SCOPAC Utilisation of RCMP data to understand coastal processes – Hydrodynamic Controls on beach response in Swanage Bay.

Aims & Background

To assess the hydrodynamic drivers of beach response in Swanage Bay, an eastward facing crenulate Bay on the South Coast of England, in response to requests by the Environment Agency.

Significant impacts including lowering of beach levels and flooding have been observed during a number of extreme events, including the 2014 'Valentine's Day Storm', 2016's 'Storm Angus', and 2018's 'Beast from the East'. However, significant changes in beach level have also been observed in the absence of storm conditions. Regular topographic beach profiles are collected in the area, providing a record of beach change, however this data had not been related to hydrodynamic conditions to date.

A Northwards littoral drift is observed in the bay, and it has been suggested that there may be a southerly circulation of this material offshore, which then feeds the southern sections of the beach, to then be fed northwards again (Figure 1). This is presumed to occur during storms which are capable of mobilising sediment in the deeper offshore area.

A WaveRadar Rex has been in place at Swanage Pier since March 2007, to provide real-time tidal elevations and residuals. This was installed as tides are particularly difficult to predict in this area, due to the double high waters and low tidal range. Tidal surge measurements are essential here, as they can have major impacts on both beach response and flood risk (0.5m surge is half the tidal range on neap tides). The ability to monitor waves is a consequence of the chosen instrumentation, and was not the main purpose of the installation. The position of the instrument also subjects it to spray during storm events, which can lead to erroneous measurements. Hence, it has not previously been used to assess beach volume changes. It should be noted that wave direction is not measured by these instruments, and the nearest DWR (Boscombe) is not representative of local conditions due to refraction within the Bay.

Figure 1Sediment Transport Map, SCOPAC sediment Transport Study (STS). New Forest District Council (2017) 2012 Update of Carter, Bray & Hooke, 2004. SCOPAC Sediment Transport Study.

Methods

An MSc project was undertaken by Toby Miller and co-supervised by Dr Charlie Thompson (CCO), with advice from Dave Picksley (EA) and Dave Harlow (BCP Council). Additional analysis was undertaken by CCO staff. A number of CCO data sources were utilised, including the Swanage Pier Rosemount WaveRadar Rex, the Boscombe Directional Wave Buoy (DWR), a short-term AWAC deployment, topographic beach profiles and bathymetric data. This was combined with data from the Poole Bay DWR, operated by Cefas.

A combination of time-series and statistical analysis was carried out to assess the drivers of beach change within the bay.

Results

Analysis of the topographic profiles confirms a Northwards drift, indicating that waves are impacting the bay from the South East. This suggests significant diffraction around Durlston Head, which is supported by analysis of the directional change between wave measurements by the Poole Bay DWR, and the Swanage AWAC, and simple inshore wave modelling.

The central portion of Swanage Bay was nourished in 2006, and since this time, there has been an overall trend of beach loss in the South, and to a lesser extent in the central sections, with stable beach volumes in the North, implying an offshore loss to offset the Northwards longshore drift. However, there is considerable seasonal and annual variability in beach volumes.

Time series analysis of wave parameters indicates 35 individual storms occurred over the comparison period (2012-2019), where significant wave heights (Hs) exceeded the storm trigger of 1.2m. Not all of these resulted in significant beach volume changes, and four instances with recorded impacts were investigated in more detail.

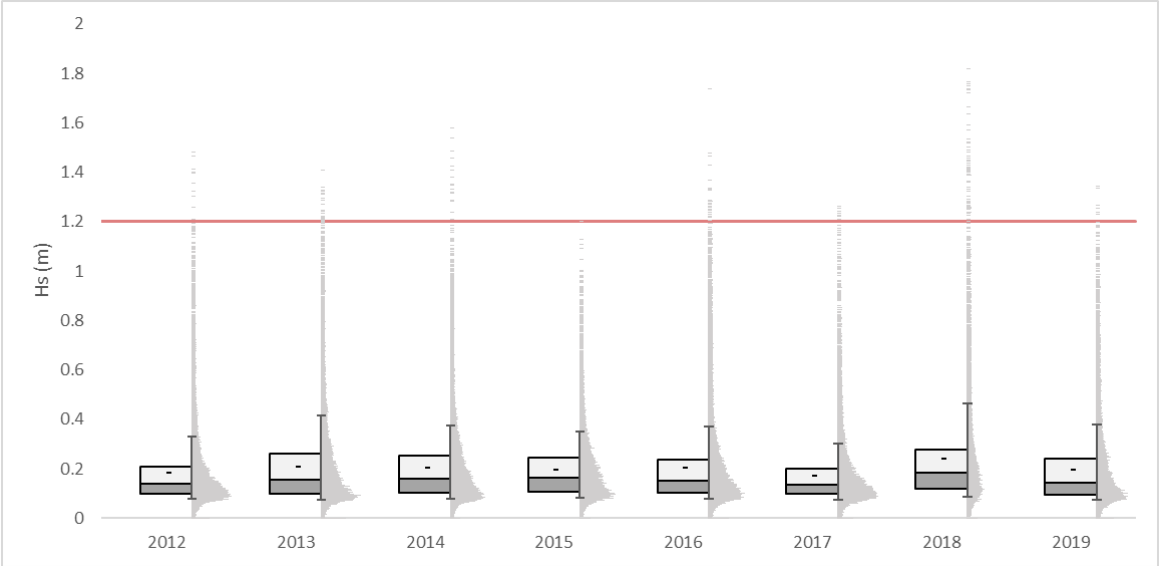

Figure 2 Box and Whisker Plot indicating annual distributions of significant wave heights measured at Swanage Pier. The red line indicates the storm threshold of 1.2m.

In February and March 2018, the 'Beast from the East' (2018) led to a significant reduction in beach volume in the Southern portion of the beach, however this showed rapid recovery. Wave heights were elevated, including some of the highest recorded by the instrument, and this coincided with unusual Easterly waves. This likely resulted in a higher component of cross-shore transport than typical. The peak of the storm was 3 hours after high tide, likely limiting the impact.

In November 2016, 'Storm Angus' caused overtopping and flooding, however beach volumes increased between the nearest before- and after- storm profiles. The latter profiles were collected 4 months post-event as scheduled spring profiles, and may indicate either rapid cross-shore recovery, little initial storm impact, or an onshore feed to the beach. The direction of this event was more southerly than in 2018, which would have led to a reduction in wave energy through refraction. The surge during the storm exceeded 0.7m approximately 2 hours before the peak of the storm, and the flooding was likely caused by a combination of the surge and waves.

The 2014 'Valentine's Storm' caused flooding and damage to the sea wall. The 2013/14 storm season had significant impacts across the South coast, although due to the orientation of the Bay a greater number of extreme significant wave heights were recorded in Swanage during 2018. Profiles on either side of the 2014 series of events show no significant loss of material on the beach, however two events may have resulted in the reported flooding and damage. A storm peaking on the 4th Feb, had significant wave heights of 1.6m (Hmax = 2.3m) combined with a surge of 0.72m an hour before high water on spring tides. The second was on the 14th itself where Hs was 1.35m (Hmax = 1.9m) but which occurred four hours after high water, with a surge of ~0.5m.

While not associated with an extreme event, a significant lowering of the beach was observed in March 2012, resulting in a request for a post-storm survey. This event was just below the storm threshold, peaking at 0.78 m, however it did occur during the spring tide. Similar to in 2018, the waves approached from the east.

Statistical analysis indicates that wave height, period and direction are all drivers of beach volume change, however the bi-annual collection of the topographic beach data means that more detailed analysis was not possible.

Conclusions

Both longshore and cross-shore sediment transport are occurring within Swanage Bay, as expected from a Crenulate Bay. Cross-shore losses tend to recover quickly, although there is an ongoing trend of beach lowering across the Southern and Central portions of the Bay since nourishment work was undertaken in 2006. Cross-shore transport appears greatest during storm events which have a more easterly component. However the lack of directional data at Swanage itself makes it difficult to confirm this.

Flooding and overtopping appears to be closely related to storm surge and the tidal stage at storm impact, rather than wave height directly. However, joint-probability analysis is not currently suited to this site as the datasets are too short to ensure statistical robustness, and nearby records are not representative of the local conditions. This would be possible once approximately 10 years of concurrent data were available (2022).

This study highlighted several knowledge gaps which would benefit from further data or analysis. The low frequency (2-per year) nature of the topographic profiles means that the impact of individual storms could not be pinpointed unless a post-storm profile is requested. When these are available, their offshore extents can be significantly shorter than the other profiles (due to logistical and safety reasons), which makes direct comparison of volume difficult. However, recovery can be seen in subsequent survey data.

The available bathymetric data were not sufficient to confirm the presence of a southerly sediment transport offshore of the bay, however the ongoing lowering of the beaches suggests that the current feed from offshore is not sufficient to maintain beach volumes. Growth of the offshore bar implies this may be a longer-term store of beach material, and additional bathymetric surveys may confirm whether the offshore bar is a suitable source of nourishment material for the beach.

The inshore wave data provided by the WaveRadar Rex is a consequence of the instrumentation chosen to measure tides, and is not as accurate as data provided by the Datawell Directional Wave Buoys typically used throughout the Regional Coastal Monitoring Programme. As such it should be used with caution. Validation was possible during the short period of overlap with a deployed AWAC, however a more precise assessment of the storm effects on Swanage bay would require a targeted field campaign, or more detailed modelling efforts.

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