Managing European Shorelines and Sharing Information on Nearshore Areas

messina

A Case Study Documenting Monitoring and Modelling Techniques used at Bournemouth, U.K – A Local-Specific Approach to Coastal Monitoring.

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1. INTRODUCTION

Beach monitoring projects within the UK have often been confined to short stretches of coastline usually established in conjunction with individual beach recharge schemes. Effective planning and implementation of shoreline management requires high quality, long-term, time-series data sets, at appropriate spatial and temporal resolution, to predict long-term coastal evolution and to determine design conditions for coastal protection and flood defence projects (Bradbury et al., 2005).

Bournemouth Borough Council currently operates coast protection policies established after many years of practical experience and maintenance, following close collaboration with the Government's research organisation, the Hydraulics Research Station, now operating in the private sector as H R Wallingford Limited. At the present, DEFRA (previously the Ministry of Agriculture, Fisheries and Food (MAFF)) have grant-aided the Council's programmes of coast protection works and monitoring programmes.

Predictions of the state of the future coastline as a reaction to the changes in climate have lead to revisions in the future coast protection policies necessary to protect the Bournemouth coastline. In optimising the most economic solutions for the future coast protection of the coastline, alternative defences have been examined and costed, together with an assessment of the level of benefits if such defences were to be implemented
(www.bournemouth.gov.uk/Residents/Environment/Coastal_Management.asp, 2005).

A vital part of any coastal defence scheme is accurate monitoring data that allows for an understanding of current and past patterns in coastal evolution. This information is essential to inform shoreline management planning and design conditions for operational flood and coastal defence strategies. Long-term local coastal monitoring programmes as operated by Bournemouth Borough Council, have demonstrated considerable cost-savings, allowing greater confidence in efficient design of coastal works.

2. GEOGRAPHICAL OUTLINE

The exposed coastline of southeast England is characterised by soft sedimentary geology that is vulnerable to erosion, and extensive areas of low-lying land and high coastal urbanisation that are vulnerable to flooding. Approximately 10% of the population and billions of pounds of infrastructure are at risk from flooding within southeast England, within a vulnerable area that exceeds 480km2. Annual damages averted by maintaining present levels of coastal protection and sea defence are estimated at £203m per year, whilst capital project investment on defences within the region exceeds an average of £30 million per year and annual maintenance costs exceed £4.3m (www.se-coastalgroup.org.uk, 2005).

The Bournemouth coast lies on the South Coast of the UK between Poole in the west and Christchurch in the east. The Dorset and East Devon coast is one of the most significant earth science sites in the world, displaying a remarkable combination of internationally renowned features. As such, it has been designated as a World Heritage Site and is now known as the Jurassic Coast (Figure 1).

Figure 1. Location map of the Jurassic Coast.

It has a unique historical importance to the founding of geology and geomorphology and it remains at the forefront of modern earth science research. The features are displayed within an unspoilt and accessible coastline of great beauty.

The Site displays a near continuous sequence of Triassic, Jurassic and Cretaceous rock exposures representing almost the entire Mesozoic era, together with outstanding geomorphological features such as landslides, a barrier beach and lagoon, cliffs and raised (fossil) beaches (www.jurassiccoast.com, 2005).

3. PAST AND PRESENT MONITORING TECHNIQUES

Shoreline management methods have altered significantly during the past 10 years. Most sea defence and coastal protection schemes are now developed around dynamic elements, such as beach recharge or recycling, often in conjunction with beach control structures. The departure from hard engineering presents a complex risk management scenario that requires high quality information to support effective management; it relies heavily on an understanding of coastal processes at work and the effects that these processes have on shoreline evolution.

In the 30 years between 1970-2000 almost 2 million m^3 of sand has been used to replenish the beaches at Bournemouth and Poole. Since the predominant direction of long shore transport at Poole Bay is from west to east, new sand gradually feeds the beaches at Southbourne and Hengistbury Head to the east, and beyond into Christchurch Bay (www.poolebay.net, 2006).

Poole Bay extends from Poole Harbour tidal inlet to the southwest and Hengistbury Head/Christchurch Ledge to the east. The Bournemouth component of this frontage has experienced a progression of protection measures to control erosion and safeguard the sandy beaches that are so vital to its tourist economy (Bray and Carter, 1995). A shift from a 'hard' engineering approach to a 'soft' engineering approach occurred in 1974 when one of the largest and longest running programmes of beach replenishment in the UK was established.

A pilot replenishment scheme, known as Beach Improvement Scheme 1 or BIS1, was carried out in 1970 whereby 84,500m^3 of dredged sand was positioned at Mean Low Water (MLW) along a 1.8km frontage (Elliott, 1989). Two further replenishment schemes followed with the fourth being carried out at present.

The second scheme (BIS2) involved import and dumping of 1.4m million m^3 dredged sand at sites over 400m offshore the position of mean low water. Approximately 650,000m^3 of sand was then pumped ashore and reprofiled (Newman 1978, Halcrow 1980, Wilmington 1982). The beach was intensively monitored thereafter by beach profiling, which extended up to 450m offshore. Surveys were undertaken at frequent intervals along 38 survey lines between Alum Chine and Hengistbury Head. Comparison immediately before and after nourishment revealed that the intertidal zone had gained 725,000m^3 of sediment compared to the 650,000m^3 pumped ashore, thus suggesting onshore transport of 75,000m^3 of sand from dump sites during the operation (Lacey, 1985; Harlow and Cooper, 1994; 1996). Thereafter, the intertidal zone lost material, offshore and by littoral drift, but the nearshore and offshore zones continued to accrete. After 1979, all zones lost material and by 1982, the intertidal zone in many areas had returned to its prenourishment volume. A third replenishment scheme was undertaken in three phases from 1988-1990 involving the deposition of 998,730m^3 of dredged fill directly onto the beach. This material was pumped onshore above MHW and allowed to form its own profile. The coincidental dredging of the Poole Harbour entrance at the same time as the need for beach replenishment material substantial reduced the costs of BIS3 (Turner 1994).

BIS4 is currently underway with 1.1 million m^3 (1.65 million metric tonnes) of sand dredged from Poole Harbour channels and approaches being used to replenish the beaches at Poole, Bournemouth and Swanage to protect them from erosion (Figure 2). Replenishment of Bournemouth's beaches began on Wednesday, 18th January 2006 at Double Dykes, Hengistbury Head and is moving westwards to Boscombe Pier. The 600,000m^3 of beach material to be used is selected to match that naturally occurring on the beaches (e.g. a sand & shingle mix at Double Dykes). A second contract to complete Bournemouth's beaches during winter 2007 will replenish from Boscombe Pier westwards to the Borough Boundary with Poole, using beach material dredged from commercial sources (www.poolebay.net, 2006).

Pumping a 50/50 mix of sand and water through the onshore pipeline

Sand bunds create a 'lagoon' to retain new sand, and avoid losses to the foreshore

TSHD "HAM 311"

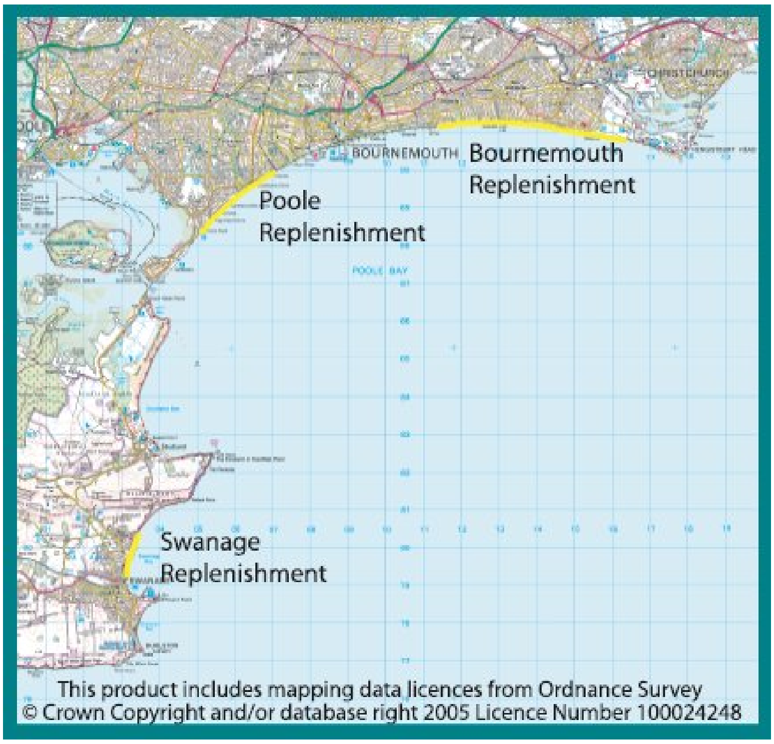

Figure 2. Location map indicating the areas of beach replenishment (www.poolebay.net, 2006)

A daily diary is kept online on the project website (www.poolebay.net) with information on daily totals of material pumped ashore and averages for the weekly and monthly periods (Figure 3). These values are being verified by a thorough topographic survey of the area pre and post replenishment. Profile lines are being measured at 10m intervals using Geographical Positioning System (GPS) along the frontage. A calculation of the cross-sectional area of the beach allows for comparisons to be made to the figures quoted by the dredging team. An example of survey data collected by the contractors survey department can be seen in Figure 4, with the red line being the pre-recharge profile, the green line being the theoretical replenished beach when the sand was first pumped ashore and finally, the blue line actual response of the beach following exposure to wind and wave attack.

The on-going need for beach replenishment was originally identified in the 1999 Shoreline Management Plan for the area, based on the outcome of the three previous beach replenishment schemes. A subsequent report by Halcrow (2004) suggests that a

DAILY DIARY

- Swanage diary
- Poole diary

Bournemouth - January/February 2006

Bournemouth statistics [1]	loads	m^3	metric tonnes	tons
Total pumped ashore to date	170	453,778	680,667	669,917
Average per day (26 days)	7	17,453	26,180	25,766

Bournemouth beaches are to receive 600,000m³ of new beach material; more than that will be pumped ashore to allow for various factors (more)

February		Daily Total (m^3)
12th	*'Countryfile'* on BBC1 this morning featured the beach replenishment and other stories from Poole Harbour. 4 loads pumped ashore	8,733
11th	Beach replenishment (5 loads)	11,323
10th	The *Waterway* completed her final discharge at 00:05 this morning, bound for Amsterdam. Beach replenishment (5 loads)	10,813
9th	Beach replenishment (7 loads)	20,950
8th	Beach replenishment (9 loads)	23,852
7th	The sinkerline was moved this morning, to the bottom of Gordon Steps at Southbourne, the BBC filmed aboard the *HAM 311* and 9 loads were pumped ashore - busy day!	24,015
6th	Beach replenishment (7 loads)	18,719
5th	Beach replenishment (8 loads)	21,845

Figure 3. Example of the Daily Dairy from the project website.

further 3 million m^3 will be required over the next 50 years in order to maintain protective beach levels and widths. It is essential that this stretch of coastline continues to be monitored as part of the Regional Strategic Coastal Monitoring Programme in order to provide highly accurate positional data on beach levels and sediment transport. The advantage of beach replenishment is that it can be adjusted to cope with unforeseen situations provided that adequate monitoring is undertaken (Stive et at, 1991). The availability of such a long-term monitoring record for Bournemouth both prior to the RSCMP and now within this programme is very rare and must be considered a valuable asset (Harlow and Cooper, 1996).

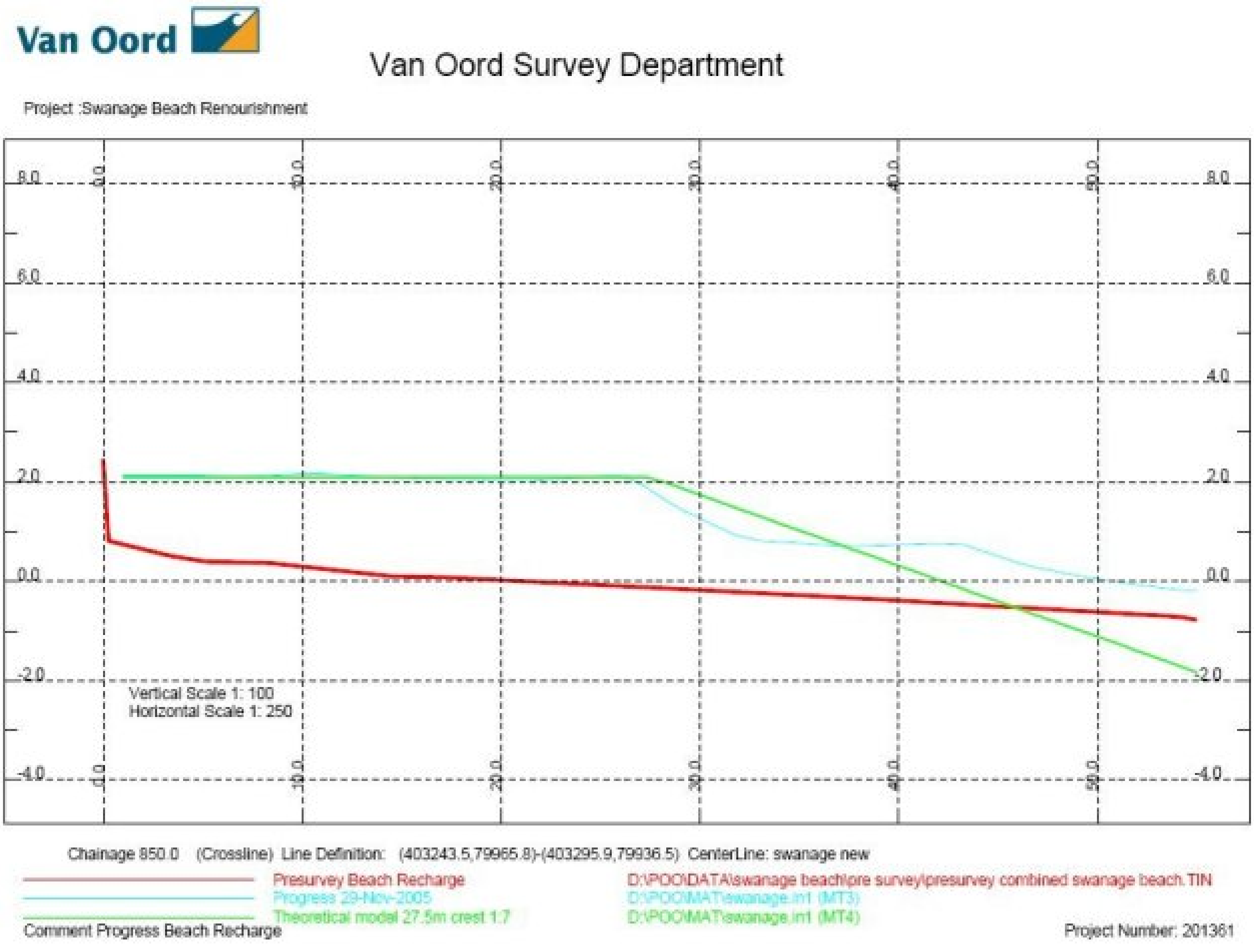

Figure 4. Example of profile survey data collected pre-survey and post-survey (www.poolebay.net, 2006).

4. DATA COLLECTION AND ANALYSIS

A bi-annual beach profiling survey was instigated in July 1974 and was maintained until 2002 when the Regional Strategic Coastal Monitoring Programme (RSCMP) took over. The RSCMP aims to provide a more holistic approach to coastal monitoring by creating a region wide policy and a standardised methodology that each local authority or the lead authority should follow. Additional monitoring was carried out with regards to particle size testing, aerial survey, real-time tide and wave data and Particle size testing of the beach material, twice annually to match the topographic surveys was also undertaken at Bournemouth between 1974 and 2002. This was not picked up by the RSCMP and so is still undertaken by Bournemouth Borough Council today.

Annual aerial surveys from 1987 have also formed part of the monitoring of coastal evolution at Bournemouth. These aerial surveys are now undertaken as part of the RSCMP and also include photogrammetric profiling along the South-East coast.

Real-time tide data and wave data are collected by both the tide gauge on Bournemouth Pier and the directional wave rider buoy located at Boscombe. Tidal data at Bournemouth has been recorded since 1974 although the original gauge fell into disrepair in about 1990 and was only replaced by the present Proudman Oceanographic Laboratory (POL) gauge in 1995.

Daily weather records have been kept by hand from 1974 until 1999, when electronic stations were installed.

Finally, the littoral drift direction at each groyne in Poole Bay has been recorded from 1993 to date in order to try and understand some of the complex responses of sediment transport in the area.

The collection and analysis of data is now carried out as part of the RSCMP. Data collection from topographic surveys is collected using Global Positioning Systems. Kinematic GPS provides the opportunity to capture data with a vertical accuracy of approximately +/-2-3cm and horizontal positioning at approximately double the accuracy making it ideal for beach surveys. A minimum of two GPS receivers linked by a radio is required. One receiver acts as a base station, providing corrections, the other is a mobile station used for collection of data.

Techniques in current use include both profiling and also continuous data collection of spot height data. Once every five years a baseline survey is carried out on all beaches within the South-East Strategic Regional Coastal Monitoring Programme area. These surveys provide a detailed topographical map of the beach through a combination of profile lines spaced at 50m intervals and continuous data taken every two seconds from shore parallel lines at 5m spacing. This combination allows a digital ground model (DGM) to be produced allowing profiles to be drawn at any location indicating changes in beach levels in comparison to previous surveys.

Subsequent surveys are determined by spatial and temporal factors. The profile interval varies from 100m-500m depending on the risk-based analysis of the area. Profiles spaced at 100m are generally in areas where barrier beaches run parallel to hold the line frontages at high exposure sites or where the beach has coastal structures where a high risk hold the line beach management plan sites exists. Profile lines spaced at 500m are likely to be where a ‘do nothing’ option exists on a low-risk/low-exposure site.
Thousands of beach profiles will be collected during the course of the programme with some sites being surveyed as many as 4 times per year. Where possible data from historical programmes, such as those of Bournemouth, are incorporated within the data sets to provide information on longer-term changes in beach levels.

Data is downloaded and stored in a software programme known as SANDS (Shoreline and Near shore Data System) (Figure 2). This programme provides a powerful facility through which input data can be analysed to establish links between forcing and response. It also allows weather and shore condition data to be entered, stored, inspected and compared. By analysing both climatic and beach profile data, trends in coastal response can be detected. SANDS is also capable of storing, retrieving and analysing a wide range of environmental data, reports and records (www.halcrow.com/sands/, 2005).

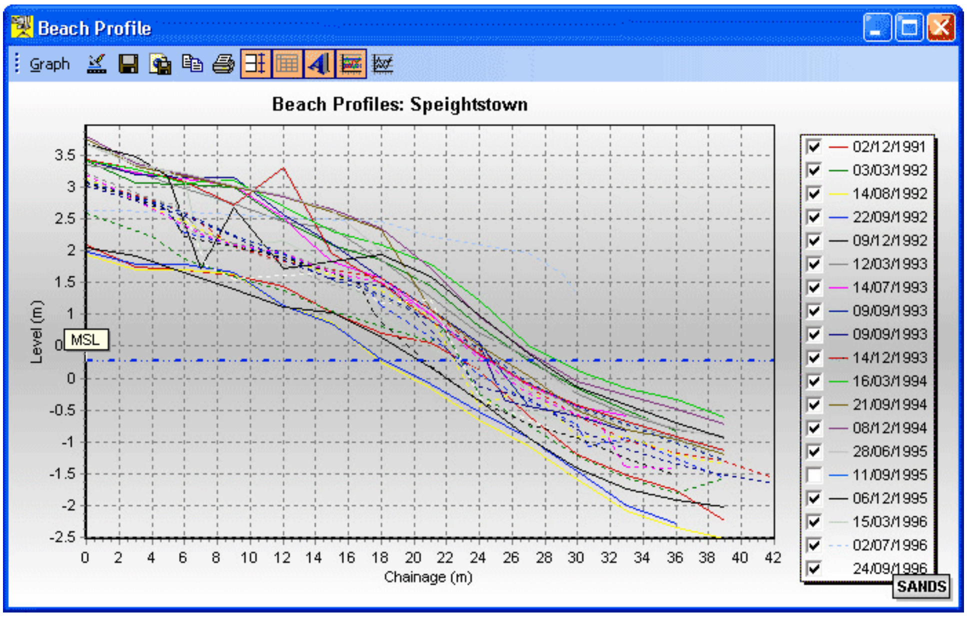

Figure 2. An example of beach profile data stored in SANDS.

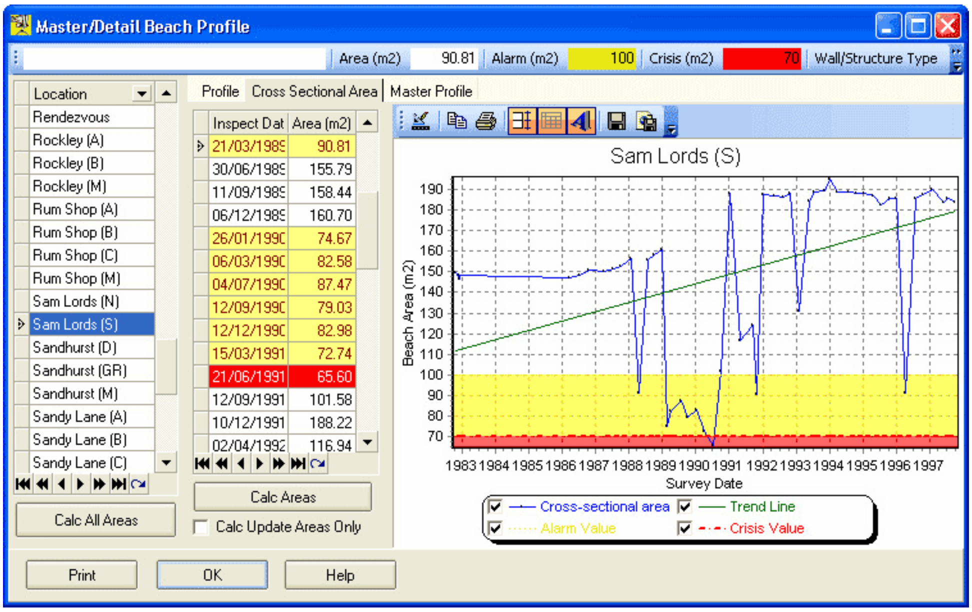

Figure 3. An example of cross-sectional area data derived from the master profile.

5. CONCLUSION

The monitoring data collected since 1974 in Bournemouth has provided an invaluable data source for coastal scientists and engineers alike. This stretch of coastline is one of the best documented in terms of monitoring data and this data has provided a basis for the design and development of coastal defence works in the area. Long-term local coastal monitoring programmes as operated by Bournemouth Borough Council, have allowed for considerable cost-savings to be made, providing greater confidence in efficient design of coastal works. The need for future replenishment schemes can now be predicted using the long-term monitoring data that is available, changing the management philosophy from a reactive to a pro-active one (Harlow and Cooper, 1996).

With regards to the specific replenishment schemes at Bournemouth (BIS1-4), these have been extremely successful, so much so that residents and tourist now take Bournemouth's excellent sandy beaches for granted. Future replenishment schemes could potentially be more effective as a protection measure if a coarse fill were used, but this is undesirable from and amenity point of view. Not all future replenishments will coincide with the dredging of Poole Harbour, so an alternative 'borrow' source must be found. If the cost of, and demand for, beach fill increases in the future, emphasis will move towards more efficient conservation or sediments, with beach monitoring as a critical component of this strategy (Harlow and Cooper, 1996).

REFERENCES

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