpose of this data capture and analysis is the development of a long-term continuous dataset of Wooli beach position. Prior to the initiation of the coast-cams, only very sparse data on beach position was available in the form of historical aerial photographs that represent only snapshots of the beach position and provides little if any information with respect to the patterns of beach change and how the beach responds to particular events. Wooli Beach is over 7 km long. This dataset provides hourly images each day along a stretch of Wooli Village Beach some 420 m long (Figure 1.1).

While these data can be applied to a range of uses (e.g. determining the extent of beach erosion during a particular wave event, or multi-annual return period events, the duration of beach recovery after a particular erosion event, validation of sediment transport modelling, etc.), here we consider the fluctuation of the high tide position along the length of the beach monitored on a daily basis. While there are a number of variables that effect the location of the high tide mark (neap versus spring tidal phase, barometric pressure, wave set-up, wind set-up, wave height and period, etc.), the high tide mark is a useful proxy for the width of the beach at any one time. Much of these variations are seen as ‘noise’ in the data versus the overall trends.

Figure 1.1. The field of view from the coast-cam system is represented by the green line, with the Wooli water tower denoted with the star, which is 33.5 m above Australian Height Datum (AHD), which is approximately mean sea level (MSL).

2 Methods

2.1 Image Selection

The automated image capture software (see Mead, 2012) effectively filters poor quality images based on available light (day/night). For this analysis, daily beach position was the focus, and so the clearest images for each of the 3 cameras each day were required. The images required further filtering as met-ocean conditions often created poor images for processing – sun-strike, rain/salt-spray on the camera housing, sea mist, etc. This was achieved by removing all images with specific RGB values (too bright due to glare, or too dark due to cloud cover or shadowing, and so on). Early morning images were selected as a priority, because the low angle of the sun light creates a shadow zone landward of the high-tide beach berm, thus identifying the apex/berm crest. The images in the proceeding and subsequent hours were used to ensure that the berm was accurately identified.

Evaluation of the high-tide/storm berm in many images could not be completed for a number of reasons, but primarily because of metrological conditions. At some points, even in a clear image a berm was indistinguishable as it was not prominent due most likely to a gently sloping/planar beach. However, this may be in the wake of a significant storm event where the berm has been driven to the landward extent of the beach. At other times, interference from beach traffic prevents clear identification (walkers, quad bikes, logs, etc.). In general, wherever there was ambiguity with the location of the berm crest the data point (daily in this case) was disregarded. In total, 221 rectified images from the southern (right) camera were used in the analysis, 203 from the centre, and 181 from northern (left).

2.2 Evaluation of the High-Tide Berm

Following industry standards for image analysis, the high-tide mark is used to determine the beach position, rather than the vegetation line which is often used for longer term beach position analysis. This method does have limitations with respect to the changing wave run-up elevations due to the wave heights, direction, period and high water level on any given day, which are similar to the limitations of using

MSL to consider beach position due to the changing width of the swash zone. However, in terms of weekly, monthly and yearly trends, this variability is smoothed and overall trends become apparent – i.e. the variations are seen as ‘noise’ in the data versus the overall trends.

For the daily analysis, transect were overlaid on the images. Where the transect and berm line intersect a point was marked and the pixel location recorded. For the northern images four transect locations where used; in both the central and southern images five berm locations were marked (Figure 2.1). Transects are numbers from north to south (top of rectified image to bottom of rectified image) To convert the pixel location values of berm position to metric values, the pair of rectifying coordinates (see Mead, 2012) closest to the study area was used.

For the monthly analysis the best images for berm identification closest to the 10th of each month was annotated along the length of the berm. Localised overtopping of the berm was ignored and simple interpolation of the berm line was used. For each monthly image the entire length of the beach position was recorded (rather than 4-5 points along transects as in the daily datasets).

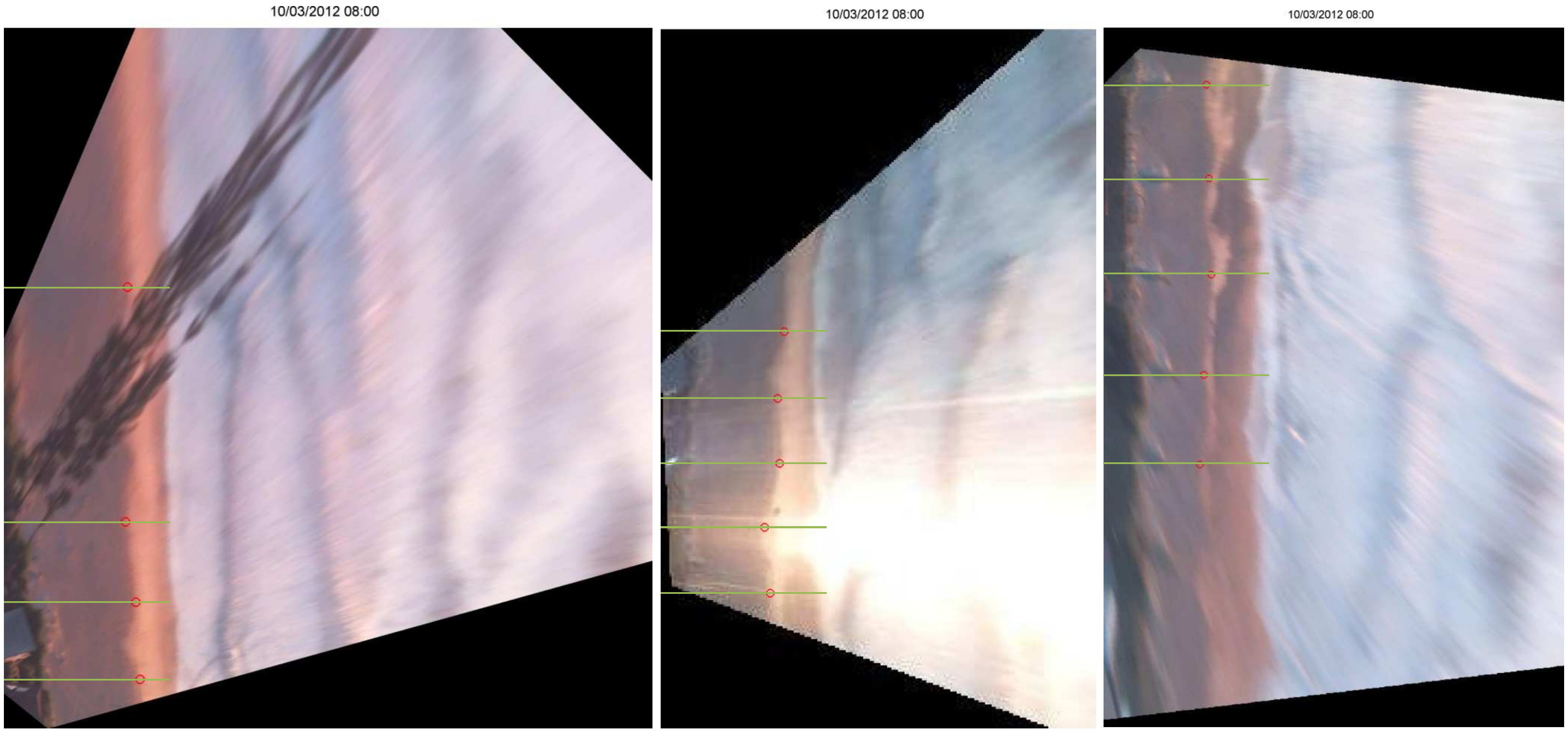


Figure 2.1. The red-circles indicate the pixel/point where the beach normal transects intersect with the high-tide berm.

3 Results

3.1 Daily Images

Figure 3.1 to Figure 3.3 present the results of the daily image analysis for the beach normal transects from the north to the south of the field of view (Figure 2.1). An obvious feature is the daily variability between beach locations, with Table 3.1 providing the mean and maximum retreat/advance daily change in beach position.

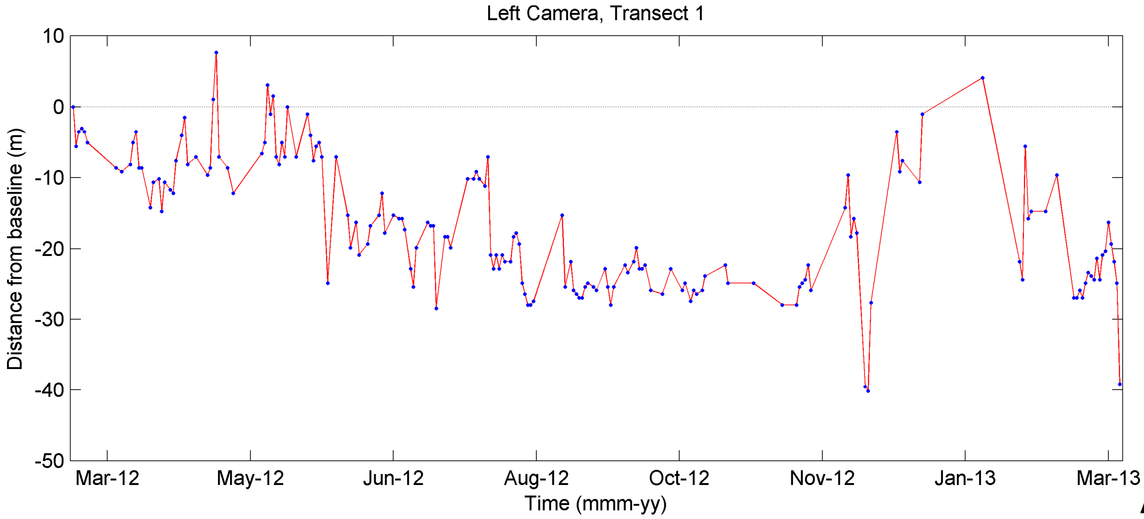
Table 3.1. Daily high-tide beach positional changes calculated from all transects.

Daily Beach Change	Meters
Average	±3.2
Max Retreat	-21.5
Max Advance	18.4

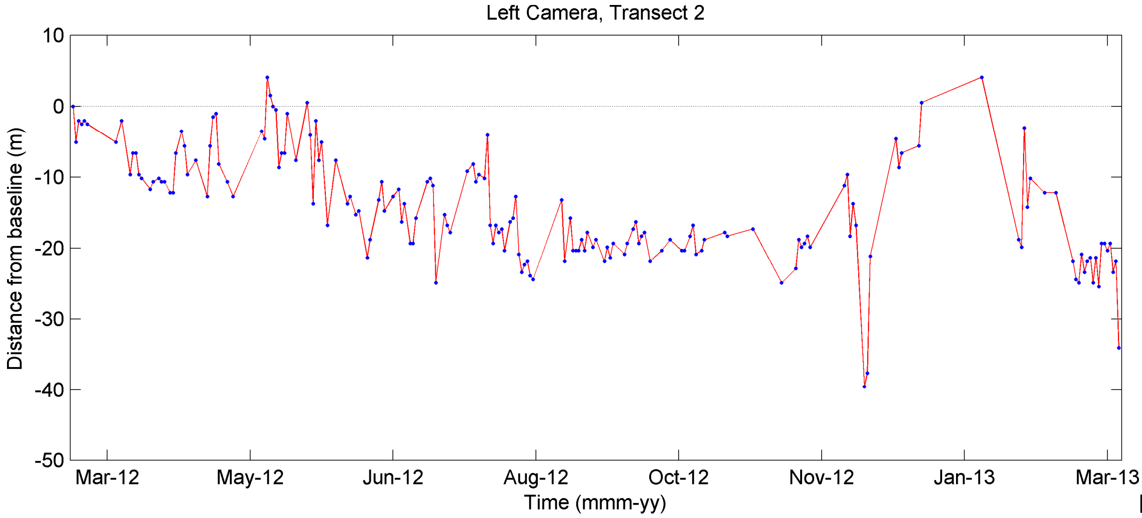
The northern camera clearly shows the seasonal variation of the beach position, with the beach most accreted in late summer (March/April 2012) and most eroded in the late winter months (August-November 2012) (Figure 3.1). The beach can be seen to be returning to the wider summer mode by January, although this is punctuated by a large erosion event in late November/early December 2012, and the series of erosion events from late January through to mid-March 2013 due to the intense storm activity during the summer of 2013. Following these storms, the beach is in the most eroded position of the year at the end of the data set (Figure 3.1 C & D).

A similar although more subtle trend from summer to winter to summer beach location can be seen in the data for the central Wooli camera (Figure 3.2). However, along this stretch of beach the most obvious feature is the large amount of advance (rather than retreat) that occurred in late June/early July. At the end of the year-long dataset, although the erosion due to the storm events in this period can be seen, the beach position in March is similar to the position recorded in the winter months.

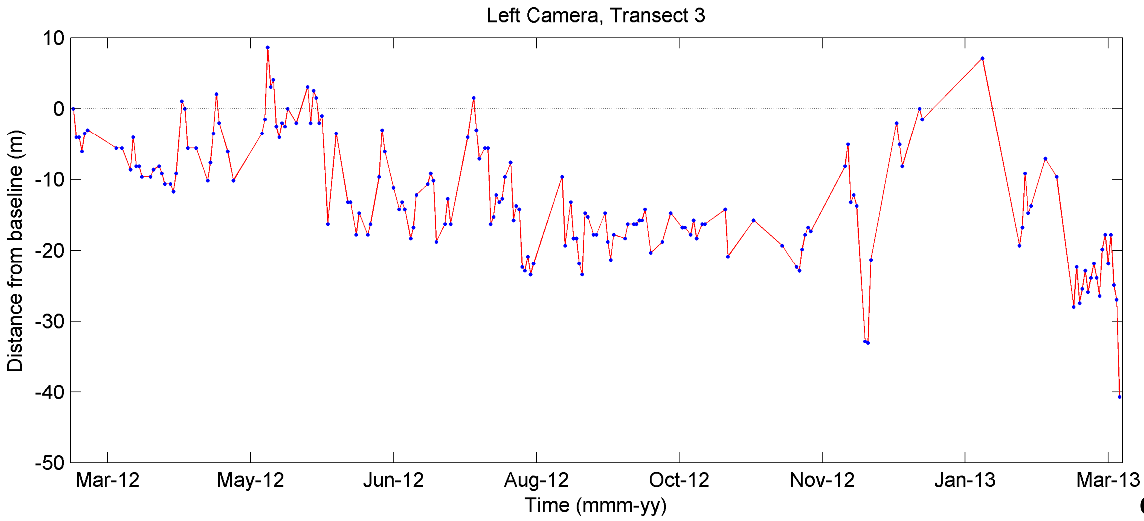
The southern camera daily dataset again incorporates the summer-winter-summer trend of accretion-erosion-accretion (Figure 3.3). However, the beach recovery in the summer of 2013 is markedly lower than that recorded by the northern and centre cameras, with little if any recovery in the most southern transects (Figure 3.3 D & E).


Left Camera, Transect 1
Distance from baseline (m)
10
0
-10
-20
-30
-40
-50
Mar-12
May-12
Jun-12
Aug-12
Oct-12
Nov-12
Jan-13
Mar-13
Time (mmm-yy)

A


Left Camera, Transect 2
Distance from baseline (m)
10
0
-10
-20
-30
-40
-50
Mar-12
May-12
Jun-12
Aug-12
Oct-12
Nov-12
Jan-13
Mar-13
Time (mmm-yy)

B


Left Camera, Transect 3
Distance from baseline (m)
10
0
-10
-20
-30
-40
-50
Mar-12
May-12
Jun-12
Aug-12
Oct-12
Nov-12
Jan-13
Mar-13
Time (mmm-yy)

C

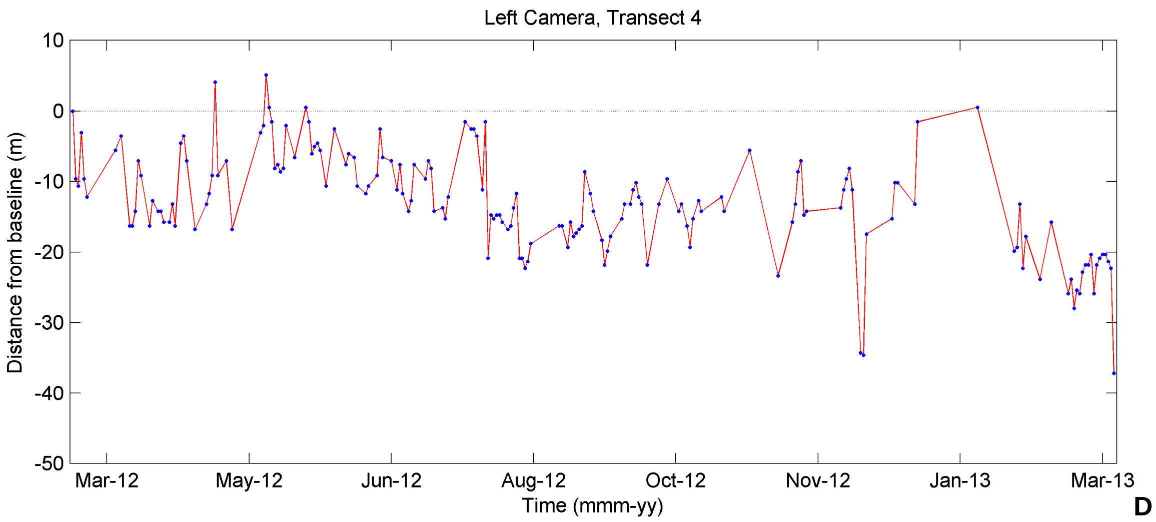
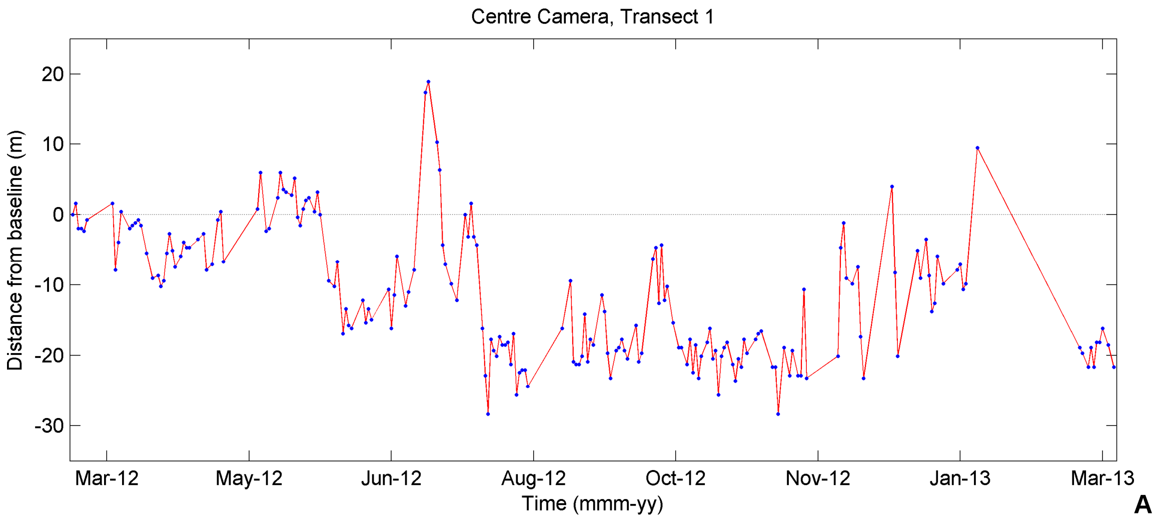
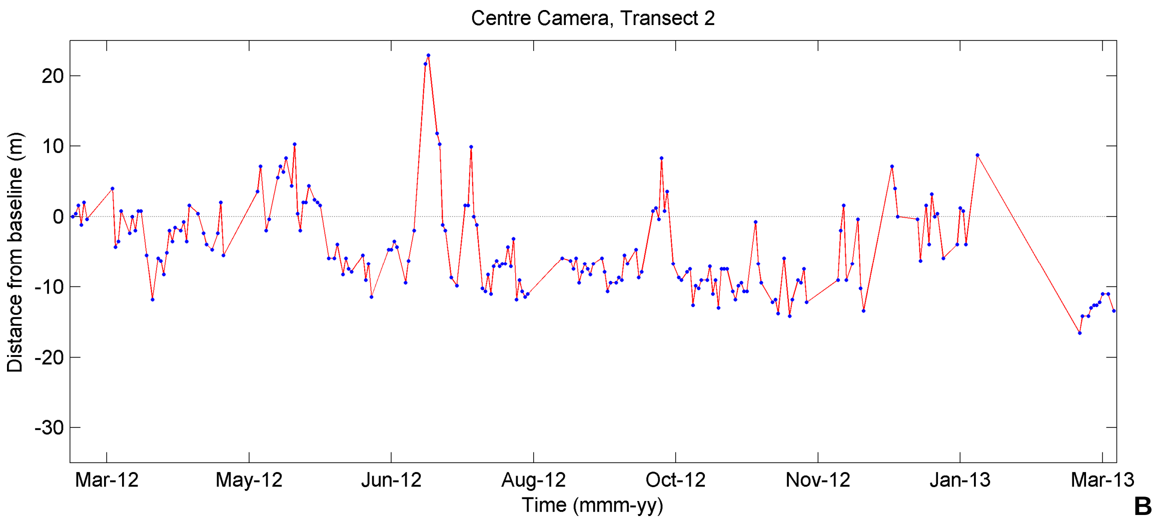


Figure 3.1. High-tide beach location for the 4 transects on the northern camera (Figure 2.1).





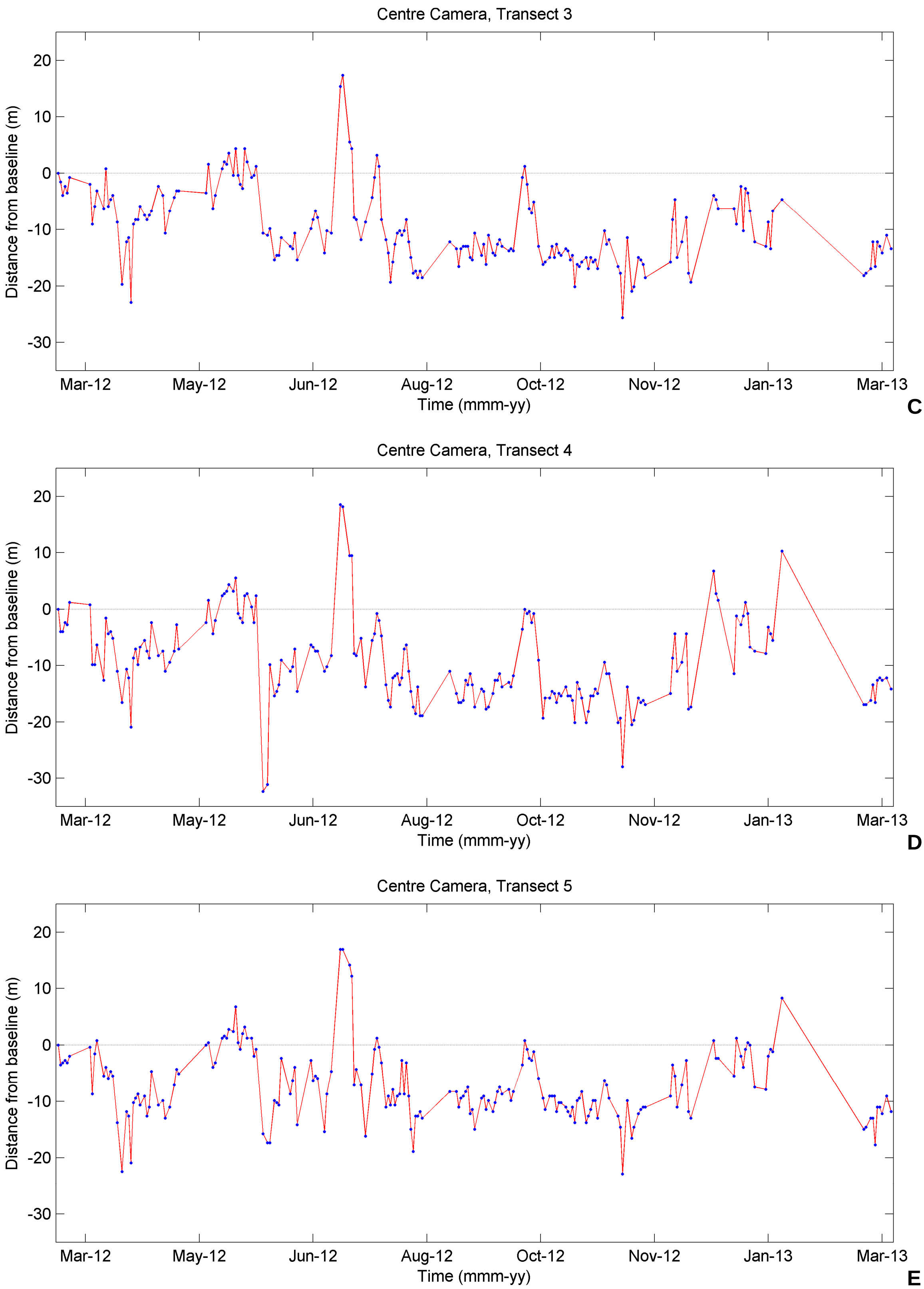
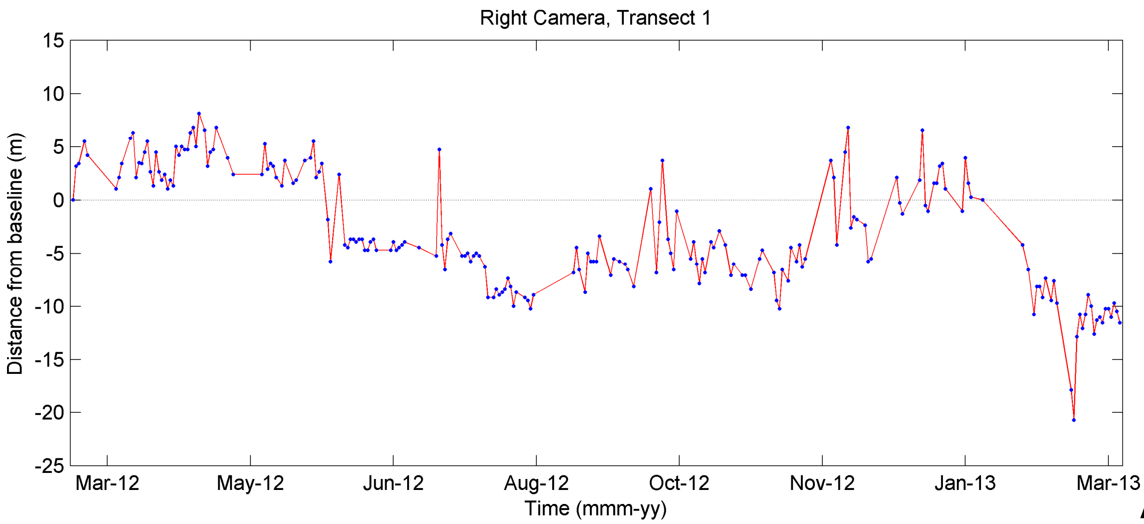
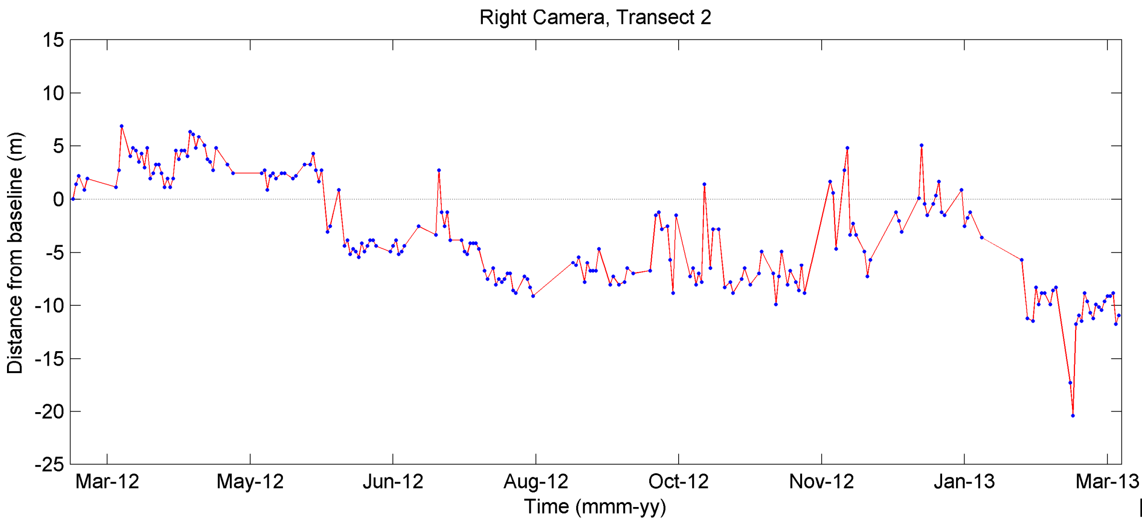


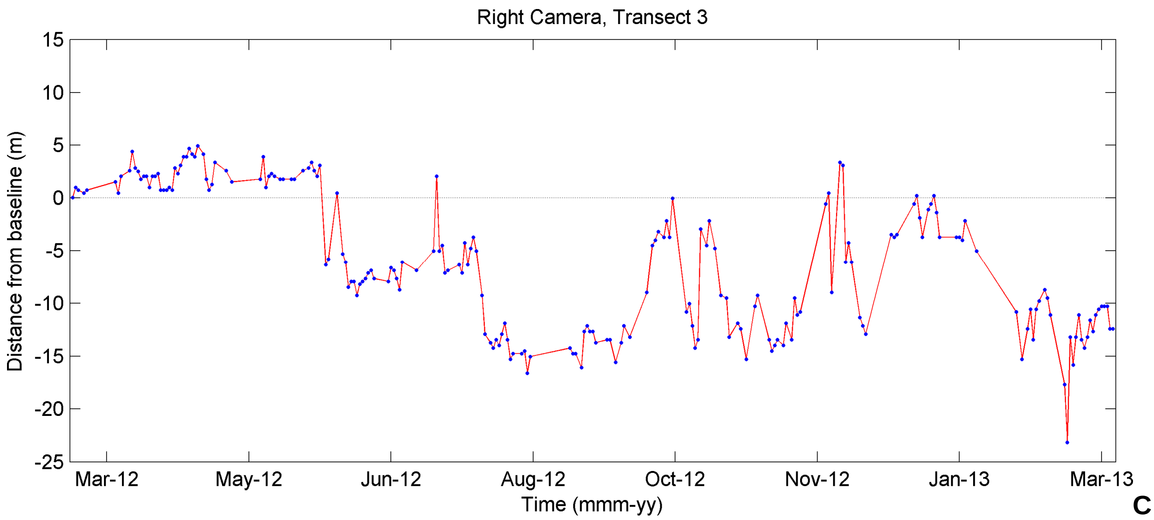
Figure 3.2. High-tide beach location for the 4 transects on the central camera (Figure 2.1).


Right Camera, Transect 1
Distance from baseline (m)
15
10
5
0
-5
-10
-15
-20
-25
Mar-12
May-12
Jun-12
Aug-12
Oct-12
Nov-12
Jan-13
Mar-13
Time (mmm-yy)

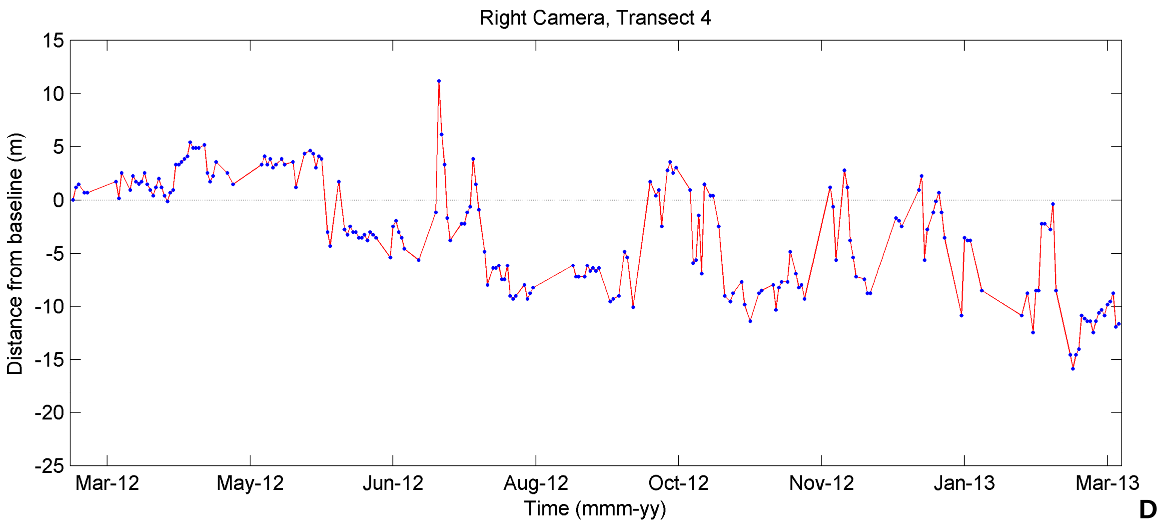
A


Right Camera, Transect 2
Distance from baseline (m)
15
10
5
0
-5
-10
-15
-20
-25
Mar-12
May-12
Jun-12
Aug-12
Oct-12
Nov-12
Jan-13
Mar-13
Time (mmm-yy)

B


Right Camera, Transect 3
Distance from baseline (m)
15
10
5
0
-5
-10
-15
-20
-25
Mar-12
May-12
Jun-12
Aug-12
Oct-12
Nov-12
Jan-13
Mar-13
Time (mmm-yy)

C



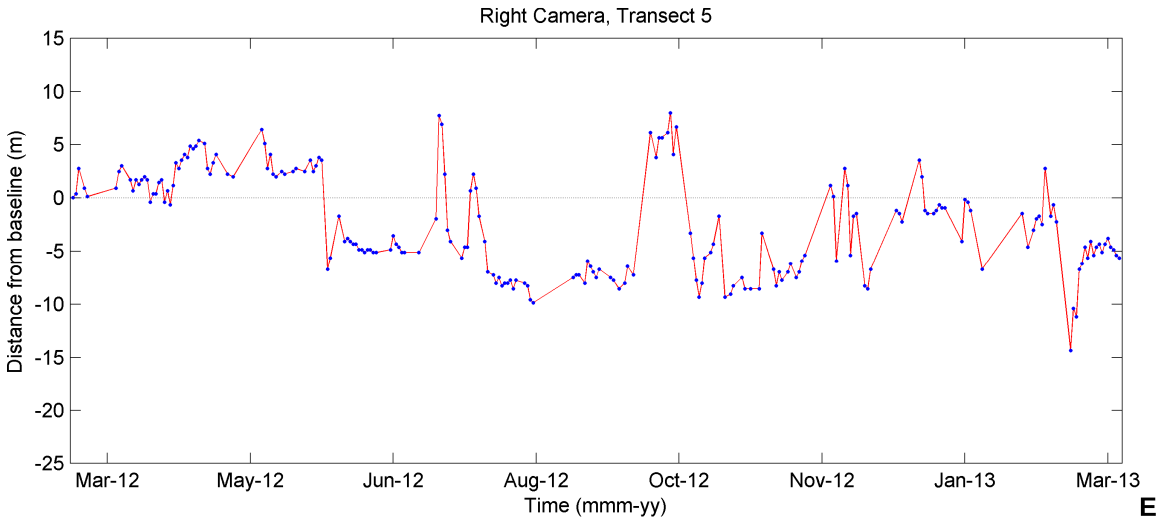


Figure 3.3. High-tide beach location for the 4 transects on the southern camera (Figure 2.1).

3.1 Monthly Beach Position

The monthly locations of the high-tide beach mark close to the 10th of each month are presented in Figure 3.4 to Figure 3.6. While these results follow those presented for the 14 daily transects analysed for the 3 camera areas, that also show that the beach fluctuations are not constant changes both on-offshore and alongshore, i.e., there is variability along the length of each area. Such variability is usually driven by the morphology of the nearshore bars and the consequent feedback that can lead to temporary stability and relatively large perturbation in comparison to the offshore features (e.g. Coco and Murray, 2007).

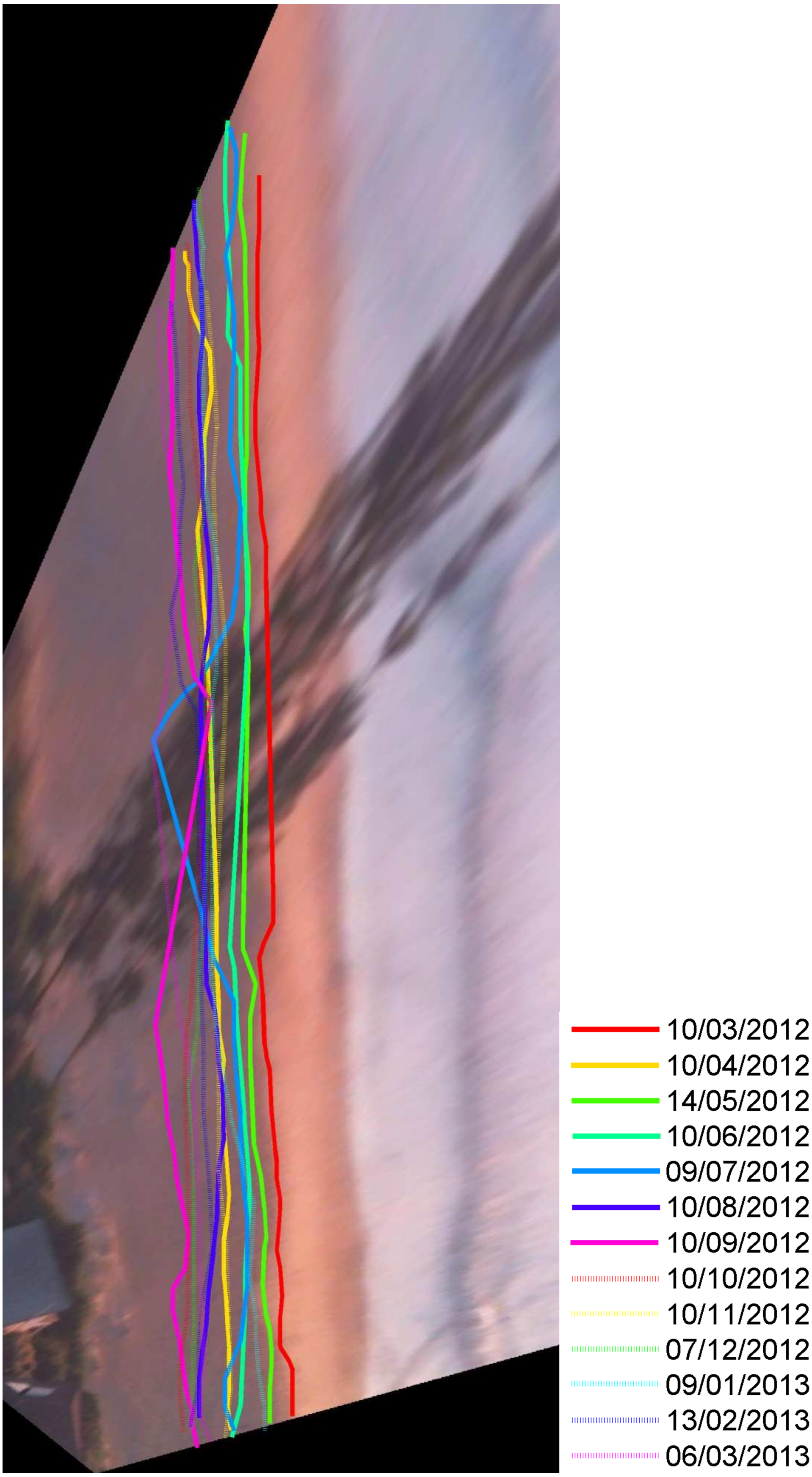


Figure 3.4. Monthly beach position for the northern camera.

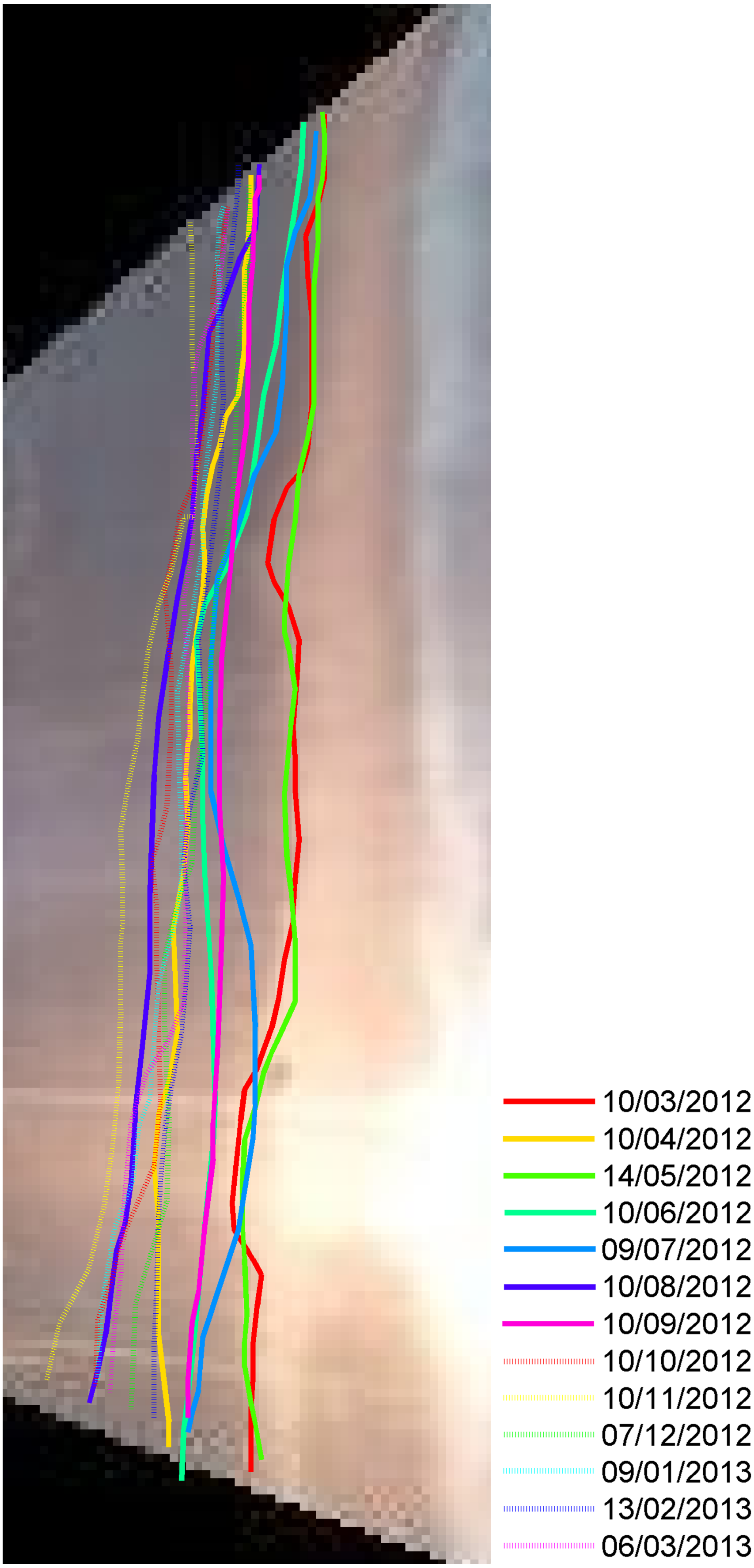


Figure 3.5. Monthly beach position for the central camera.

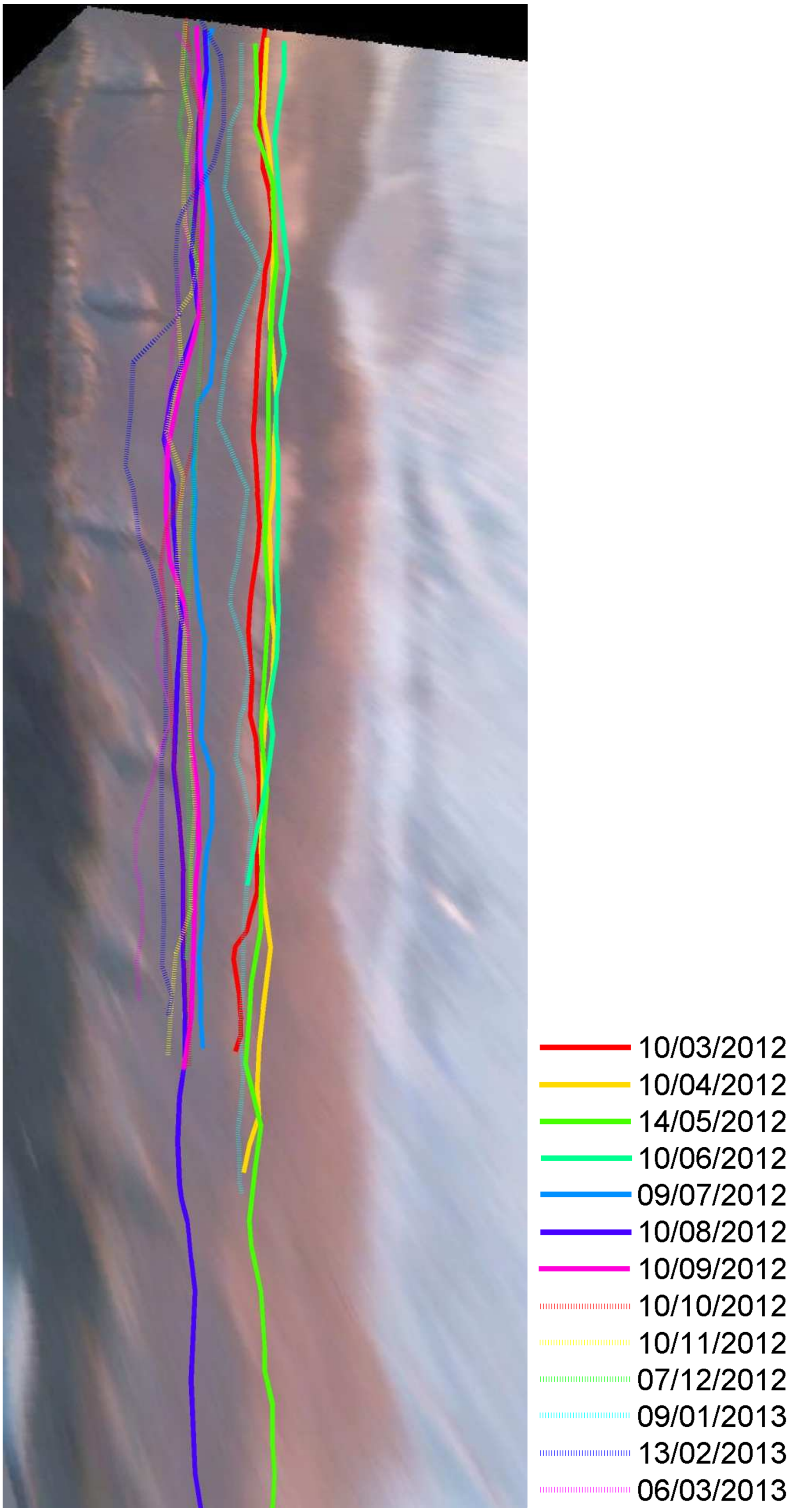


Figure 3.6. Monthly beach position for the southern camera.

4 Discussion

The analysis of the dataset of rectified beach images has provided a comprehensive picture of the beach changes between March 2012 and March 2013 along the southern part of Wooli Village. Here we have considered the fluctuations of the beach position along the length of the beach monitored (~420 m) on a daily basis. However, it is important to note that these data can be applied to a range of uses (e.g. determining the extent of beach erosion during a particular wave event, or multi-annual return period events, the duration beach recovery after a particular erosion event, validation of sediment transport modelling, etc.), and so will be very useful with respect to the development of a Beach Management and Protection Strategy for Wooli Beach.

Analysis of the daily and monthly high-tide beach locations shows the expected summer-winter-summer beach position, which refers to accreted-eroded-accreted, and is a fundamental beach dynamic on most beaches worldwide. In basic terms, the long period summer swells build the beach, while the short period winter storms take sand offshore to form more distinct shore-parallel bars (e.g. Dean, 1988; Short and Wright, 1984). However, the storms of the 2013 summer have also left their mark on the beach, with aggressive erosion events clear in the data.

The overall beach position is mostly further eroded than it was a year earlier. Whether this is the result of the recent storms, part of the rotation mechanism described by Ranasinghe *et al*. (2004) where we would expect the beach width in the area of Wooli Village to be reduced as sediment is redistributed to the north due to swing to El Nino conditions, or a combination of both, will become more obvious with each additional year of data collection. The beach profile monitoring of Brian Saye indicates that the northern parts of the beach have indeed accreted substantially in the past year. It is also important to note that although the beach position is most accreted in March 2012 in the northern camera area, the beach is most accreted in April and June for the central and southern camera areas, respectively. Thus, although storms have impacted on the summer beach ‘health’, there is still potential for the beach to accrete in the southern area of Wooli Village. Indeed, Table 3.1

suggests that the beach has the ability to recover just as fast as it can erode, which has been recorded on New Zealand's north eastern coast (Mead *et al*., 1998) and on the Gold Coast (variations of 18 m/day are the average, while single events can result in 60 m of beach change (Turner, 2004)).

There is good agreement in beach position with the beach profile data collected by Brian Saye, which validates the analysis presented here. For example, Figure 4.1 presents the Saye profile data for S17, which approximately corresponds to the northern transect (Transect A) of the northern camera (Figure 2.1 and Figure 3.1A). The beach berm position can be seen to remain relatively constant until between the June and November 2012 surveys, when it can be seen to retreat, which matches the results of the camera image analysis. However, while not as coarse as historical aerial photographs, the beach profiles also do not provide any information with respect to short term variability or the drivers of it (e.g. the impacts of particular storm events).

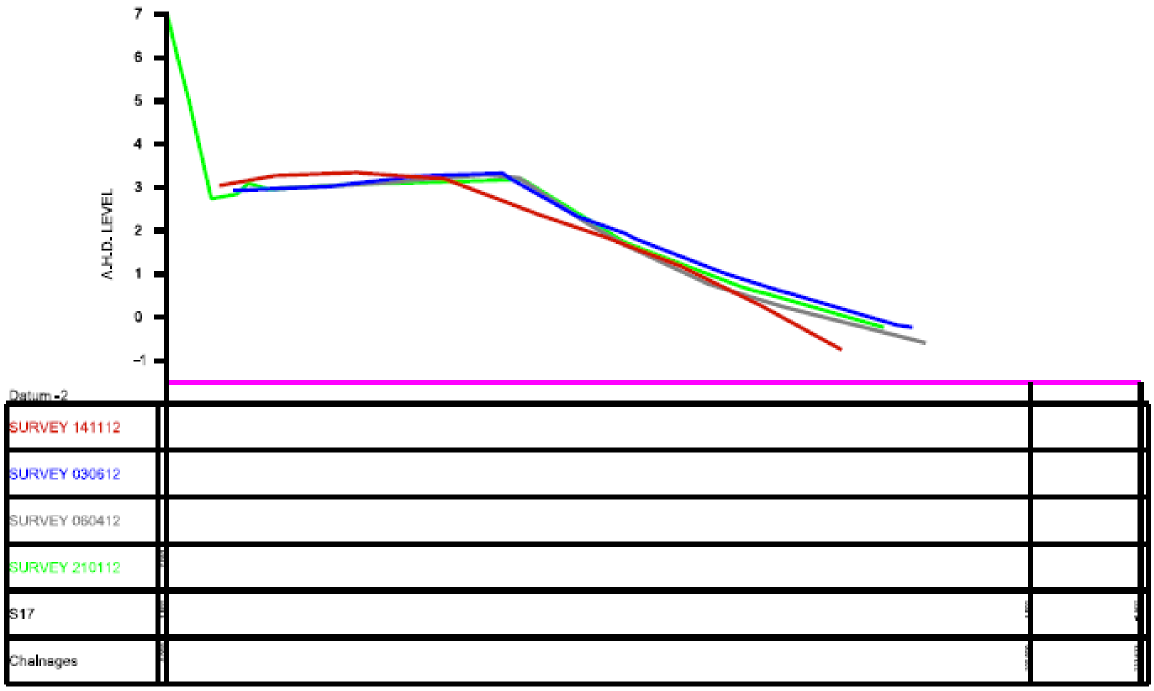


Figure 4.1. Beach profiles at location S17, which approximately corresponds to Transect A for the northern camera position (Figure 2.1 and Figure 3.1A).

It is clear that effective management and protection of Wooli Beach is a complex task. No single source of data capture and analysis is yet available which provides the dataset needed to adequately support this task in terms of long-term data for the complete beach at a detailed level on a frequent basis.

The daily coast-cam system and quarterly 'whole-beach' surveys will substantially assist to fill in the detailed dataset that has been unavailable to previous studies. As the duration of data collection increases, future studies will no longer need to rely so heavily on the 12 'points in time' of photogrammetry data spread across over 70 years.

References

Coco, G. and Murray, A. B., 2007. Patterns in the Sand: From Forcing Templates to Self-organization. *Geomorphology*, 91: 271–290.

Dean, R., 1988. Prediction of Eroded versus Accreted Beaches. Coastal Engineering Technical Note, USACE CERC, 1988.

Mead, S. T., K. P. Black & J. A. Hutt, 1998. Tay Street - Mount Maunganui, Report *1: Design and Physical and Biological Processes.* Joint report, Department of Earth Sciences, University of Waikato and NIWA, July, 1998.

Mead, S. T., 2012. Wooli Coastal Camera – Rectification. Report prepared for Coastal Communities Protection Alliance-Wooli Inc., July 2012.

Mead, S. T., and E. Atkin, 2013. Wooli Photogrammetry Analysis. Report prepared for Coastal Communities Protection Alliance-Wooli Inc., February 2013.

Ranasinghe R., R. McLoughlin, A. D. Short and G Symonds, 2004. The Southern Oscillation Index, wave climate, and beach rotation. *Marine Geology*, 204: 273-287.

Turner, I., 2004. Analysis of Shoreline Change: February 2004 to July 2004. Report 10: Northern Gold Coast Coastal Imaging System. WRL Technical Report 2004/07, Water Research Laboratory, University of New South Wales.

Wright, L. D., and A. D. Short, 1984. Morphological Variability of Surf Zones and Beaches: A Synthesis. *Marine Geology* 56: 93-118.