SCOPAC Sand Dunes Study

Document: 1 Version: 1

Sand Dunes at Sandbanks, Poole:
Background, Evolution and Future

BCP Council

09 September 2020

Document history

SCOPAC Sand Dunes Study

Sand Dunes at Sandbanks, Poole: Background, Evolution and Future

BCP Council

This document has been issued and amended as follows:

Version	Date	Description	Created by	Verified by	Approved by
1.0	09.09.20	Sand Dunes Report – SCOPAC Minor Study	LB	MW	AF

Contents

Executive Summary

The original premise of this report was to capture information about sand dune installation as part of coastal protection works at Sandbanks, Poole in the mid-1990s. Further to this is an opportunity to understand wider sand dune development in Poole Bay. This is because anecdotally it seems sand dunes have been proliferating naturally in Poole Bay since these periods of management. This includes in areas east of Sandbanks where they have unexpectedly appeared and not been formally managed or protected. Since sand dunes can add a more resilient line of defence to beach alone, this opportunity should be explored, at what could be a critical point in the potential development of them for ecological, recreational, and coastal protection benefits. Furthermore, it is sensible to look at dune systems that have been in place before Sandbanks as a form of comparative baseline.

Dunes could incidentally form an important part of both coastal protection and seafront management – although many aspects of modern management of these systems and understanding their mechanisms of formation and growth, in practical terms, are not well researched.

As a starting point in this minor research project, we have assessed aerial photography to quantify their plan-shape changes since 2001.

The analysis of aerial photographs in this study has shown that across the period investigated, Sandbanks has grown from roughly 3,591m^2 2001 to over 10,000m^2 in 2019, despite cut backs caused by storms. Sandbanks is downwind from the Studland dune system, which we also found to have significantly grown. It is hypothesised that the growth at Sandbanks may have been influenced by dune dispersal from this more natural system. Similarly, the more recent formation of dunes behind rock groynes at Branksome could be attributed to the spread of dunes from Sandbanks. These results highlight the success of dune growth around Sandbanks, providing better resilience against coastal erosion than fine sand alone. As well as providing a line of protection, sand dunes capture windblown sand and creates diversity along the frontage.

Other areas to explore beyond the scope of this project are the trade-off relating to coarse vs. fine material in management of beach replenishments. A coarser beach is more resilient to erosion and also does not blow onto the promenade as easily (generating a need for expensive clearance operations). Meanwhile finer material can be lower priced and accessible as part of the harbour entrance dredges (and inevitably makes up a proportion of most replenishments) and desirable for amenity. Whilst finer material has been viewed as less resilient in terms of coastal protection (i.e. being lower mass, wind and small waves remove it more easily from the beach) it needs to be understood whether this is perhaps less the case if it is needed to feed growing dune systems that, due to their root structures etc, are actually a strong line of defence.

This study received a contribution from SCOPAC as part of the 2020-2025 Research Programme ‘Improved Utilisation of Data’ fund. The aim of the award is to showcase the value of data collected through the South-east and South-west Coastal Monitoring Programmes, demonstrating how analysis can advance coastal process understanding and future coastal management decisions (www.channelcoast.org).

1 Introduction

1.1 Sand Dunes

Coastal sand dunes form in areas where there is an adequate supply of sand and winds strong enough to transport this sand inland. For this to occur, an intertidal area large enough for this sand to dry out between high tides must be present, as well as dune-building vegetation which can trap it (UK BAP, 2008).

Sand dunes hold many functions, including:

- As natural forms of coastal protection against erosion and flooding. Their ability to defend the coastline is greatly enhanced by the presence of associated vegetation, which stabilises sediments and provides a form of roughness to attenuate wave energy (Hanley *et.al.,* 2014).
- Providing habitats for plants and animals, including many rare species. This owes to the diversity of ecological niches found within these environments due to their spatial heterogeneity (Everard *et.al.,* 2010). Additionally, as a location which experiences groundwater recharge, coastal sand dunes retain freshwater and act as a buffer against saltwater intrusion (Martínez *et.al.,* 2008).
- Playing an important role in providing the area with amenity value, often creating popular recreational areas.

Across England and Wales, coastal sand dunes cover has been estimated at 200km^2. The largest single system is located on the Sefton Coast, extending 20km^2, yet several other systems cover more than 5km^2. Despite this, smaller dune systems along the east and south coasts of England still hold significant flood defence value (Pye *et.al.,* 2007b). The largest area of dune heath on the south coast is Studland (also the nearest relevant dune system to this investigation), covering 0.75km^2.

Due to their exposed nature, coastal sand dunes are particularly susceptible to the increasing risks of sea level rise and increased storminess which have the potential to erode these systems. As well as this, their use for agriculture, afforestation, recreation and development further exacerbate the potential for dune degradation. In England and Wales, roughly 35% of coastal dunes in England and Wales have experienced net erosion, resulting in the use of many dune stabilisation techniques since the 1950s; whilst 35% of dunes have experienced net stability and 30% show accretion where there is an adequate supply of sediment (Pye *et.al.,* 2007b).

1.2 This Case Study

This investigation focuses on the dune system on the Sandbanks Peninsula (Figure 1), a sand spit located on the east side of the entrance to Poole Harbour, at the western end of Poole Bay in southern England. Historically, the majority of Sandbanks consisted of sand dunes but due to residential development and beach erosion they had been depleted considerably. As a result, the Sandbanks Coast Protection Scheme was constructed in two phases between 1995 and 2001. Phase 1 (1995/6) involved construction of four rock groynes and regeneration of approximately 1,200m^2 of new sand dunes by planting marram and Sea Lyme grass. Phase 2

(2001) involved four additional new rock groynes and further re-generation of sand dunes. In order to achieve this a nursery area to grow suitable planting material was set aside at the rear of Sandbanks Pavilion. Seeds were taken from the grasses in the sand dunes created in 1995/6 and germinated in a greenhouse. When ready, the small plants were planted out in the nursery and then later transferred to the areas designated for sand dunes.

Figure 1 Sand dunes at Sandbanks (photograph taken by Lia Bennett).

Various periods of erosion have been managed at Sandbanks by coastal protection strategies, most recently resulting in an accretion in dune area and apparent spreading of dunes further east along the Poole frontage at Branksome Chine, around the landward end of rock groynes which were installed in 2010. We seek to understand the history of dune evolution here to assess the success of management which has taken place and future implications. The focus here is on Sandbanks but several other dune sites locally are assessed in terms of change over the same period (Section 3.2.2).

1.3 Aims

The aims of this proposed study are:

- To undertake a review of development of the sand dunes since 1995 to quantify exactly how they have established and evolved since this period. This includes how the dune ecology has evolved as part of this from the original seed grasses used, and spatial and volumetric change.
- Determine the ongoing pressures/issues for dune management in this area.

- Assess the utility of the dunes for flood and coastal erosion risk management.

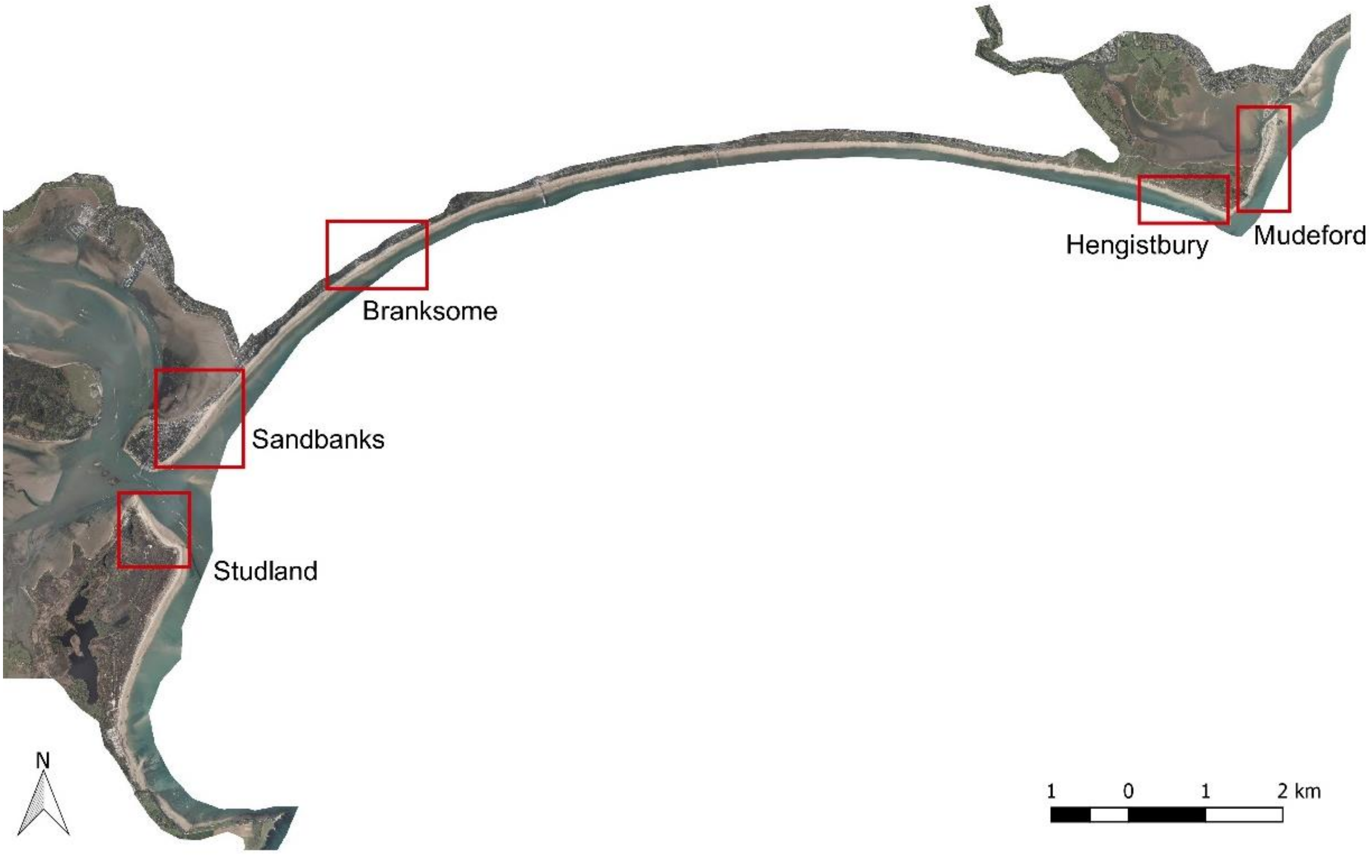


Figure 2 Overview of the study area.

2 Sandbanks- Background

2.1 Hydrodynamics, beach material, and topography

The tidal range at Poole is small, approximately 2.0m during spring cycles and 1.0m during neap cycles (New Forest District Council (NFDC), 2017). It has a strongly distorted tidal curve indicating the presence of a double high water and a short 'stand' at low water (HR Wallingford, 2006). At the harbour mouth, some of the most rapid currents are experienced in the whole of Poole Bay, where peak ebb flows approach 2.5ms^{-1} (NFDC, 2017). Slightly further north, towards the neck of the peninsula, there is a reduction in tidal velocities which continues to reduce further east along the coast. These flow dynamics were modelled by HR Wallingford (2006) and can be seen in both ebb and flood conditions.

The dominant wave direction at Poole is from the south to south-west, owing to longer fetch and period swell waves which originate in the Atlantic Ocean. Though less morphologically influential, shorter period wind waves do occur in from the east and south-east and significant storms can occasionally be brought from this direction (Bournemouth Borough Council (BBC), 2010a).

The particle size at Sandbanks was investigated in 1994 where 30 surface samples of beach and seabed sediment were collected where the beach was shown to comprise of sand with an average D_{50} of 0.27mm. Since then the frontage has been replenished, in 2003 and 2006 (with materials from Poole Swashway and Harbour, D_{50} of 0.53mm). The length of coastline between Sandbanks and Hengistbury Head along Poole Bay, presently has 79 groynes. Of these, 25 are made of rock and 54 of wood.

Sandbanks is quite low-lying topography (Figure 3) where elevations along its neck barely exceed +4 to +6 mODN. The area is made up of marine sands overlain by wind-blown sand which has resulted in the formation of a single ridge of dunes in places (Pye *et.al.,* 2007a). Natural loses of material here occurs both north eastwards to Poole Bay and westward to Poole Harbour entrance (NFDC, 2017). In response to natural spit recession over the last century, defences in the form of seawalls, groynes and dune building have been used to stabilise the foreshore. Following this, the spit has been extensively developed for recreational and residential purposes, and its expansion in ecology such as grassland and sand lizards has designated Sandbanks a Site of Nature Conservation Interest (SNCI) (BBC, 2010b). However, future sea level rise will increase the pressures of recession faced by Sandbanks.

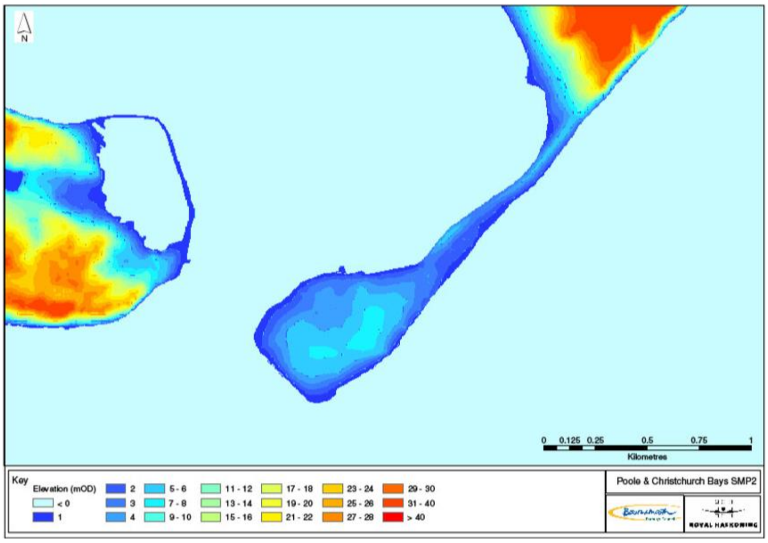


Figure 3 Topographic map showing the low-lying nature of Sandbanks Spit (BBC, 2010a).

Although the morphology of Sandbanks peninsula indicates a net east to west littoral drift of sand, in actual fact drift and transportation is rather complex here (NFDC, 2017). This is because the littoral transport regime is influenced by the almost shore-parallel East Looe tidal channel (between Hook Sand and Sandbanks beaches, as shown in Figure 4), in which tidal currents flowing towards Poole Harbour entrance are capable of moving fine sand. The presence of Hook Sand (Figure 4), a discrete accumulation of sediment in the western part of Poole Bay, causes refraction and attenuation of incoming waves (BBC, 2010a). Additionally, it is said that this offshore bar formation could supply sand to the beach as it migrates onshore (NFDC, 2017).

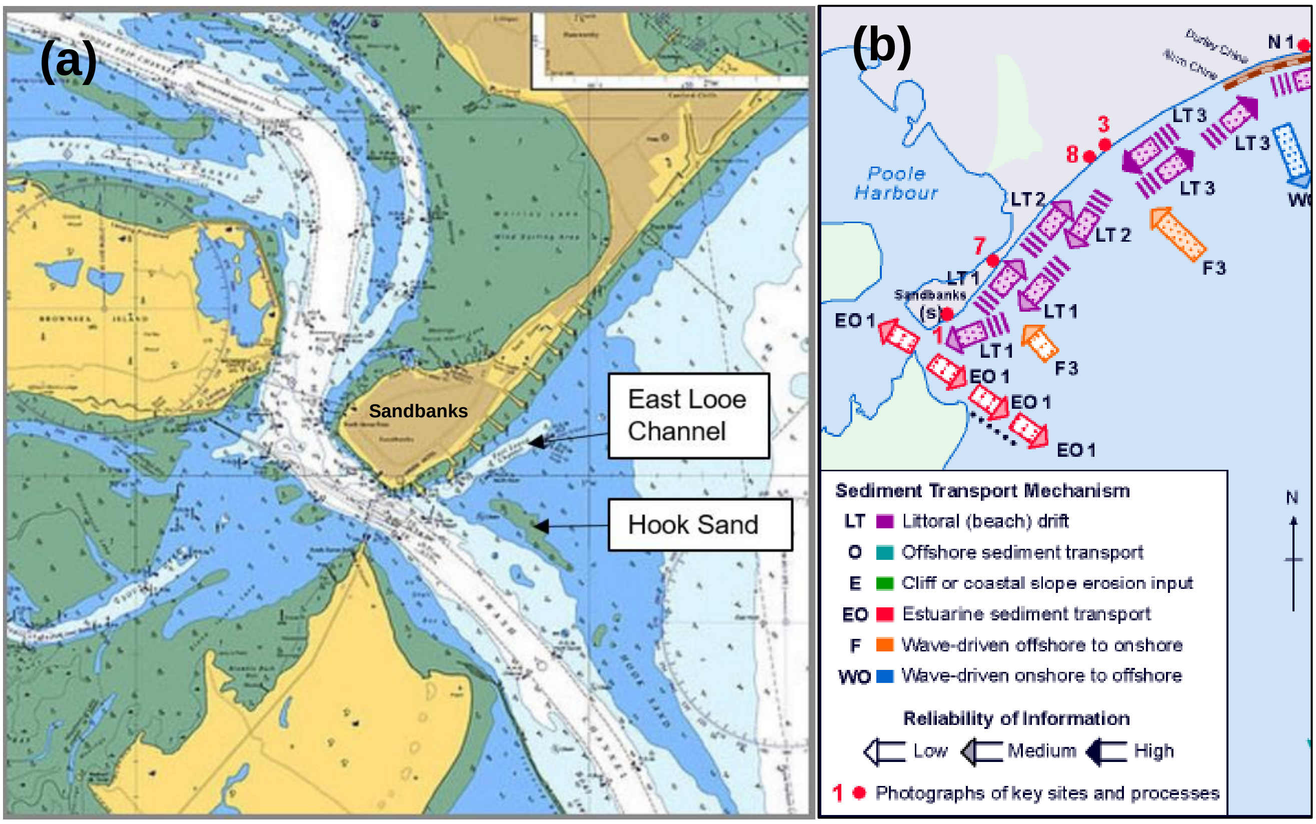


Figure 4 (a) Location of the East Looe Channel and Hook Sand in relation to Sandbanks, and (b) the sediment transport pathways within the region (NFDC 2017).

2.2 History of Beach Works

In 1896, Sandbanks first experienced a problem with erosion. To prevent breaching of the peninsular, fourteen groynes were constructed along the seaward frontage. These accreted sand between 1901 and 1924, creating a stable environment on which much of the development we see today was built. In 1955 the groynes fell into disrepair and many were removed as their deterioration was putting a risk to public safety. In 1991 a series of south easterly storms reduced the beach level considerably, resulting in emergency works being undertaken in the form of the construction of a new rock groyne at Midway path and local rock protection to sea walls (Robson, 2003).

Two more recent phases of coastal protection have been implemented along this section of coast, made necessary by residential development and beach erosion:

- **Sandbanks Phase 1 (1995/6)** included four rock groynes constructed along the shoreline and 1,200m^2 regeneration of new sand dunes between Sandbanks promenade and the Haven Hotel, by planting Marram and Sea Lyme grass. This successfully increased the volume of sand to this area and created a wider frontage which offered more protection to sea walls as well as increasing amenity and safety value (Robson, 2003). After 5 years, the sand dunes became well established and could be used as a source of new planting material.
- **Sandbanks Phase 2 (2001)** included four additional new rock groynes and alterations to two existing rock groynes (one of which was constructed in 1996 and the other in the 1890s.

There was further re-generation of the dunes between Sandbanks promenade and Shore Road. This included the creation of a nursery area to grow suitable planting material which was later transferred to the areas designated for sand dunes.

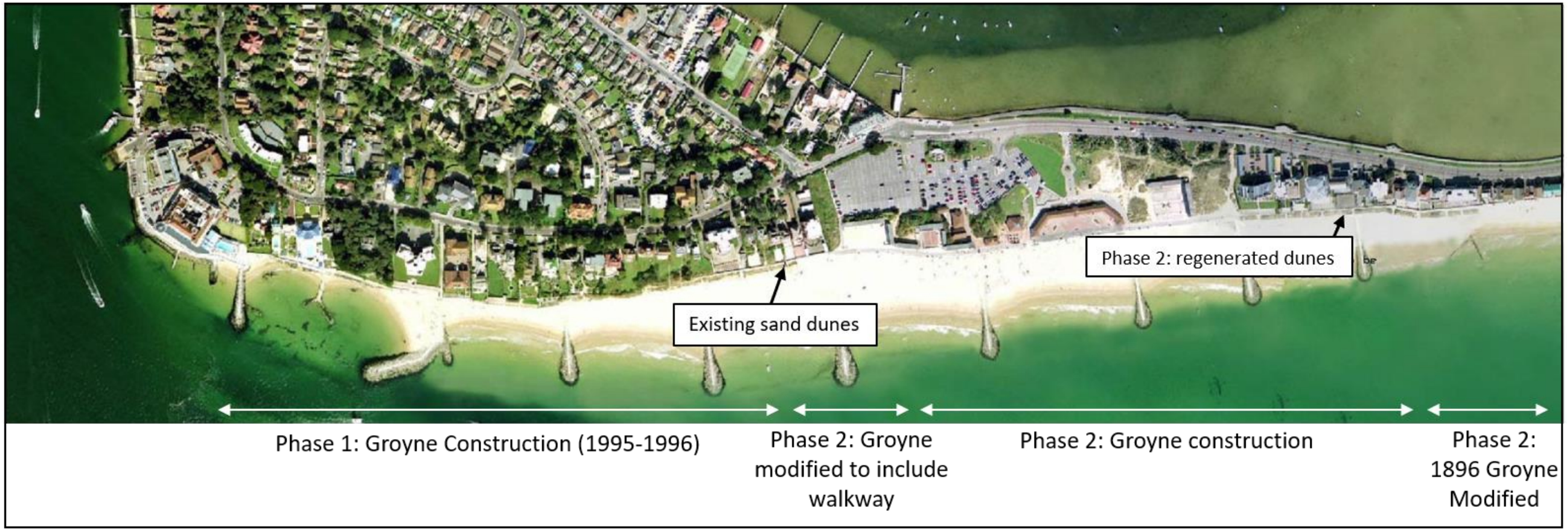


Figure 5 An overview of the modifications and additions made to rock groynes in Phase 2 of the Sandbanks coastal protection scheme.

Most of the rock used for the groynes was 3-6 tonne Portland Limestone which was delivered to site by road transport. A concrete walkway section was also constructed along the rock groyne for increased safety, the creation of which can be seen in Figure 6 below. Rock groynes were chosen for reasons of sustainability and design life economics (lifespan of at least 50 years), whilst more technically feasible than offshore breakwaters, the latter of which would not have achieved the desired results due to the offshore tidal conditions caused by the Harbour entrance.

The Sand Dune Regeneration was part of the works with growth of suitable planting material for regeneration implemented during Phase 2 of the coastal protection works as follows:

- **Summer/Autumn 2000**: Seeds were collected from the existing dune areas (generated in Phase 1) followed by germination and growth under controlled conditions in greenhouses.
- **March 2001**: Fencing was constructed by contractors to protect new dune areas.
- **March/April 2001**: A new nursery area at the rear of Sandbanks Pavilion was set aside and cleared of roots and sand.
- **May 2001**: Seedlings were planted in cleared nursery area to 'grow on'. These were later transferred to the areas designated for sand dunes.

Figure 6 The construction of concrete walkways on groynes installed at Sandbanks.

Overall, the regeneration works were successful and are now well established with sand lizards inhabiting here. This holds ecological importance as sand lizards are rare and strictly protected by the British and European law; making it an offence to kill, injure, capture or disturb them or their habitat (ARC Trust, 2018). There were some practical issues in the artificial dune development, such as when vulnerable areas of Sandbanks dunes were fenced off during phases of past coastal protection to reduce trampling of the planted marram grass that was essential for dune stabilisation. However, this presented issues surrounding restricting public access to sections of the beach – including a dog being injured on the wire fencing.

Post-construction phases described above, an approx. 700m section of beach further eastward continued to erode and put properties at risk. Therefore, beach replenishment was carried out in 2003 and 2006 with 105,000m^3 and 450,000m^3 sand respectively placed onto the beaches of Poole during these operations (the 2003 works focusing more on Sandbanks). The total length of beach re-nourished in 2003 was 1,020m, between Sandbanks and Shore Road (the location of which is shown in Figure 7), increasing the width of the beach by an average of 50m. The results of these works pre and post replenishment can be seen in Figure 8 below (Robson, 2003).

Figure 7 Overview of features at Sandbanks, including the extent of two renourishment schemes in 2003 and 2014.

Figure 8 Before (left) and after (right) beach replenishment was carried out at Sandbanks in 2003, showing a large elevation in beach level (Robson, 2003).

3 Analysis of sand dunes around Poole Bay

3.1 Sandbanks – Review of beach levels and photos

This section reviews information from the Channel Coastal Observatory Annual Reports, as well as recent photo observations. A net gain in beach levels and profiles across the period of 2007 to 2017 is evident from Figure 9 and Figure 11 respectively. Between 2003 and 2007, as shown in Figure 10, the cross-sectional area of profiles showed less accretion than in more recent years, with decreases in certain areas.

Figure 9 Topographic difference plot: Sandbanks peninsula - elevation changes June 2007 to April 2017 (CCO, 2017).

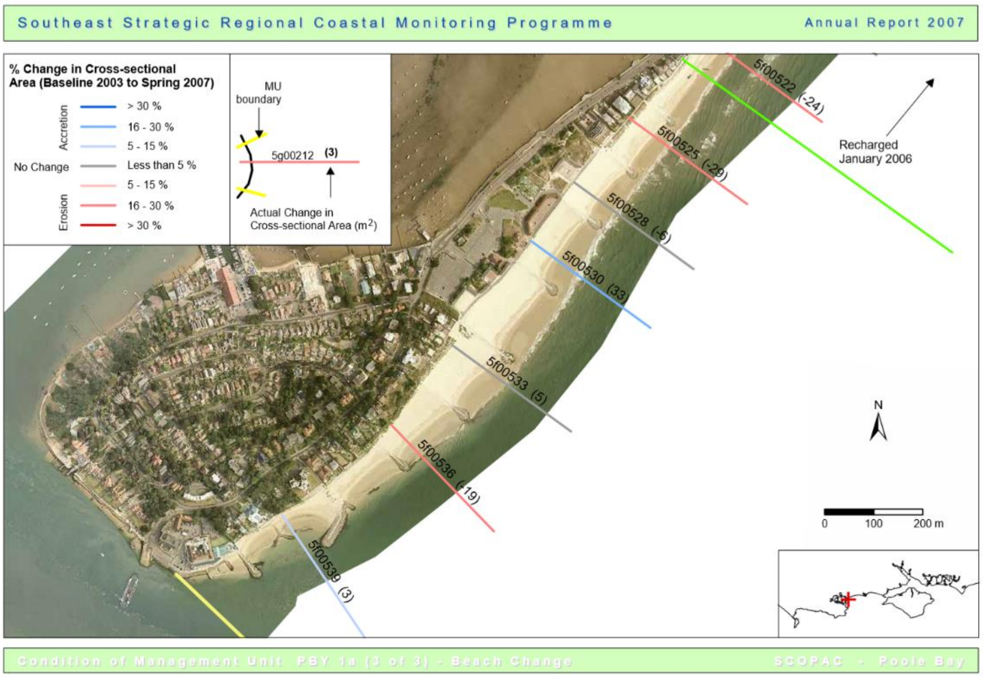


Figure 10 Percentage change in cross-sectional area at profiles- 2003 to Spring 2007 (CCO, 2007).

Figure 11 Percentage change in cross-sectional area at profiles- June 2007 to April 2017 (CCO, 2017).

The net gain between 2007 and 2019 is despite the 2013/14 winter storms where, just north of the peninsula, a significant amount of sand was lost (Figure 12). In response to this, in December 2014 139,000m^3 of sand was delivered to the frontage from Sandbanks rock groyne to the end of the beach huts at Canford Cliffs (www.poolebay.net), the extent of which is shown in Figure 7. Recent storms have also been observed to cut back the dunes rapidly, such as storm Ciara in February 2020 which resulted in undercutting; as shown in Figure 13. These photographs show that there is a well-developed root structure present in the dunes, providing strength as shown by the cliffed profile of the sand.

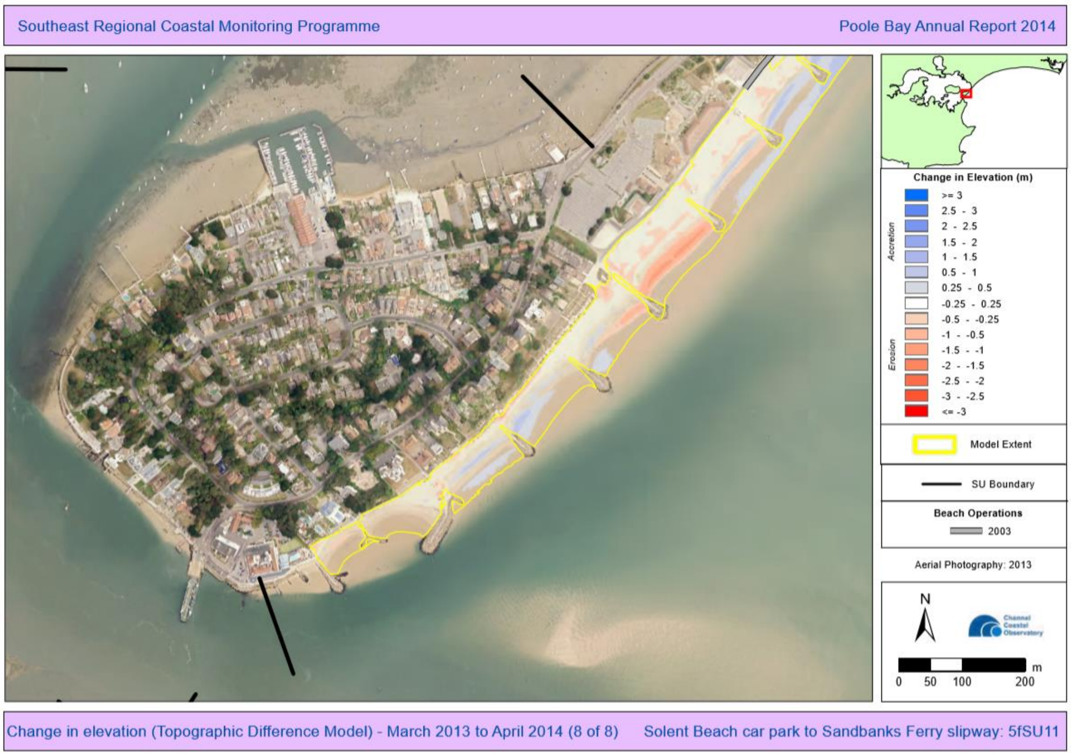


Figure 12 Topographic difference model of Sandbanks between March 2013 and April 2014, showing the impact of the 2013/14 winter storms on the elevation of the dunes (CCO, 2017).

Figure 13 Undercutting at Sandbanks post storm Ciara on the 9th February 2020 (Photographs taken by Lia Bennett).

3.2 Area Calculations

This section focuses on the area derived from digitising dune outlines from geo-rectified aerial photography provided via the Channel Coastal Observatory. The dates for aerial photos are outlined in Table 1.

Table 1 Dates spanning the aerial photography coverage for the years referred to.

	Date Acquired	
Year	Start Date	End Date
2001	06/05/2001	07/05/2001
2002	11/08/2002	23/08/2002
2005	24/06/2005	27/06/2005
2008	07/05/2008	24/06/2009
2013	27/06/2013	22/08/2013
2016	17/08/2016	24/08/2016
2019	20/04/2019	21/04/2019

3.2.1 Sandbanks and Studland

As shown by the blue line in Figure 14, the dunes at Sandbanks have grown since the scheme in the mid-1990s. The first set of available aerial photography from 2001 indicated 13 separate areas of dune were present on the peninsula with a total estimated area of 4,302m^2 (of which 3,591m^2 was vegetated). *To note for future analysis, from the imagery it is straightforward to spot vegetation, but some judgement is required to find the raised area that is definable as dunes.* At Sandbanks the dune area, despite various beach losses and storminess has grown to an area totalling over 10,000m^2.

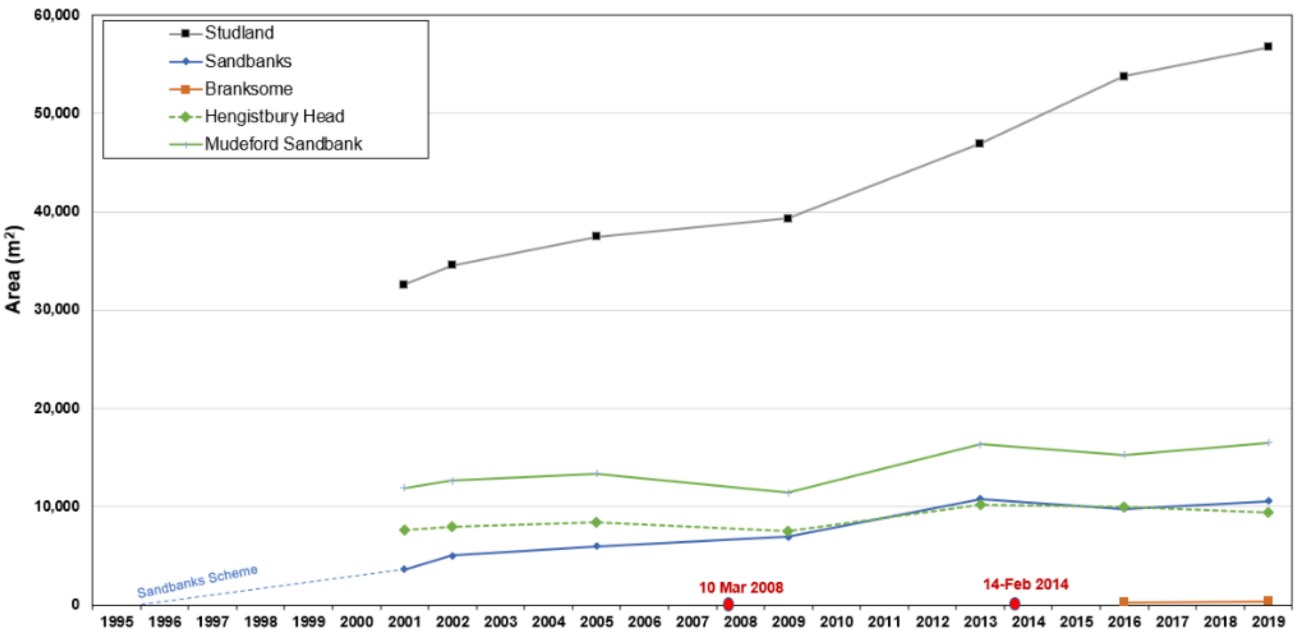


Figure 14 Area of dune vegetation at study different locations (refer to Figure 1).

As indicated in Figure 15, the dunes have spread both seaward and laterally. *Another note for future analysis would be to compare different lateral vs. cross-shore progression of dune systems in different case studies.*

Figure 15 Dune outlines for each aerial photo at Sandbanks.

Sandbanks, along with the Studland peninsula to the west, form the northern and southern boundaries of Poole's harbour entrance. Studland has a well-established natural dune system of >75ha (forming the largest area of dune heath on the South Coast). This is part of a system that formed around 500 years ago and has been growing ever since. The dunes are now a barrier that has separated the freshwater lake (Little Sea) from the sea. The aerial photos indicate over 24ha gain in vegetated area since 2001. In comparison to Sandbanks, Studland spit has experienced far less human development and the dunes are not particularly active. Stabilisation has been attributed to the presence of Marram Grass and heather which increase the roughness of the ground and encourage further aeolian deposition (NFDC, 2017). Calluna heath vegetation has rapidly spread and colonised older dune ridges and trees have grown in the dune slacks, further suppressing erosion here.

Between 1800 and 2000, 4.5km^2 of dunes were created here, with a trend of erosion in the south and net accretion in the north after the mid-nineteenth century (NFDC, 2017). The growth of these dunes is due to the supply of sand from the adjacent offshore and inter-tidal foreshore. However, vertical growth is limited by the removal of sand by south-west winds. There is a potential that these winds may transport seeds and sand to Sandbanks, influencing their growth over time.

Interestingly, over the span covered by this study the Studland dune system appears to have advanced seaward and grown in area by over 24,000m^3, with an acceleration in growth over the period 2008 and 2016 (black line in Figure 14). Note, the areas captured are relative: for the analysis and consistency, the digitisation of the landward dune area was fixed as constant in the aerials (Figure 16).

Figure 16 Dune vegetation at Studland (left 2001 and right 2019).

3.2.2 Hengistbury Head and Mudeford Spit

Hengistbury Head

Between 1937 and 1939 Hengistbury Head Long Groyne was constructed. As a direct result of this, a system of three lines of dunes known as the 'New Dunes' developed and were colonised by vegetation (BBC, 2005). Due to deterioration, the New Dunes at Hengistbury Long Groyne were fenced against recreational damage in 1979 and support a variety of plant species including Sea Bindweed, Sea Sandwort and Sea Kale; the latter of which is rare and protected under the Wildlife and Countryside Act (1981). Today, these dunes (the extent of which can be seen in Figure 17(a)) are relatively stable yet may be attacked during exceptional tidal surges such as in 1987 and 1990 (BBC, 2005) – when beach levels have been lower prior to replenishments at Solent Beach in 1989 and at Bournemouth, 2006.

They experienced slight growth over the years, but this growth peaked in 2016 and slightly declined in the 3 years that followed. However, it should be noted the 2019 aerial photography was in April whilst 2016 was August, so this may be representative of seasonal growth at the time of the photos rather than net overall change.

Mudeford

Mudeford Spit is 900m long and hosts dunes up to 7m high. The width of these dunes has in the past increased markedly, from an average of 50m in 1840 to 300m in 1885, owing to a surge of sediment supply from Hengistbury head due to ironstone mining which exposed more fine sediment (BBC, 2005). The results here suggest the dunes have expanded by around a third in area over 2001 to 2019, the latter of which is represented in Figure 17(b).

Upon construction of Hengistbury Head Long Groyne, the spit experienced a reduction in length of 900m by the mid-1940s. In response to this, concrete and rock groynes as well as recent sand nourishment has been carried out in stages between 1945 and 1996 as well as restoration of longer-term recreation-induced erosion of the dunes. In the late nineteenth century only a small remnant of the dune field was present here.

However, as with Hengistbury Head, Mudeford dunes have undergone net growth over the period of the study 2001 to 2019, with a couple of intervals of decline. It seems possible that the Mudeford Sandbank and Hengistbury Head dunes responded (reduced in area) due to storms in 2008 and 2013/14, although further work is required to confirm this. Most of the growth in dune area noted over the period covered by this study has been immediately north of and east of the long groyne where areas have been cordoned off.

Figure 17 Dunes at (a) Hengistbury Head and (b) Mudeford Sandbank in 2019.

3.2.3 Branksome

The aerial photos captured approx. 500m^2 of dune formation on the approx. 1km stretch of beach around Branksome Chine to Branksome Dene Chine, Poole. These dunes appear to have first formed sometime between 2013 and 2016 and currently reside at the landward head of the 5 rock groynes completed in May 2009, as shown in Figure 18. These consist of 20,000t of Portland limestone, part of a then £1.9 million coastal protection scheme. They lie approx. 2.3km northeast of the dunes at Sandbanks. It can be speculated that they formed from windblown seeding from the Sandbanks or Studland dunes – initiated by the placement of rock. This potential mechanism is discussed briefly in the next section.

At around 2m high, these are now notable features that the public sit on, and would be retaining over 1,000m^2 of sand which, in principle may otherwise be on the promenade. If desirable to retain these, it would be relevant to assess whether they should be protected or how they respond to interference. As noted in Figure 19, during a major promenade sand clearance operation, bulldozers drove over the dunes. Their recovery after this and in response to the upcoming (autumn/winter 2020) beach replenishment, should be assessed in future work.

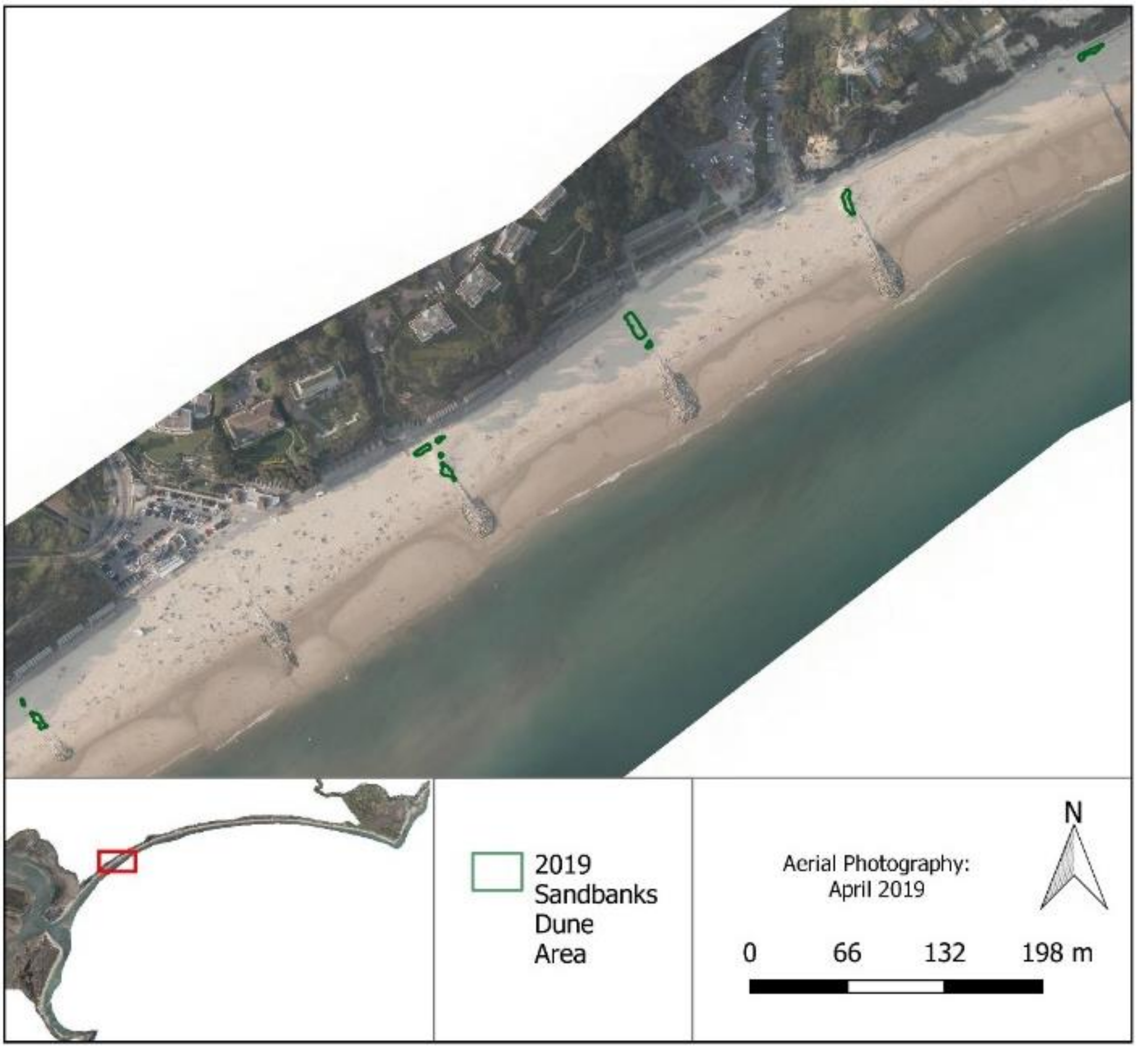


Figure 18 Areas of dune around the head of the rock groynes at Branksome.

Figure 19 Dunes at Branksome being driven over during promenade clearing in March 2020.

4 Discussion and Conclusions

4.1 Key Findings

This study's remit is not for a detailed analysis of physical processes, although some are outlined that may be relevant to discuss in future analyses. The following outlines main findings associated with this study:

- The dune system at Sandbanks, since being created following construction of rock groynes in the 1990s and being seeded in the year 2000, has grown from its original designated area of approx. 3,591m^2 to over 10,000m^2 in 2019. It appears quite resilient given the heavy cut backs caused by storms, which may be due to the frequent replenishment from Poole Harbour entrance.
- The more natural and historically significant dunes at Studland have also grown, even during the period of this study. It is uncertain why this is and what impact this has had on Sandbanks.
- Dunes have in recent years started to form at Branksome Chine, over 2km east of Sandbanks.
- The dunes at Mudeford Sandbank and Hengistbury Head have grown during the 2001-2019 interval assessed in this study.

Further discussion on these key findings are provided in the following sections.

4.1.1 Generic known spread of dune vegetation

The first point to make is that the spread of dune vegetation is quite well understood at other locations. For example, *Ammophila* species such as marram grass have the potential to survive long distance dispersal via ocean currents, depending on the prevailing conditions as well as interception by headlands. Hacker *et.al.* (2012) highlighted the potential for the spread of stabilising saltmarsh vegetation on the Pacific coast of North America, where *Ammophila breviligulata* (American Beach Grass) was seen to spread 10km between 1988 and 2009.

A similar process of dispersal may have occurred roughly 3km down-wind of Sandbanks, where smaller developments of dunes can be found behind rock groynes at Branksome Beach. In the same way, Sandbanks dunes themselves may have experienced increased growth due to dispersal from the nearby dunes at Studland Head, just south of Sandbanks. In this region, the prevailing south westerly wind direction is the reason for accretion in both of these cases.

4.1.2 The growth of vegetation around structures

What is interesting is the alignment of dunes with rock structures, both temporally and spatially. With the exception of Studland whereby the proliferation of dune vegetation is possibly due to a combination of its fine sand supply and that it is east-facing and quite sheltered; most of the new dunes in the study have been round the head end of rock groynes. An explanation for this may lie in the process of dune vegetation increasing surface roughness and absorbing the flow of wind and sediment, creating a depositional environment where a build-up of sand can occur. As described by Ritchie (1972), similar conditions may also form around barriers or man-made structures such as walls or groynes which reflect and channel the flow. This process has occurred at Sandbanks and Branksome, where areas of dunes have formed around many of the rock groyne structures built here. It may also be that the presence of rock limits frequent (potentially) damaging effects of excavators used for promenade clearing around newly forming dune.

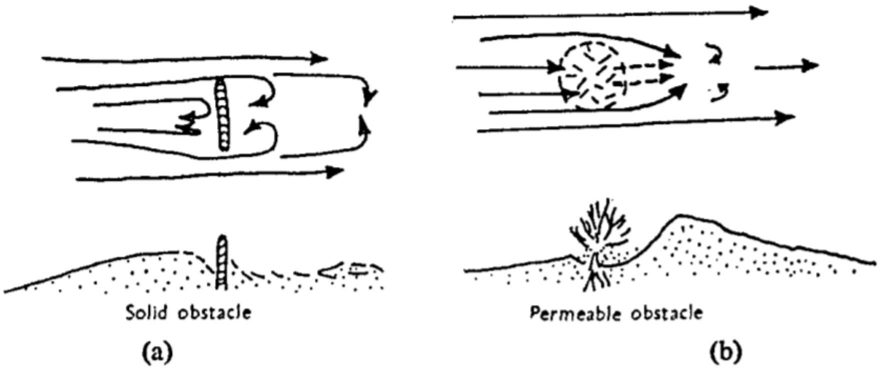


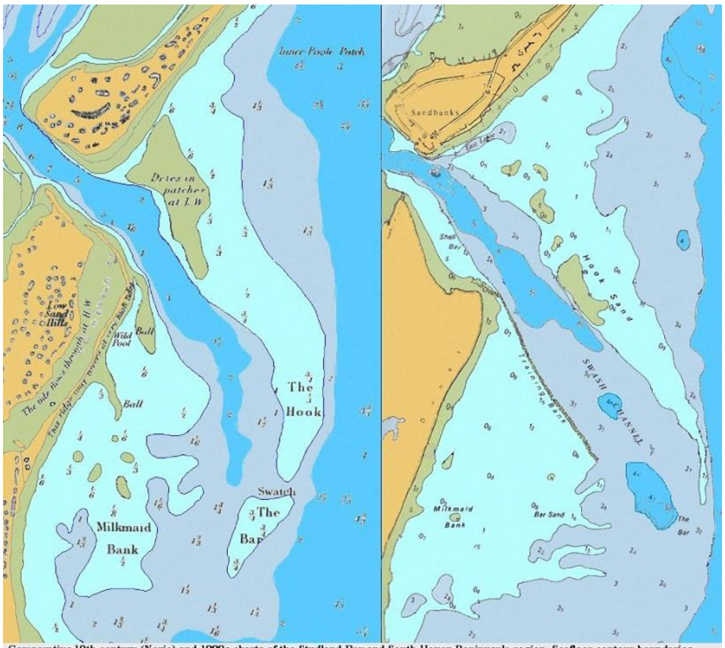
Figure 20 The effect of a) solid man-made structures and b) permeable vegetation structures on wind flow and deposition/erosion (Ritchie, 1972).

4.1.3 Storms Events

When discussing storms in the context of dunes, there are several interesting aspects to explore further:

- *The impact of storms on dunes.* This depends on particular circumstances that either hinder or assist net growth.
- *The role of dunes in coastal protection.*
- *The ability of dunes to survive in harsh, exposed conditions*. This depends not only on the intensity, duration and frequency of storms, but also on their morphological characteristics; including height, width and vegetation density, type and continuity.
- *It seems there is a stage of development whereby dunes become deep-rooted and resilient*, and this seems to have occurred at Sandbanks – but will likely be dependent on sand supply.
- *Dunes may experience destruction through inundation, overwash and scarping*; the interaction of which determines the response of dunes to the impact of storms. Although this section of coastline has experienced minimal retreat over the past nine years, there is still potential for distinct storms to impact their stability (West, 2016). It is likely that due to storms such as the historic event of November 1824 which flooded Sandbanks spit (West, 2016) and the lack of coastal protection (groynes, dunes and replenishment) in the 1990s to early 2000s, there may have been a real threat to property.

The figure below highlights the difference between Sandbanks in the 19th century, when it was a natural area of sand dunes, to its more current developed state in the 1990s.



Comparative 19th century (Norie) and 1990s charts of the Studland Bay and South Haven Peninusula region. Seafloor contour boundaries on the left-hand map are at 1 fathom (6ft = 1.8m) and 2 fathoms (3.7m). On the right-hand map they are at 2m and 4m. The maps are illustrative and have been redrawn, slightly simplified and coloured. They are not in suitable form for accurate quantitative work for which the originals should be used. They are not for navigation use. *Ian West (c) 2002*

Figure 21 The comparison between 19th century (left) and 1990s (right) offshore topography around Studland and Sandbanks (West, 2016).

4.2 Future Sand Dune Management Considerations for BCP Council

Further consideration of sand dunes across Poole and Christchurch Bays by BCP Council is recommended, to acknowledge the role of these features for sustainable coastal protection, habitat, recreational use and seafront management. The extra layer of 'sacrificial' defence offered by dunes with their root systems providing better resilience than fine sand alone, may offer enhanced erosion protection during energetic winters such as 2013/14, particularly around the western end of Poole Bay.

In addition, during previous beach replenishments there has been concern about fine beach material being insufficient for coastal protection and generating large quantities of windblown sand on the promenade – which cost seafront teams £100,000s to clear annually and block the path of cyclists and vehicles. This is partly an issue with sea level rise having already meant that the groynes and beach have reached a vertical limit against the promenade/seawall meaning this is unavoidable because the beach has to be maintained to a high level to reduce risk of failure (it is an old structure dependent on not being directly exposed to waves). Raising the promenade would be costly – an analysis referred to in Harlow (2017) refers to calculations that give a value in excess of £143,000,000 (for the 8.44km of sea wall). Sand dunes may provide a line of protection and capture and block encroachment of windblown sand, which in turn may reduce the frequency of operations needed to clear sand form the promenade by BCP Council seafront services, whilst also creating more diversity for both recreational use of the frontage and rare species that require sand dune habitat.

Further research and field trials of sand dune creation should be considered to assess the impact of sand dunes on promenade clearance and determine best methods of clearing sand from promenade to beach without adversely impacts dune habitat. Since this study, the authors have noticed an additional area of dune near Canford Cliffs (in-between Sandbanks and Branksome where analysis was provided). It is observed and speculated that the success aligns with a low height wall, and it will be assessed in any future work if such obstacles (to promenade clearance disturbing the beach before they can be established) can allow dunes to flourish.

References

Amphibian and Reptile Conservation (ARC) Trust. 2018. *Sand Lizard.* [Online] Available from: https://www.arc-trust.org/sand-lizard (Accessed: 28.07.2020).

Bournemouth Borough council (BBC), 2005. *Hengistbury Head Management Plan.* Available from: https://www.twobays.net/pdf/Hengistbury%20Head%20Management%20Plan%20October%202005.pdf [Accessed: 14.01.2020]

Bournemouth Borough Council (BBC), 2010a. *Poole and Christchurch Bays Shoreline Management Plan Review Sub-cell 5f. Hurst Spit to Durlston Head. Appendix C: Review of Coastal Processes and Geomorphology.* Report V3, 2010. Royal Haskoning UK Ltd.

Bournemouth Borough Council (BBC), 2010b. *Poole and Christchurch Bays Shoreline Management Plan Review Sub-cell 5f. Hurst Spit to Durlston Head. Appendix D: Natural and Built Environment baseline.* Report V3, 2010. Royal Haskoning UK Ltd.

Channel Coastal Observatory (CCO) 2007. *Southeast Regional Coastal Monitoring Programme: Annual Report 2007- Poole Bay.* AR 37.

Channel Coastal Observatory (CCO) 2017. *Southeast Regional Coastal Monitoring Programme: Annual Survey Report 2017- Hengistbury Head to Durlston Head*. AR 142. Southampton

Everard, M., Jones, L. and Watts, B., 2010. Have we neglected the societal importance of sand dunes? An ecosystem services perspective. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *20*(4), pp.476-487.

H R Wallingford(1995) *Poole Borough Coastal Strategy Study.* report EX3881. Report to Poole Borough Council, 112pp.

Hacker, S.D., Zarnetske, P., Seabloom, E., Ruggiero, P., Mull, J., Gerrity, S. and Jones, C., 2012. *Subtle differences in two non-native congeneric beach grasses significantly affect their colonization, spread, and impact. Oikos*, *121*(1), pp.138-148.

Hanley, M.E., Hoggart, S.P.G., Simmonds, D.J., Bichot, A., Colangelo, M.A., Bozzeda, F., Heurtefeux, H., Ondiviela, B., Ostrowski, R., Recio, M. and Trude, R., 2014. *Shifting sands? Coastal protection by sand banks, beaches and dunes*. *Coastal Engineering*, *87*, pp.136-146.

HR Wallingford. 2006. Be*ach Control Structures, Poole. Alternative coastal defence options, Sandbanks to Branksome Dene Chine*. Report EX 5200.

Martínez, M.L., Psuty, N.P. and Lubke, R.A., 2008. *A perspective on coastal dunes*. In *Coastal dunes* (pp. 3-10). Springer, Berlin, Heidelberg.

New Forest District Council (NFDC), 2017. 2*012 Update of Carter, D., Bray, M., & Hooke, J., 2004 SCOPAC Sediment Transport Study*, www.scopac.org.uk/sts.

Pye, K. and Neal, A., 1993. *Late Holocene dune formation on the Sefton coast, northwest England*. *Geological Society, London, Special Publications*, *72*(1), pp.201-217.

Pye, K., Saye, S. and Blott, S., 2007. *Sand dune processes and management for flood and coastal defence. Part 3: The geomorphological and management status of coastal dunes in*

England and Wales. Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme. Technical Report FD1302/TR.

Pye, K., Saye, S. and Blott, S., 2007b. *Sand dune processes and management for flood and coastal defence. Part 1: Project overview and recommendations. Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme*. Technical Report FD1302/TR.

Ritchie, W., 1972. *The evolution of coastal sand dunes*. *Scottish Geographical Magazine*, *88*(1), pp.19-35.

Robson, D. (2003) *Sandbanks Coast Protection*. Borough of Poole

UK Biodiversity Action Plan (UK BAP), 2008. *Priority Habitat Descriptions- Coastal Sand Dunes.*

West, Ian M. 2016. *The Sandbanks Sand Spit or Sandbanks Peninsula; Geology of the Wessex Coast*. Internet site: www.southampton.ac.uk/~imw/Sandbanks.htm. Version: 10th December 2016

Willis, A., 2001. *Braunton Burrows in context: a comparative management study*. *Coastal dune management: Shared experience of European conservation Practice*, p.65.