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Appendix C
Baseline Process Understanding

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POOLE & CHRISTCHURCH BAYS SMP2 Sub-cell 5f

Review of Coastal Processes and Geomorphology

Bournemouth Borough Council

October 2010
Report V3

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Poole & Christchurch Bays Shoreline Management Plan Review

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Glossary

This glossary of commonly used terms is provided to give explanations of the meaning of technical coastal processes terms throughout the SMP as well as more specifically in this document. It has been mostly compiled from the glossaries from two projects: Coastal Habitat Management Plans (Royal Haskoning *et al*., 2003) and Futurecoast (Halcrow, 2002), plus some additional entries to cover terminology specific to this report.

Accretion
The addition of newly deposited sediment vertically and/or horizontally.

Aeolian transport
The transport of sediment particles by wind.

Amphidromic point
The centre of an amphidromic system; a nodal point around which a standing-wave crest rotates once each tidal period.

Amphidromic system
A tidal system, usually in an enclosed basin, where the tidal wave crest moves around a fixed point during each tidal period.

Amplitude
Half the peak to trough range of a wave (water wave or sedimentary wave).

Astronomical tide
The predicted tide levels and character that would result from the gravitational effects of the earth sun and moon without any atmospheric influences.

Backshore
Area above high water that can be affected by coastal processes.

Bar
An elongate deposit of sand, shingle or silt, occurring slightly offshore from the beach. Sometimes the bar may be parallel and/or attached to the shoreline.

Bathymetry
Topography of the sea floor.

Beach
A deposit of non-cohesive material (e.g. sand, gravel) situated on the interface between dry land and the sea (or other large expanse of water) and actively ‘worked’ by present-day hydrodynamic processes (i.e. waves, tides and currents) and sometimes by winds.

Beach profile
Cross-section perpendicular to the shoreline. The profile can extend from any selected point on the backshore or top of the beach into the nearshore.

Beach recharge / replenishment

The process of using sediment sourced from elsewhere to replenish or supplement the existing sediment volume of a beach.

Bedforms
Features on the sea bed (e.g. sand waves, ripples) resulting from the movement of sediment over it.

Bedload
Sediment particles that travel near or on the bed.

Bed shear stress
The way in which waves and currents transfer energy to the seabed (and mobilise sediments).

Berm
A ridge located generally toward the rear of a beach, just above mean high water. It is marked by a break of slope at the seaward edge. Berms are often seasonal in position, with marked difference between a ‘winter berm’ and a ‘summer berm’.

Biogenic
Term applied to material, processes or activities of living or once-living organisms. Something is biogenic if it has more than 30% of material derived from organisms.

BP
Before Present – relates to dates before the present day.

Breakwater
A protective structure of stone or concrete used to break the force of waves, and afford protection from their erosive power.

CD
Chart Datum – a datum (or plane) of Lowest Astronomical Tide to which depths or heights are referred.

Clay
Fine-grained sediment with a typical particle size of less than 0.002 mm.

Climate change
Refers to any long-term trend in mean sea level, wave height, wind speed etc.

Closure depth
The depth that represents the ‘seaward limit of significant depth change’, but is not an absolute boundary across which there is no cross-shore sediment transport.

Coastal currents
Those currents that flow roughly parallel to the shore and constitute a relatively uniform drift in the deeper water adjacent to the surf zone. These currents may be tidal, transient, wind driven or associated with the distribution of mass in local waters.

Coastal defence
General term used to encompass both protection against coastal erosion and defence against flooding from the sea.

Coastal protection
Relates to the threat of erosion (but can also relate to wave overtopping or encroachment by the sea).

Coastal processes
Collective term covering the action of natural forces on the shoreline and nearshore sea bed.

Coastal squeeze
Narrowing of the intertidal zone due to the prevention of its natural landward migration in response to sea-level rise, e.g. by permanent barriers (human-built or natural).

Cohesive sediment
Sediment containing a significant proportion of clays, the electromagnetic properties of which causes the particles to bind together.

Coriolis effect
Apparent force acting upon moving particles resulting from the earth's motion. It causes moving particles to be deflected to the right in the northern hemisphere, and to the left in the southern.

Crest
Highest point on a beach face, bedform or wave.

Cross-shore
Perpendicular to the shoreline. Also referred to as shore normal.

Current
Flow of water generated by a variety of forcing mechanisms (e.g. waves, tides, wind).

Current meter
An instrument for measuring the velocity of a current.

Cuspate foreland
A large triangular area of coastal deposition, often characterised by many shingle ridges.

Datum
Any position or element in relation to which others are determined.

Deflation
The removal of material from a land surface by wind-driven processes.

Dispersion
The separation of waves by virtue of their differing rates of movement.

Distal end
The un-attached end of a Spit or Bar whose other end is attached to the shoreline at some point.

Diurnal

Having a period of a tidal day 24.84 hours.

Drift-aligned
A coastline that is orientated obliquely to prevailing incident wave fronts.

Dynamic equilibrium
A state of balance between environmental conditions acting on a landscape and the resisting earth material which themselves fluctuate around an average that is itself gradually changing.

Ebb tide
The falling tide, immediately following the period of high water and preceding the period of low water.

Embankment
A linear mound of earth that stretches some distance along the coast that protects the hinterland from flooding.

Embayment
A concave shoreline plan shape between rocky headlands, sometimes with only a narrow entrance.

Embryonic dunes
A mound of wind blown sand accumulating around the high water level and often colonised by pioneer vegetation.

Episodic
Composed of a series of discrete events rather than as a continual process.

Erosion
Wearing away of the land or sea bed by natural forces (e.g. wind, waves, currents, chemical weathering).

Eustatic
Changes in global sea-level caused either by tectonic movements or growth and decay of glaciers.

Extreme
The value expected to be exceeded in a given (long) period of time.

Fetch
Distance of water surface over which the wind acts to produce waves.

Flocculation
The change which takes place when the dispersed phase of a colloid (e.g. clay particles in suspension) forms a series of discrete particles which are capable of settling out from the dispersion medium (e.g. water).

Flood tide
The rising tide, immediately following the period of low water and preceding the period of high water.

Foreshore
A morphological term for the lower shore zone/area on the beach that lies between mean low and high water.

Glaciation
The covering of a landscape or larger region by ice; an ice age.

Glacial
Products of, or deposited by, or derived from a glacier.

GPS – Global Positioning System
A navigational and positioning system by which the location of a point on or above the earth can be determined by a special receiver at the point interpreting signals received simultaneously from a constellation of satellites.

Gravel
Loose, rounded fragments of rock larger than sand but smaller than cobbles. Material larger than 2 mm (as classified by the Wentworth scale used in sedimentology).

Greenhouse effect
The absorption and re-emission of infrared radiation, emitted from the earth, by Greenhouse gases, acting to warm the atmosphere. This is a naturally occurring process, but the levels of warming change with atmospheric greenhouse gas concentrations.

Greenhouse gas
There are several greenhouse gases. The most significant is naturally occurring water vapour. Second most important is carbon dioxide (CO_2), which is naturally occurring but also released by human activities.

Groyne
Coastal defence structure constructed perpendicular to the shore and designed to reduce the longshore sediment transport on a beach.

Gyre
A type of swirling, spiralling current. Ocean gyres can occur at many different scales, from large open ocean gyres, to small, localised gyres within a coastal bay.

Habitat
The environment of an organism and the place where it is usually found.

Headland
Hard feature, natural or artificial, forming the local limit of the longshore extent of a beach.

High water
Maximum level reached by the rising tide.

Hinterland

The land directly adjacent to and inland from a coast, extending landward from the upper limit of extreme wave and tidal energy.

Holocene
The last 10,000 years of earth history.

Hydrodynamic
The process and science associated with the flow and motion in water produced by applied forces.

Interglacial
Period of warmer climate that separates two glacial periods.

Intertidal
Area on a shore that lies between Lowest Astronomical Tide (LAT) and Highest Astronomical Tide (HAT).

Isobath
Lines connecting points of equal water depth, sea bed contours.

Isostatic
Vertical movements of the earth's crust in response to changes in the forces applied to it, e.g. as an ice sheet grows the crust is depressed, then as the ice sheet melts, and the weight is reduced, the crust rebounds.

Laminar flow
Smooth non-turbulent flow of fluid, characteristic of low fluid flow velocities and particles of sediment in the flow zones are moved by rolling or saltation.

Landslide
The large-scale mass movement of sub-aerial material down slope, or its vertical movement down a cliff face.

LAT
Lowest Astronomical Tide (CD).

LiDAR (Light Detection And Ranging)
A survey technique/system for deriving topography and elevation of the land (and sometimes bathymetry). It employs a laser and receiving unit generally located upon a stable fixed wing aircraft platform. Ground based LiDAR systems also exist and are often used for surveying areas where sharp changes in relief occurs (such as near vertical coastal cliffs).

Lithology
The description of the macro features of a rock or rock-type.

Littoral
Of or pertaining to the shore.

Littoral Drift (also referred to as longshore transport)
The movement of sediment approximately parallel to the shoreline.

Log Spiral Bay
Log spiral bays (or beaches) are created due to the presence of sheltering headlands and the refraction and diffraction caused to waves by those headlands. The refracting and diffracting waves fan out as they approach the shoreline and cause it to develop a plan form associated with a log spiral. These bays are also commonly referred to as crenulate or headland bays and are often associated with swell dominated coastlines

Longshore
Applied to sediment transport and involving the area immediately adjacent to and parallel with the coastline.

Longshore current
A current located in the surf zone, moving generally parallel to the shoreline that is generated by waves breaking at an angle with the shoreline.

Longshore transport rate
Rate of transport of sedimentary material parallel to the shore. Usually expressed in cubic metres per year.

Long-term
Refers to a time period of decades to centuries.

Low water
The minimum height reached by the falling tide.

Managed realignment
The setting back of existing coastal defences in order to achieve environmental, economic and/or engineering benefits. Typically being undertaken in estuarine systems to combat the issue of coastal squeeze.

M_2
The main lunar semi-diurnal constituent of the tide.

Macro-tidal
Greater than 4 m tidal range.

Mean water level
The average level of the water over the time period for which the level is determined.

Mean sea level
The average level of the sea over a period of approximately 12 months, taking account of all tidal effects but excluding surge events.

Medium-term
Refers to a time period of decades.

Megaripples
Bedforms with a wavelength of 0.6 to 10.0 m and a height of 0.1 to 1.0 m. These features are smaller than sand waves but larger than ripples.

Meso-tidal
2 to 4 m tidal range.

MHW
Mean High Water.

Micro-tidal
Less than 2 m tidal range.

MLW
Mean Low Water

Morfa
A feature that develops, or sediment accumulations which occur, as a result of the influence of processes at an estuary mouth.

Morphodynamics
The mutual interaction and adjustment of the seafloor topography and fluid dynamics involving the motion of sediment.

Multi-recurved
Describes the distal end of a Spit (such as Hurst Spit) which has systematically curved round on itself in response to forcing from waves and currents.

Neap Tide
A tide that occurs when the tide-generating forces of the sun and moon are acting at right angles to each other, so the tidal range is lower than average.

Nearshore
The zone which extends from the swash zone to the position marking the start of the offshore zone (~20m).

Ness
Roughly triangular promontory of sand or shingle jutting into the sea, often consisting of mobile material e.g. shingle.

Numerical modelling
Refers to the analysis of coastal processes using computational models.

OD
Ordnance Datum – a specific datum or plane to which depths or heights are referred to.

Offshore
Area to seaward of nearshore in which the transport of sediment is not caused by wave activity.

Overtopping
The process where water is carried over the top of an existing defence due to wave activity.

Pleistocene

An epoch of the Quaternary Period (between *c.* 2 million and 10,000 years ago) characterised by several glacial ages.

Pocket beach
Small beach comprised of either sand or shingle that commonly has headlands on either side preventing longshore drift.

Post-glacial
The period of time after the withdrawal of the last ice sheet.

Progradation
The outward building of a sedimentary deposit, such as the seaward advance of a shoreline.

Progressive wave
A wave that is manifested by progressive movements of waveforms.

Quaternary Period
The last 2 million years of earth history incorporating the Pleistocene ice ages and the post-glacial (Holocene) Period.

Reef
A submerged feature which can be either naturally occurring due to bedrock geology or manmade as a form of coastal defence (and in some cases as 'recreational' surfing reefs). A reef will cause waves to break due to its elevation being higher than the seabed around it. Some reefs can be exposed at low tide.

Refraction (of water waves)
The process by which the direction of a wave moving in shallow water at an angle to the contours is changed so that the wave crests tend to become more aligned with those contours.

Regression
The horizontal movement of a shoreline in a seaward direction as result of a relative fall in sea level.

Relative sea-level
Mean sea-level relative to the land, taking account of both isostatic and eustatic components.

Relict
Features or sediment formed or deposited by processes no longer active in the area.

Residual water level
The components of water level not attributable to astronomical effects.

Return period
In statistical analysis, an event with a return period of *N* years is likely, on average, to be exceeded only once every *N* years.

Ripple

Undulations in the sediment surface produced by fluid movement. Oscillatory currents (e.g. wave currents) produce symmetric ripples whereas a well defined current direction produces asymmetric ripples.

Rock platform
Gently seaward sloping, intertidal bench cut into the land mass by the action of waves and also known as a wave-cut platform.

Runnels
Linear depressions on shallow foreshores separated by low broad ridges (swash bars).

Run-up
The rush of water up a structure or beach as a result of wave action.

S_2
The main solar semi-diurnal constituent of the tide.

Salient
An accumulation of sediment extending seawards towards an island breakwater or other obstruction, but not connecting to it.

Saltation
A term used to describe the movement of a particle being transported that is too heavy to remain in suspension. The particle is rolled forward by the current, generates lift and rises, loses the forward momentum and settles to the bed.

Sand
Sediment particles, mainly of quartz with a diameter of between 0.063 mm and 2 mm. Sand is generally classified as fine, medium or coarse.

Sand wave
Bedforms with wave lengths of 10 to 100 m, with amplitudes of 1 to 10 m.

SAR (Synthetic Aperture Radar)
Satellite based survey system, which employs an active radar system to derive topography and elevation of the land.

Sea defence
Construction engineered to reduce or prevent flooding by the sea.

Sea level or Mean sea-level
Generally refers to 'still water level' (excluding wave influences) averaged over a period of time such that periodic changes in level (e.g. due to the tides) are averaged out.

Sea-level rise
The general term given to the upward trend in mean sea level resulting from a combination of local or regional geological movements and global climate change.

Sediment
Particulate matter derived from rock, minerals or bioclastic matter.

Sediment sink

A point or area at which sediment is irretrievably lost from a coastal cell or transport pathway, such as an estuary or a deep channel in the sea bed.

Sediment source
A point or area from which sediment arises such as an eroding cliff or river mouth.

Sediment transport
The movement of a mass of sedimentary material by the forces of currents and waves.

Semidiurnal
Having a period of approximately one half of a day (12.4 hours). The predominant type of tide throughout the world is semidiurnal with two high waters and two low waters each day.

Shallow water
Commonly, water of such depth that surface waves are noticeably affected by bottom topography. It is customary to consider water of depths less than half the surface wave length as shallow water.

Shingle
Gravel-sized beach material normally well rounded as a result of abrasion.

Shingle ridge
Feature of the upper beach, comprising built up deposits of shingle often fronting lower lying backshore.

Shoreface
The subtidal zone (extending from below mean low water and to about 10 to 20 m depth), where sedimentary processes are governed by wave action.

Short-term
Refers to a time period of months to years.

Significant wave height
The average height of the highest of one third of the waves in a given sea state.

Silt
Sediment particles with a grain size between 0.002 mm and 0.063 mm, i.e. coarser than clay but finer than sand.

Slack water
The state of the tidal current when its velocity is virtually zero, particularly when the reversing current changes direction.

Sorting
Process of selection and separation of sediment grains according to their particle size (or shape, or specific gravity).

Spit

Narrow accumulation of sand or shingle generally lying parallel to the coast with one end attached to the land and the other projecting seawards, often formed across the mouth of an estuary.

Spring tide
A tide that occurs when the tide-generating forces of the sun and moon are acting in the same directions, so the tidal range is higher than average.

Standing wave
Type of wave in which the water surface oscillates vertically between fixed points (called nodes) without progression.

Still-water level
Water level that would exist in the absence of waves.

Storm beach deposits
An accumulation of coarse sediments that are deposited on a beach above the high-water mark by high water levels brought about by storm action. This accumulation often forms a ridge or beach berm.

Storm surge
A rise in water level on the open coast due to the action of wind stress as well as atmospheric pressure on the sea surface.

Surf zone
The nearshore zone along which waves become breakers as they approach the shore.

Surge
Changes in water level as a result of meteorological forcing (wind, high or low barometric pressure) causing a difference between the recorded water level and the astronomical tide predicted using harmonic analysis.

Suspended load
The material moving in suspension in a fluid kept up by the upward components of the turbulent currents or by the colloidal suspension.

Swash-aligned
A coastline that is orientated parallel to prevailing incident wave fronts.

Swash bars
Low broad ridges separating linear depressions (runnels) on shallow foreshores. Formed by sediment movement in the surf and swash zones.

Swash zone
The area onshore of the surf zone where the breaking waves are projected up the foreshore.

Swell (**waves**)

Wind-generated waves that have travelled out of their generating area. Swell characteristically exhibits a more regular and longer period and has flatter crests than waves within their fetch.

Talus slope
Cliff slope consisting of rock fragments, also referred to as a scree slope.

Terrigenous sediment
Particles and deposits derived from the land.

Threshold velocity
The minimum velocity at which the sediment on the bed becomes mobile.

Tidal current
The alternating horizontal movement of water associated with the rise and fall of the tide.

Tidal prism
The amount of water that enters and exits an estuary every flood and ebb tide respectively.

Tidal range
Difference in height between high and low water levels at a point.

Tide
The periodic rise and fall of the water that results from the gravitational attraction of the moon and sun acting upon the rotating earth.

Till
Poorly-sorted, non-stratified and unconsolidated sediment carried or deposited by a glacier.

Tombolo
An accumulation of sediment extending from the shore to an offshore island, formed by the deposition of material when waves are refracted / diffracted around the island.

Transgression
The horizontal movement of a shoreline in a landward direction as result of a relative rise in sea level.

Wave climate
Average condition of the waves at a given place over a period of years, as shown by height, period, direction etc.

Wave height
The vertical distance between the crest and the trough.

Wave length
The horizontal distance between consecutive wave crests.

Wave period
The time it takes for two successive crests (or troughs) to pass a given point.

Wind current
A current created by the action of the wind on the water surface.

Wind set-up
Elevation of the water level over an area caused by wind stress on the sea surface.

PREFACE

The Shoreline Management Plan (SMP) Review for Poole and Christchurch Bays will review and assess all the policies and recommendations set out in the first SMP produced ten years ago. The new SMP2 aims to set high-level strategic policy for coastal erosion and flood risk management, through the development of a well-researched and considered document. The principal objective is policy setting that promotes sustainable management of erosion and flood risks over the next 100 years and assists with adaptation to the effects of climate change.

An important aspect of the SMP Review is the production of a number of technical reports, which underpin and support the development of policies. This report – the 'Coastal Processes Review' is one of these documents and is an important part of the work undertaken during Stage 2 of the SMP2 development (Defra 2006).

Scope of the coastal processes review

This document reviews the coastal processes and geomorphology for Poole and Christchurch Bays, it draws together the outputs and conclusions from a range of key texts and sources, analyses and studies. It presents important baseline understanding that underpins the technical development of policies within the Shoreline Management Plan (SMP) in a form that is accessible to a non-technical audience.

The review draws directly from a number of high-level reports such as SMP1, Futurecoast, and other regional studies, providing an overview of the current understanding in relation to the needs of the SMP2 analysis. The review also adds any subsequent information in confirmation or clarification to the areas of continued uncertainty. This includes reference to Hengistbury Head, although this particular feature is dealt with in more detail within Annexe IV of Appendix C. The review does not undertake any new analyses or quantification related to the coastal processes. Rather the review uses previous analysis to provide a coherent description of the overall pattern of coastal behaviour.

This coastal processes review document is structured as follows:

Section 1 provides a review of available literature and information, identifies key texts and information sources and how and where these have been used.

Section 2 considers and describes the broad scale background to the coast, discussing the interaction between the open coastline, the underlying geology and the nearshore area. This highlights the major sediment sources, pathways and sinks, and their driving forces such as waves, tides and currents, and the resulting historical changes and current geomorphological form.

Section 3 considers the more localised shoreline processes in the context of the broader scale understanding developed in *Section 2.* For this, the SMP sub-cell 5f frontage has been divided into a further division of six 'process units'. These are:

- *Hurst Spit to Hengistbury Head (Christchurch Bay)*
- *Christchurch Harbour**
- *Hengistbury Head to Handfast Point (Poole Bay)*
- *Poole Harbour**
- *South Haven Point to Handfast Point (Studland Bay)*

- *Handfast Point to Durlston Head (Swanage)*

*Christchurch Harbour and Poole Harbour are briefly mentioned here but are considered in more detail as part of the baseline Estuary Processes Assessment (Annexe II). This review also incorporates information from the Estuary Strategy Studies for the area. A review of the estuary strategies in relation to potential impact of the coastal regime has been undertaken and is reported, in a format recommended by the SMP2 Procedural Guidance, as a separate appendix.

It should be noted that the general protocol and nomenclature for the geographical describing of SMP frontages in England and Wales, uses a north to south, east to west and then south to north approach (one could term it 'clockwise') starting from the north east coast of England and working around to the north west coast). For Poole and Christchurch, this means the coast is described in an east to west direction. This may not fit well with the general understanding of processes that work predominantly in the opposite direction, i.e. west to east, for this SMP. However, in order to provide consistency at a national level and to also correlate with the abutting sections from the adjoining Shoreline Management Plans (the West Solent SMP to the east and the South Devon and Dorset SMP to the west), this description follows the east to west nomenclature.

1 INTRODUCTION

1.1 Review of literature and information

The first Shoreline Management Plan (SMP1) was produced in 1999, drawing on an already considerable body of work that existed for the area. It was recognised prior to and during the development of the SMP1 that due to the complex nature of the coast there remained a high degree of uncertainty associated with coastal processes and geomorphological evolution. Therefore an important aspect of the intervening time period between SMP1 and SMP2 was to address those gaps in knowledge.

Following the SMP1, strategy studies have been completed for Poole Harbour (2003), Durlston Bay (2005), Bournemouth (2004) and Purbeck (2007). An ongoing strategy study is underway for Christchurch Bay but this has not yet reached completion. There have also been additional local investigations and project based studies covering key parts of this coastline.

In considering both the broadscale and localised coastal processes for this review, two key texts have been extensively utilised:

1. Futurecoast, produced by Halcrow on behalf of Defra in 2002, was specifically designed to inform SMP2s. Futurecoast is a broad-scale assessment of the coastal processes and geomorphology of the coast of England and Wales. It identifies the historical and contemporary evolution of the coastline and provides an assessment of how the coast will evolve over the next 100 years.

2. Following the production of Futurecoast, in 2004 the Standing Conference on Problems Associated with the Coastline (SCOPAC) delivered an updated version of their 1991 Sediment Transport Study for the central-southern coast of England. This updated study was undertaken on behalf of SCOPAC by the Rivers and Coastal Environments Research (RACER) department of the University of Portsmouth. David Carter and Dr Malcolm Bray were principally responsible for producing this work and much of the current understanding presented in this document is thanks to their great depth and breadth of local knowledge. The study provides an additional layer of detail for the sub-cell 5f SMP frontage to that provided by Futurecoast and allows a more detailed description of individual process units to be given. All Figures showing sediment transport have been reproduced directly from this study.

In addition to the two key texts identified above, extensive reference has also been made to the outputs from the Channel Coastal Observatory (CCO) and the South-east Strategic Regional Coastal Monitoring Programme, which has been running since 2002. Data outputs from this programme include topographic beach profiles, wave climate statistics, aerial photography, LiDAR and detailed nearshore bathymetry. Annual reports bring these data together into concise documents designed for use by Local Authority coastal engineers and coastal managers. The work undertaken by the CCO, and in particular Professor Andrew Bradbury and Dr Travis Mason, has further developed the understanding of this coastline and in particular the ongoing geomorphological response of the beaches and cliffs to the forcing energies of waves and tides.

The outputs from the long-running Bournemouth Borough Council (BBC) monitoring programme are also highly valuable and relevant to this study, particularly the reports and interpretations of the data produced by Dr David Harlow and other members of the BBC coast protection team. This work has made a very important contribution to the understanding of local coastal processes and morphological trends over time. It also gives a valuable indication of the performance of sea and coastal defences.

All studies and plans published since the publication of the SMP1 in 1999 are detailed in Tables 1.1 to 1.5. These include collected data and mapping studies. They are included at the end of this document.

1.2 Extent and Scope

The SMP2 sub-cell 5f covers the extent of coast from Hurst Spit in the east through to Durlston Head in the west, a coastline of some 130km including Poole and Christchurch harbours. Much of this linear distance is contained within Poole Harbour and the open coastline, (excluding the waterfronts of Poole and Christchurch Harbours) and is approximately 48km long. Figure 1.2 shows the SMP2 coastline chainage (distance from origin) working from Hurst Spit westwards.

The coast in this sub-cell comprises four well-defined open coast bays:

- Christchurch Bay
- Poole Bay (including Studland Bay)
- Swanage Bay
- Durlston Bay

The sub-cell contains four significant river catchments, containing the following watercourses:

- Beckton Bunny and Walkford Brook discharging into Christchurch Bay
- The River Mude, River Avon, River Stour and Bure Brook discharging into Christchurch Harbour;
- The Bourne Stream discharging into Poole Bay at Bournemouth;
- Branksome Chine discharging into Poole Bay at Branksome Chine Beach;
- The River Corfe, River Piddle, River Sherford and the River Frome discharging into Poole Harbour;
- Swan Brook and Ullwell Stream discharging into Swanage Bay.

The most significant of these watercourses are the River Mude, River Avon, River Stour, River Frome, River Piddle and the River Sherford.

Other significant physical features in this area are North Head Shoal, Dolphin Bank and Shingles Bank, which act as sediment sinks.

The key locations, features and the sub divisions of the SMP frontage that are referred to in this report are shown in Figure 1.2. It is important to note that the initial sub division provided by SMP1 was into seven conceptual process units of Christchurch Bay, Christchurch Harbour, Poole Bay, Poole Harbour, Studland Bay, Swanage Bay and Durlston Bay. This has since been subdivided by other studies reflecting improved understanding of coastal behaviour or the specific intent of the different studies

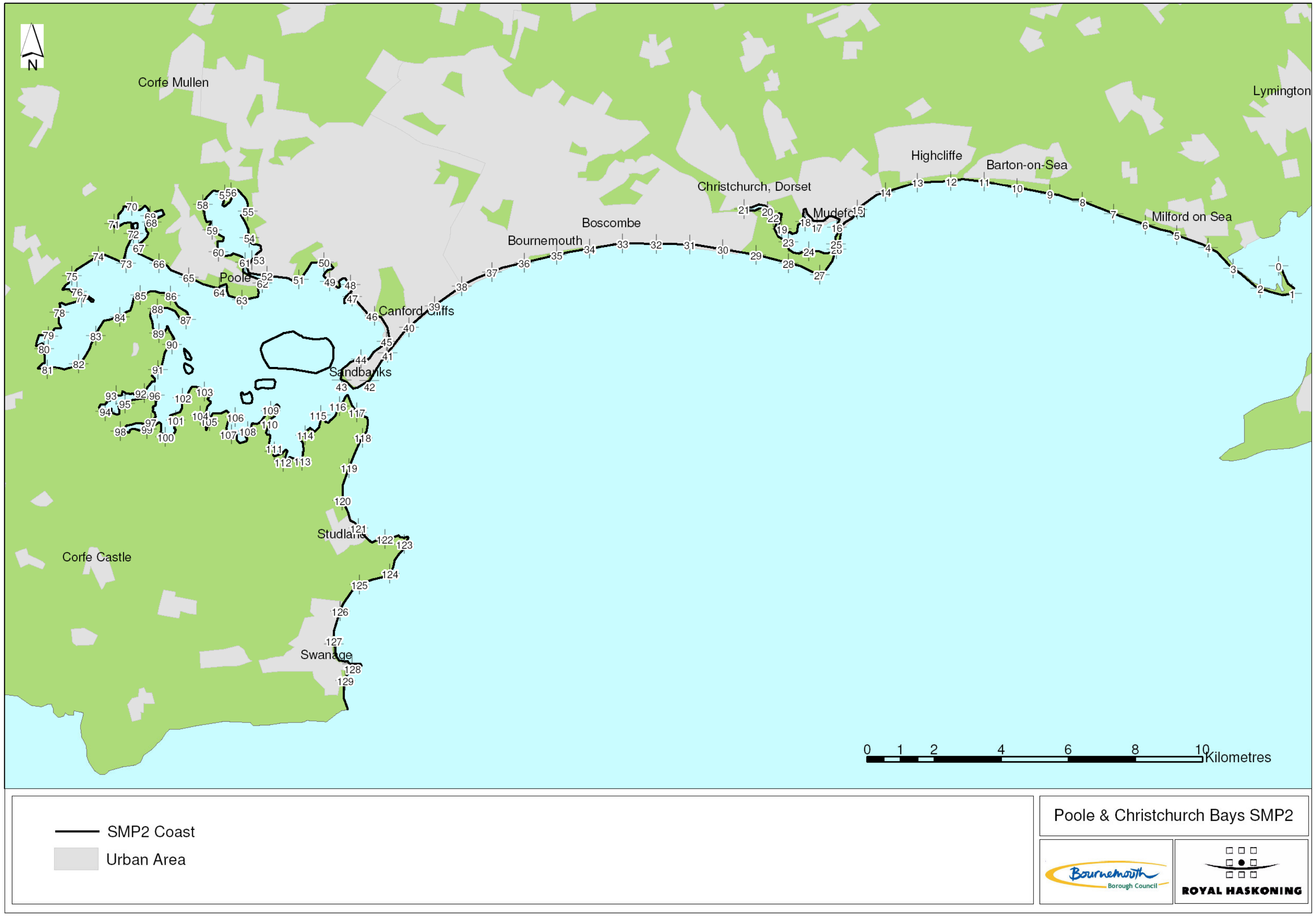
N
Corfe Mullen
Lymington
Highcliffe
Barton-on-Sea
Christchurch, Dorset
Mudeford
Milford on Sea
Boscombe
Bournemouth
Poole
Canford Cliffs
Sandbanks
Studland
Corfe Castle
Swanage
0 1 2 4 6 8 10 Kilometres
SMP2 Coast
Urban Area
Poole & Christchurch Bays SMP2
Bournemouth Borough Council
ROYAL HASKONING

Figure 1.1 SMP2 coastline for Poole and Christchurch bays, showing chainage and main urban areas.

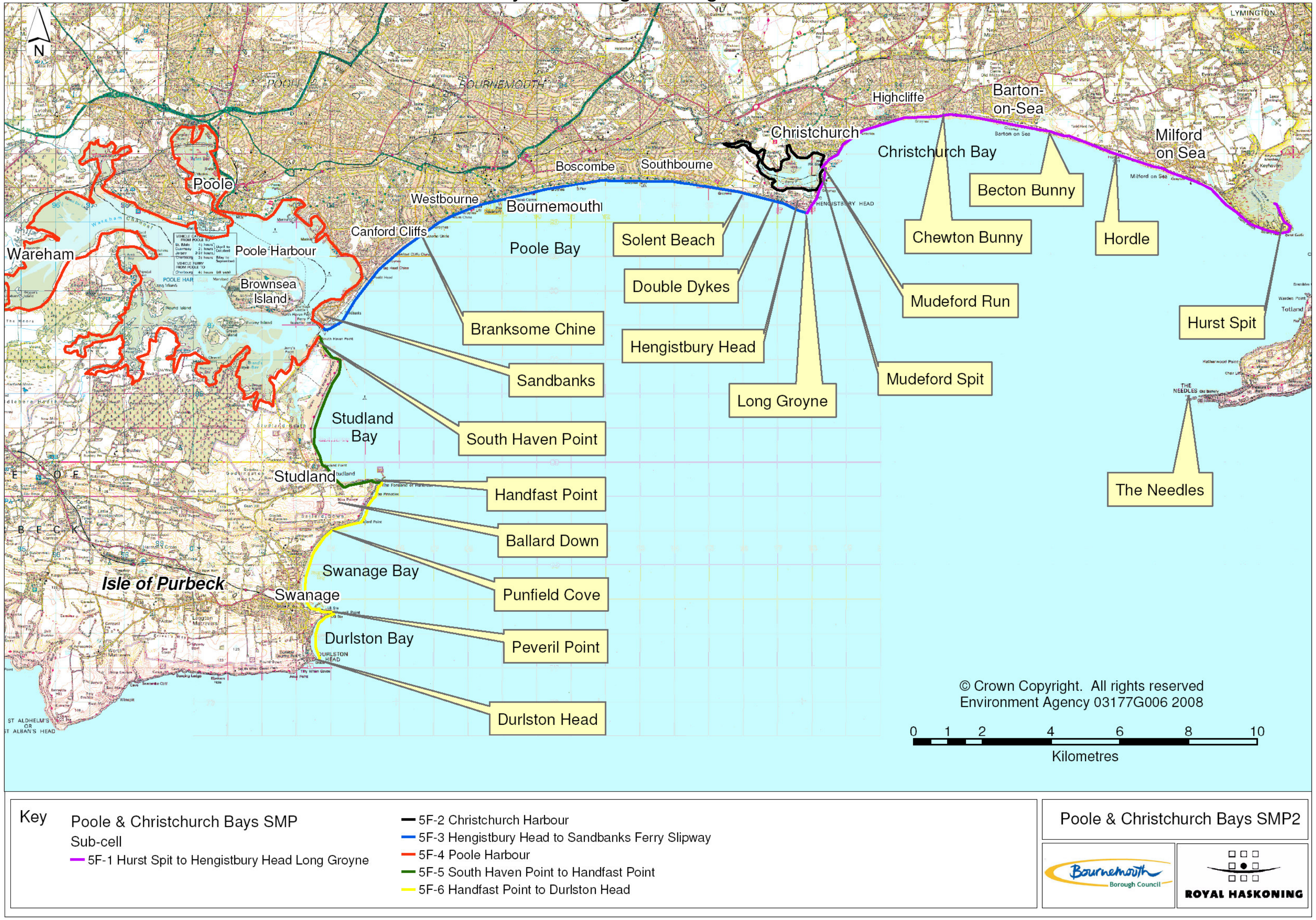

Figure 1.2 Poole & Christchurch Bays SMP frontage and process units showing key open coast locations

2 COASTAL DESCRIPTION AND OVERVIEW

Section 2 provides a general overview of the nature and characteristics of the Hurst Spit to Durlston Head coastline. It identifies the important coastal landforms and features within the SMP frontage and describes the shoreline processes that have influenced and shaped the present day coastline.

2.1 Summary Points

Section 2.1 gives a series of points aimed at providing the reader with an instant overview of the characteristics of the SMP coast and its principal features and processes.

- The shoreline of sub-cell 5f is situated within the central south coast of England, due west of the Solent River and the Isle Wight. The shoreline principally comprises cliffs and gravel and sand beaches. There are also areas of mature sand dunes, some fixed, some more dynamic and mobile. Heavily developed urban frontages also dominate some parts of the frontage, particularly around the Bournemouth area. A variety of manmade defences exist across all the frontages and in recent years sand and shingle replenishment works have formed an important part of the management regime.

- There are four well-defined open coast bays contained within the frontage:

    - Christchurch Bay
    - Poole Bay (including Studland Bay)
    - Swanage Bay
    - Durlston Bay

- There are two natural sheltered harbours contained within the SMP frontage – Christchurch Harbour and Poole Harbour (Poole Harbour being much the larger of the two). Both harbours are protected by spits, which form a harbour mouth. These spits have had an historical tendency to migrate, but are now fixed with defences. Both harbour mouths are maintained and periodically dredged.

- Poole Harbour contains a number of islands within its boundary, the largest and most prominent of which is Brownsea Island. Other Islands include Furzey Island, Green Island, Long Island and Round Island. Brownsea is predominantly owned by the National Trust (the John Lewis Partnership own the castle on Brownsea) and contains important examples of both the natural and historical environment. Brownsea Island is a very dominant feature within Poole Harbour and its proximity to the mouth of the Harbour links it closely to the behaviour of the two spits.

- Separating and marking the boundaries of the bays are a series of important, controlling natural geomorphological coastal features. Collectively these features dictate the shape of the coastline and separate the harbours from the open coast. From east to west these are:

    - Hurst Spit
    - Mudeford Spit
    - Hengistbury Head
    - Sandbanks Spit

- South Haven Peninsula
- Handfast Point (the Foreland)
- Peveril Point
- Durlston Head

- There are also a number of important controlling manmade structures positioned along the shoreline, which assist in dictating the movement and retention of sediment. Poole, Swanage and Christchurch Bays have defences; mostly groynes to trap sediment, while Durlston and Studland Bays are predominantly undefended. Poole Harbour has coastal defences along its northern side, and the southern side is undefended. A detailed review and condition assessment of these defences is given in the Defences Assessment Review (Appendix C, Annexe III). The Long Groyne at Hengistbury Head is a particularly influential single structure within the SMP frontage. Other influential structures include the training banks situated around the mouth of Poole Harbour.

- Offshore bathymetric features also have a strong influence of the shoreline position and plan form of the coast through the influence they exert on incoming waves. There are inshore banks located within the 10m contour and sand deposits found in 10m and 20m depths, such as Dolphin Sands. Other important bathymetric features are Christchurch Ledge, Shingles Bank, Dolphin Bank (Christchurch Bay) and Hook Sand (Poole Bay) (see Figures 2.13 and 3.1). Sediments are generally in the form of gravels, with localised deposits of sand, gravely sand, rocks and pebbles.

- The dominant wave direction is from the south to south-west, which corresponds with the direction of longest fetch and longer period swell waves originating in the Atlantic Ocean. Shorter period wind waves from the east and south-east are less frequent although significant storms do occur from this direction.

- The tidal range is generally small across the entire SMP frontage and decreases from west to east. The tidal range of Christchurch Bay is the lowest on the south-central channel coast with a tidal range at its mouth of 1.4m during springs and 0.8m during neaps. The tidal curve is very distorted by shallow water effects along most of the SMP frontage, producing a double high water between Swanage and Christchurch.

- Waves and tides are the dominant sediment transport mechanisms along this frontage. The low tidal range tends to concentrate wave energy (and therefore littoral drift) into a narrow nearshore zone. Sediment is mainly transported from west to east, in response to the dominant wave direction although some localised sediment transport reversal has been observed in Poole Bay due to tide and wind/wave forcing. Tidal currents are generally not strong enough to transport significant amounts of sediment in isolation, however they will combine with wave induced currents to assist in the general west to east littoral transport of sediment. Tidal currents also assist in the net offshore movement of finer sediments, leaving coarser grains inshore.

- The infrequent storms from the east and south-east can mobilise large amounts of sediment in very short periods and transport it offshore.

- There is a localised gyre (a type of rotating current) off Sandbanks, which is clockwise in direction and is responsible for the deposition of sediment at Hook Sand, just north of the entrance channel to Poole Harbour. Both Harbours demonstrate ebb dominated tidal regimes. This dictates that the net transport of sediment tends to occur out to the seaward side of the harbour mouths.

- Hengistbury Head plays an important role in stabilising the plan shape of Poole and Christchurch Bays. It also shelters Christchurch Harbour from wave action. Handfast Point (also known as The Foreland), Peveril Point and Durlston Head help form Studland Bay, Swanage Bay and Durlston Bay respectively.

- There is a perceived threat of breaching at Double Dykes (Hengistbury Head) and at Studland Bay, both low-lying and highly susceptible to erosion. Historically, both Mudeford Spit and Hurst Spit have been breached, prior to intervention with defences.

2.2 Geology and coastal evolution

The present day coastline, has been very much shaped by a process of glaciation and the rising and falling sea levels associated with these climatic episodes. Three periods of glaciation have occurred during the recent geological timescale, but it was the final period of glaciation and the eventual retreat of the icecap around 9000 years ago, which led to rising sea levels and the breaching of an extensive chalk ridge, which ran westwards from The Needles (Isle of Wight) to Ballard Down. As a result of this breaching, over 220 km^2 of land has been eroded (Harlow 2005), leading to the present plan form and configuration of the Poole and Christchurch Bays frontage.

Human intervention in the last 100 years or so has further modified the configuration of the Bays. Hard engineered coast protection structures and sea defences, plus the replenishment of beach material, continue to artificially hold the frontage in a 'stable' form.

In geological terms, soft Tertiary sands and clays underlay the coastal zone from the eastern boundary of the SMP (Hurst Spit) through to Studland (Futurecoast 2002). From Studland through to Durlston Head, the geology becomes more resistant, with limestones and chalks present. Shingle deposits supported by clay form the eastern end of the frontage (Hurst Spit). The Tertiary cliffs begin at Milford-on-Sea reaching heights of 35m at Barton on Sea and 36m at Warren Hill (Hengistbury Head).

Hengistbury Head exerts control on the plan forms of both Christchurch and Poole Bays, although it is a relatively soft geological feature. Its resistance to coastal erosive forces is attributed primarily to the presence of ironstone nodules (the focus of previous mining activities). These nodules lend resistance to what is otherwise a rather un-resistant feature comprised mainly of unconsolidated, erodable material (Futurecoast 2002).

The Tertiary cliffs at Hengistbury Head are primarily composed of Barton Clay, Hengistbury Beds, with overlying Boscombe Sands. These deposits are capped by Plateau Gravels. This formation continues west into Poole Bay and toward Bournemouth and Poole where the cliffs are formed of Eocene sands and clays.

The geology of Swanage Bay comprises Wealden beds of sands and clays, while the shoreline is primarily comprised of chalk. The Wealden beds have eroded more rapidly than the resistant headlands of Ballard Point and Peveril Point. South of Swanage Bay the geology becomes more resistant, with Jurassic Limestones of the Portland and Purbeck beds present. Durlston Bay itself has been created by the erosion of softer clays that emerge at the shoreline.

During the Pleistocene, rising sea levels caused significant cliff and shoreline erosion within Christchurch and Poole Bays, which liberated very large amounts of sediment into the nearshore system. This, together with sediment released by tidal scour of the western approaches to the Solent, is thought to have been transported eastwards by littoral drift to form Hurst Spit (in a range of different forms before reaching its current form).

2.3 Geomorphology

Figure 2.1 below, which is derived from satellite SAR data shows the general topography of the coastline. The low-lying areas around the mouth of the Solent and Hurst Spit, Christchurch Harbour and Poole Harbour can be clearly seen. Higher topography dominates along the Barton on Sea, Bournemouth, Swanage and Durlston frontages.

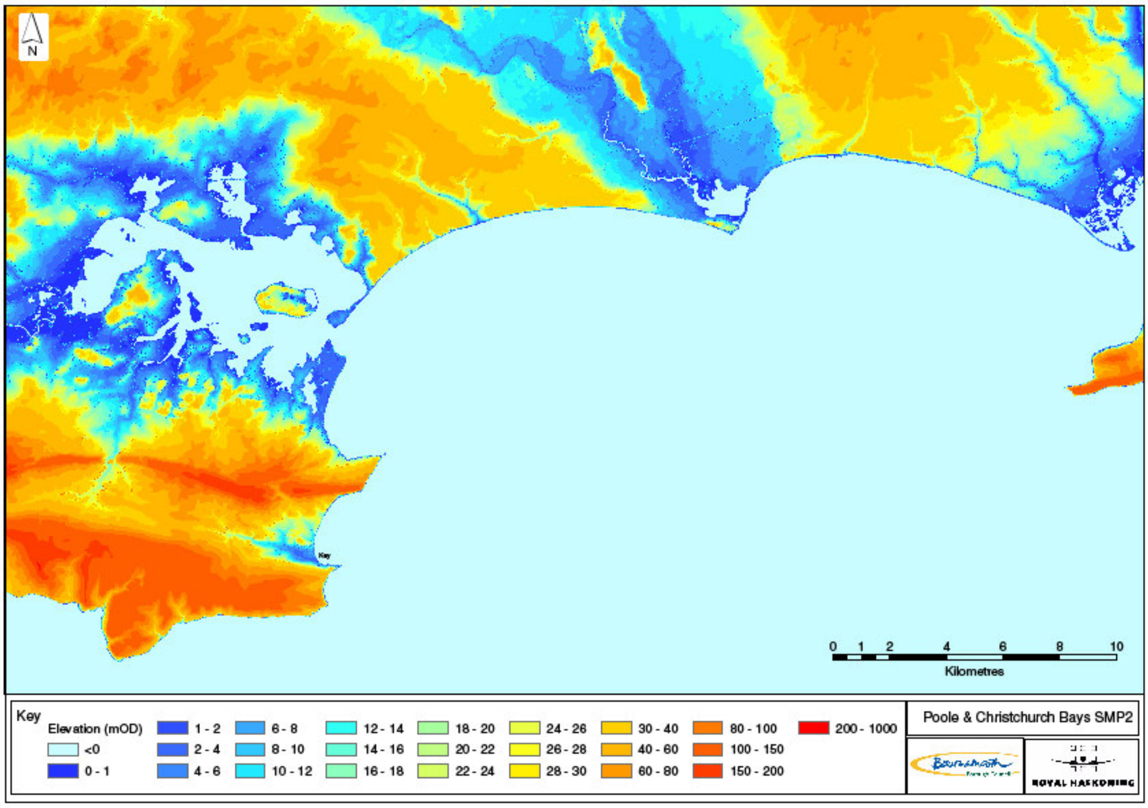

Figure 2.1 Topography of the Poole and Christchurch SMP frontage (derived from SAR)
(Source: Environment Agency)

Bays

First inspection of the SMP shoreline immediately reveals that there are four well-defined open coast bays (as noted in the summary above) contained within the frontage that dominate the overall plan form. These are:

- Christchurch Bay
- Poole Bay (including Studland Bay)
- Swanage Bay
- Durlston Bay

All of these bays are well-defined ***log spiral bays***. Log spiral bays (or beaches) are created due to the presence of sheltering headlands and the refraction and diffraction caused to waves by those headlands. The refracting and diffracting waves fan out as they approach the shoreline and cause it to develop a plan form associated with a log spiral. These bays are also commonly referred to as crenulate or headland bays and are often associated with swell dominated coastlines (and often where there is one dominant angle of wave approach, whether shore normal or oblique).

It is generally thought that the bays are still adjusting their shape following the breaching of the former chalk ridge that extended between the Isle of Wight and Ballard Down on the Isle of Purbeck, as mentioned above.

Natural Harbours

There are two natural sheltered harbours contained within the SMP frontage; Christchurch Harbour and Poole Harbour. The two harbours account for approximately 100km of shoreline and as such they are very important within the overall scope of the SMP.

Poole Harbour is a large relatively shallow inlet with extensive areas of intertidal mudflat and upper saltmarsh, providing a natural transition to the gradually rising land around the periphery. The north-eastern side of the estuary is now quite heavily developed including areas of reclaim. The Harbour is fed by the River Corfe, River Piddle, River Sherford and the River Frome.

Figure 2.2 Aerial photo of Poole Harbour mouth
(Source: Channel Coastal Observatory)

Poole Harbour contains a number of islands within its boundary, the largest and most prominent of which is Brownsea Island, located in the eastern part of the Harbour, close to the mouth. Brownsea Island is owned by the National Trust (with the exception of the castle, which is owned by the John Lewis Partnership) and contains important examples of both the natural and historical environment. Figure 2.2 shows Poole Harbour Mouth, including Sandbanks Spit, Brownsea Island, Furzey Island (and the Goathorn Peninsula to the south-west) and the northern tip of the Studland Peninsula. Other Islands within Poole Harbour include Green Island, Long Island and Round Island.

Christchurch Harbour is the estuary of the Stour and Avon rivers, and is effectively a wide and shallow lagoon. Its mouth is formed from two sand and gravel spits, with a narrow, maintained entrance (see Figure 2.3 below). The spits were naturally mobile features, with a history of growth and breakthrough, although Mudeford Spit is currently fixed by groynes and Mudeford Quay is heavily modified and fixed in position. There are extensive mudflats and saltmarshes although the upper parts of the estuary which have been reclaimed - this has limited the estuary volume. The estuary is ebb dominant, which helps keep the estuary clear of sediment deposition, and a maximum flow ratio is high enough to form a plume at all stages of the tide. This dictates a net movement of transport outside of the Harbour mouth through the Mudeford Run.

Figure 2.3 Christchurch Harbour Mouth showing Mudeford Spit (bottom centre) and Mudeford Quay.
(Source: Channel Coastal Observatory)

Both harbours are protected by spits, which form a harbour mouth. These spits have had an historical tendency to migrate, but are now fixed with defences. Both harbour mouths are maintained and Christchurch Harbour mouth is periodically dredged.

Headlands and spits

Separating and marking the boundaries of the bays are a series of important controlling natural geomorphological coastal features. Collectively, these features dictate the shape of the coastline and separate the harbours from the open coast. Within this series of features, the following act as principle control features that dictate the presence of the bays:

- Milford Cliffs (linked to the Isle of Wight)
- Hengistbury Head
- Handfast Point (the Foreland) (see Figure 2.4)
- Peveril Point
- Durlston Head

Figure 2.4 Handfast Point – controlling headland at the south end of Studland Bay
(Source: Channel Coastal Observatory)

In addition there are the two harbour inlets, and the major estuary at the end of the area (Solent) with their subsequent development of spits:

- Hurst Spit
- Mudeford Spit
- Sandbanks Spit
- South Haven Point
- South Haven Peninsula (Studland)

Hurst Spit: Of the four spits, Hurst Spit is the most easterly and its north point forms the boundary with the West Solent SMP. Hurst Spit is orientated roughly north-west – south-east. Its seaward edge faces south-west and it is exposed to the dominant south-westerly wave climate, however it is still very sheltered from any east or south-easterly waves by the Isle of Wight. Hurst Spit shelters a complex area of wetland habitat / saltmarsh directly to the north-east (see Figures 2.5 and 2.6) and although this area is covered by the West Solent SMP, the future management of Hurst Spit's seaward face is intrinsically linked to the habitat sheltered on its leeside.

Hurst Spit is a shingle feature, resting on a clay bench, and is generally quite stable, although differing wave directions do reform the distal end of the spit. It is considered to be quite a recent feature resulting from nearshore processes. During the severe storms of 1989/1990, Hurst Spit experienced landward rollback of up to 80m in places (SCOPAC 2004). Bradbury et al, (2005) also report that large-scale over-washing occurred during the storm event of December 1989 (the response of the barrier was estimated to correlate with the forcing from a 1 in 50 year event).

Significant replenishment of the foreshore of Hurst Spit has taken place during the 1990's. The current management regime continues to put effort into recycling foreshore material along the Spit and artificially managing its profile. Figure 2.5 shows Hurst Spit captured by vertical aerial photography. Figure 2.6 shows the topography of the Spit, derived from SAR data.

Figure 2.5 Aerial photograph showing Hurst Spit
(Source: Channel Coastal Observatory)

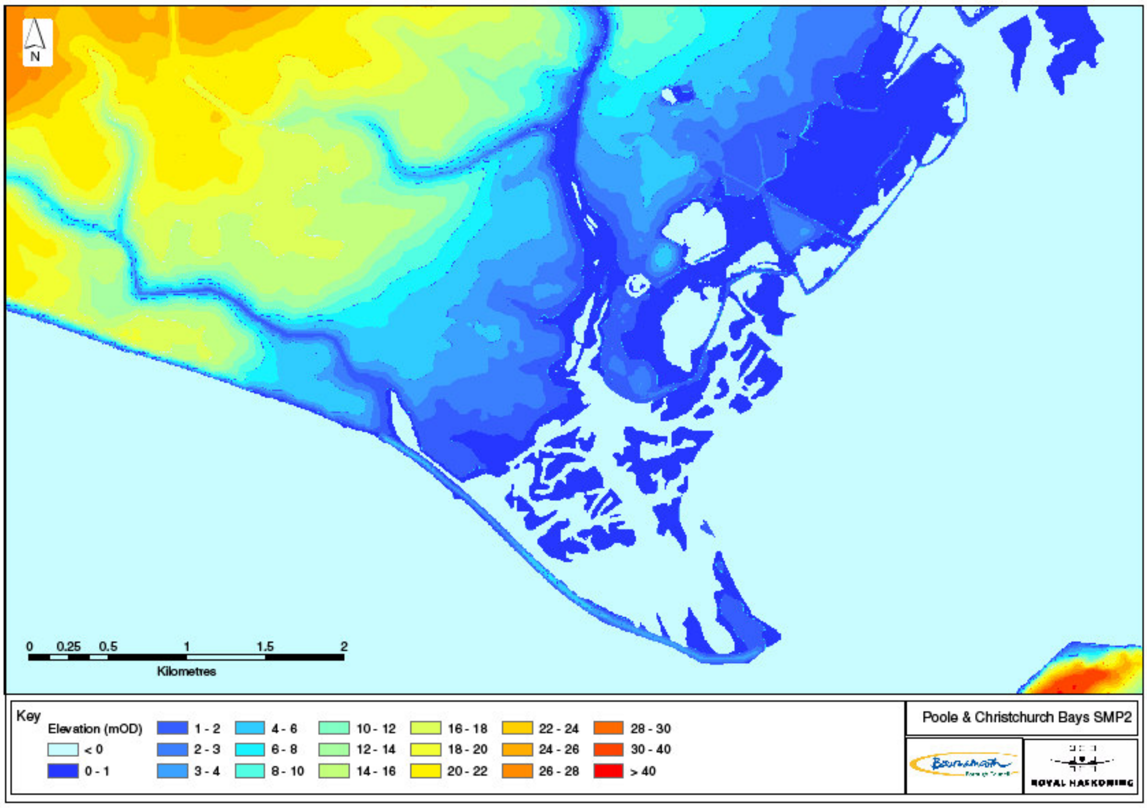

Figure 2.6 Hurst Spit topography (derived from SAR data)
(Source: Environment Agency)

Mudeford Spit: This spit (also known as Mudeford Sandbank) is located at the mouth of Christchurch Harbour, orientated north – north-east, with its base attached to Hengistbury Head. It marks the western end of Christchurch Bay. The stretch of navigable water known as Mudeford Run provides access to Christchurch Harbour. To the north of the Mudeford Spit is the Mudeford Quay Spit (also referred to as Haven House Spit), which provides a boundary for the north-western side of Mudeford Run.

The spit is primarily of a mixed sand and gravel composition. Finer sands have accumulated on top of the spit forming dunes and sandhills up to 7m in height (SCOPAC 2004). It currently extends approximately 900m in length, although historically it has been much longer and evidence shows it has been a dynamic and mobile feature. Earliest records of the Spit's existence date from around 1660. It was breached on several occasions in the last century (e.g 1911, 1924 and 1935). The mining of ironstone nodules on Hengistbury Head and then the installation of the Long Groyne originally caused sediment saturation at the Spit but then ultimately starved the Spit of sediment. Ironstone ore was first mined from the Head itself, but once this supply was exhausted, ironstone nodules were then removed from the beach, reducing the protection to the toe of the cliffs.

Formal protection of the Spit began in 1931. Installation of concrete and rock groynes on the seaward face in combination with a replenishment programme has been ongoing between 1945 and 1996. These protection works have effectively stabilised its morphological form. The site of the final breach in 1935 is the present day location of Mudeford Run – the entrance to Christchurch Harbour (see Figure 2.7 below).

The recent observed trend for Mudeford Spit is a net seaward advance of the mean high water mark. Recent modelling undertaken by HR Wallingford (1999) indicated a 70% probability of the Spit being breached under 1:100 year conditions. Figure 2.7 below shows the position and orientation of Mudeford Spit in relation to Hengistbury Head.

Figure 2.7 Hengistbury Head showing position of Mudeford Spit
(Source: Channel Coastal Observatory)

Figure 2.8 shows the topography and relative elevation of the Spit within the overall Christchurch Harbour - Hengistbury Head area. The Figure indicates an elevation of only around 2 – 4mOD, indicating its historical predisposition to breaching.

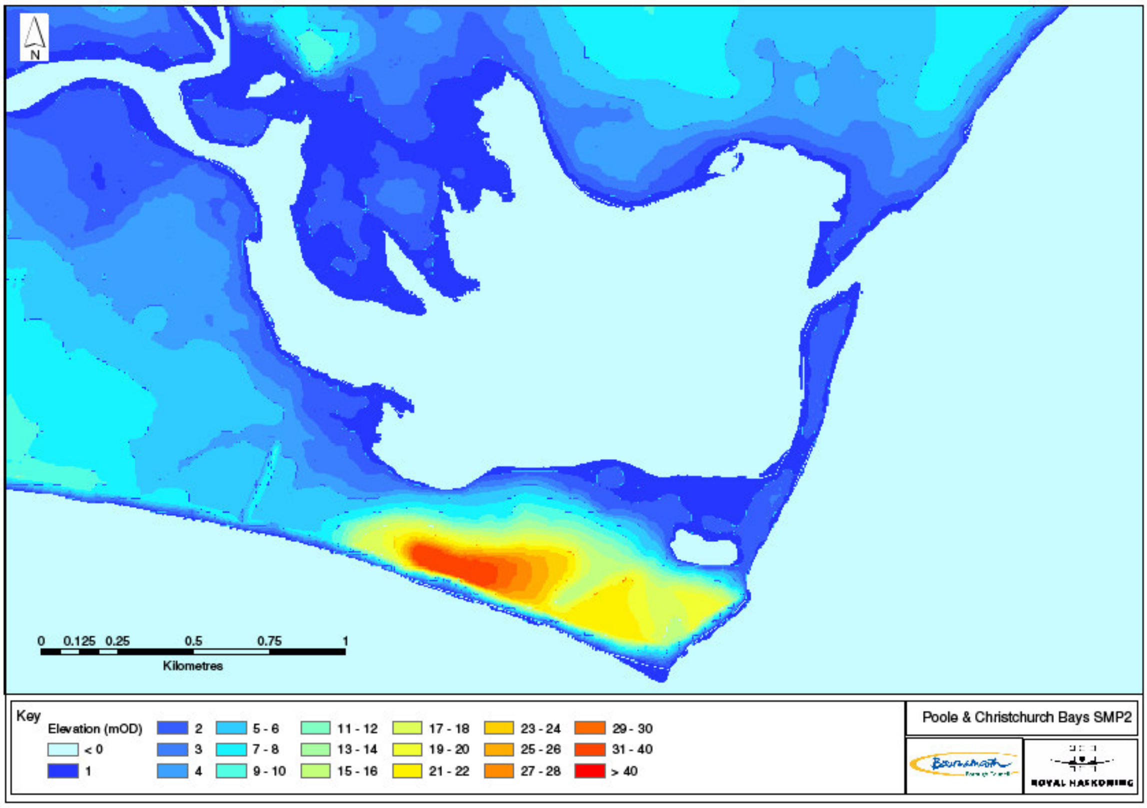

Figure 2.8 Mudeford Spit and Hengistbury Head topography, derived from LiDAR data
(Source: Environment Agency)

Sandbanks Spit: Sandbanks is the sandy northern spit located at the western end of Poole Bay. Its south-western tip (together with South Haven Point to the south) constrains the navigable entrance to Poole Harbour. The seaward face comprises a sandy foreshore, stabilised and artificially fixed by a series of seawalls and groynes. Natural response to wave and tidal energy is therefore very limited. There are low-lying mudflats and saltmarsh in Poole Harbour, protected by the spit's lee side, although the saltmarsh is of limited extent.

Historically, in the recent Holocene, Sandbanks Spit underwent some landward recession in response to rising sea levels. Installation of defences in the last century has effectively fixed it in place. As sea level rise accelerates, pressure upon this frontage will increase and the Spit will want to respond to the pressures of higher water levels and increased wave heights, plus the increasing tidal prism in Poole Harbour. The Spit may attempt to both roll back landward and accommodate a wider harbour entrance channel in response to these pressures.

Sandbanks Spit links with the coastal processes active in both Studland Bay and Poole Harbour. Sediment exchange occurs between these process units via the harbour's ebb tidal delta (Hook Sand). There may also be a limited sediment supply to Sandbanks from the adjacent westerly part of Poole Bay, due to periodic interruptions to the dominant westerly wave climate, however Harlow (2005) reports that there appears to be no evidence of the well-established littoral drift reversal which Futurecoast (2002) identifies for central Poole Bay.

Figure 2.9 shows the low-lying topography of Sandbanks Spit. As with the Mudeford Spit, elevations along its neck barely exceed 4 – 6mOD. It also shows the eastern part of Brownsea Island and its large freshwater lagoon, which is contained and defended by a seawall and rock armour revetment structure along its eastern and northern perimeter (Figure 2.2 shows the Spit seen from a vertical aerial photo).

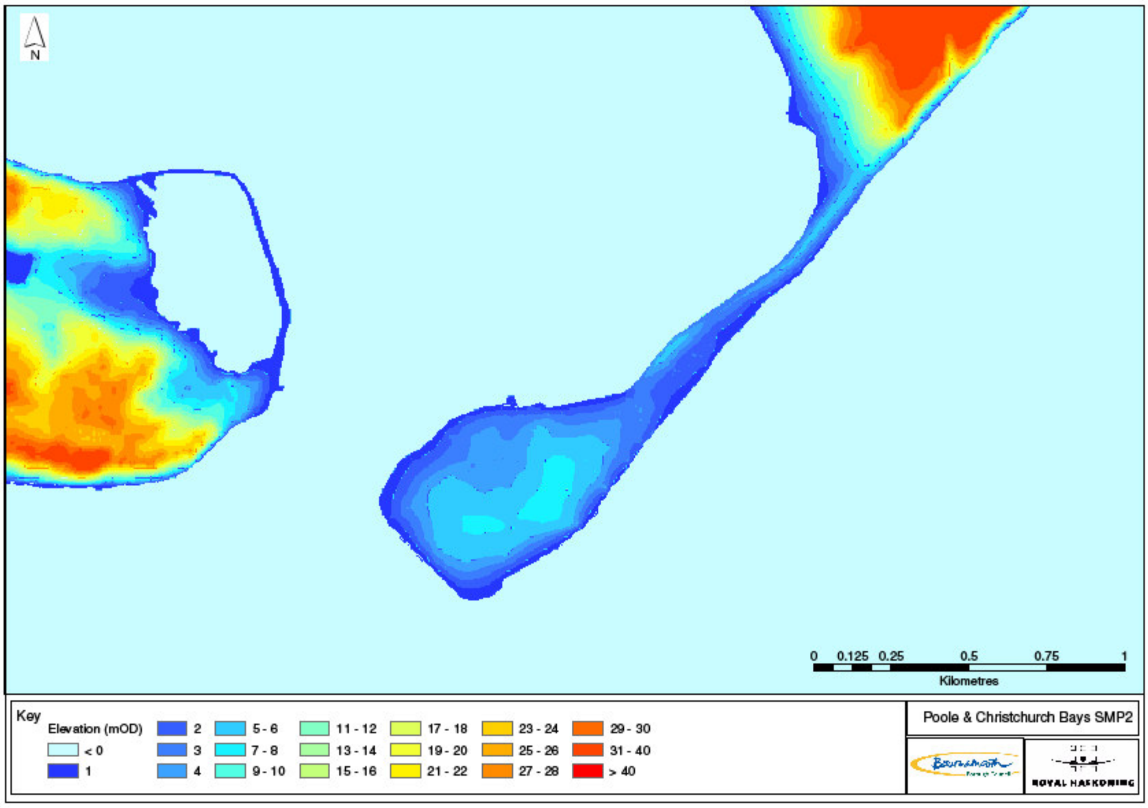

Figure 2.9 Sandbanks Spit topography (derived from LiDAR)
(Source: Environment Agency)

South Haven Peninsula (Studland): The sandy promontory at Studland, the South Haven Peninsula, is effectively a succession of dunes ridges and slacks that have accumulated on the southern spit of Poole Harbour's entrance (Figures 2.10 and 2.11). It is a well-known site managed by the National Trust with the large-scale accumulations of sand. These are protected to an extent at the northern end of the peninsula by gabions and training works that control the position and behaviour of Poole Harbour mouth. A ferry slipway is present at South Haven Point effectively anchoring it in place.

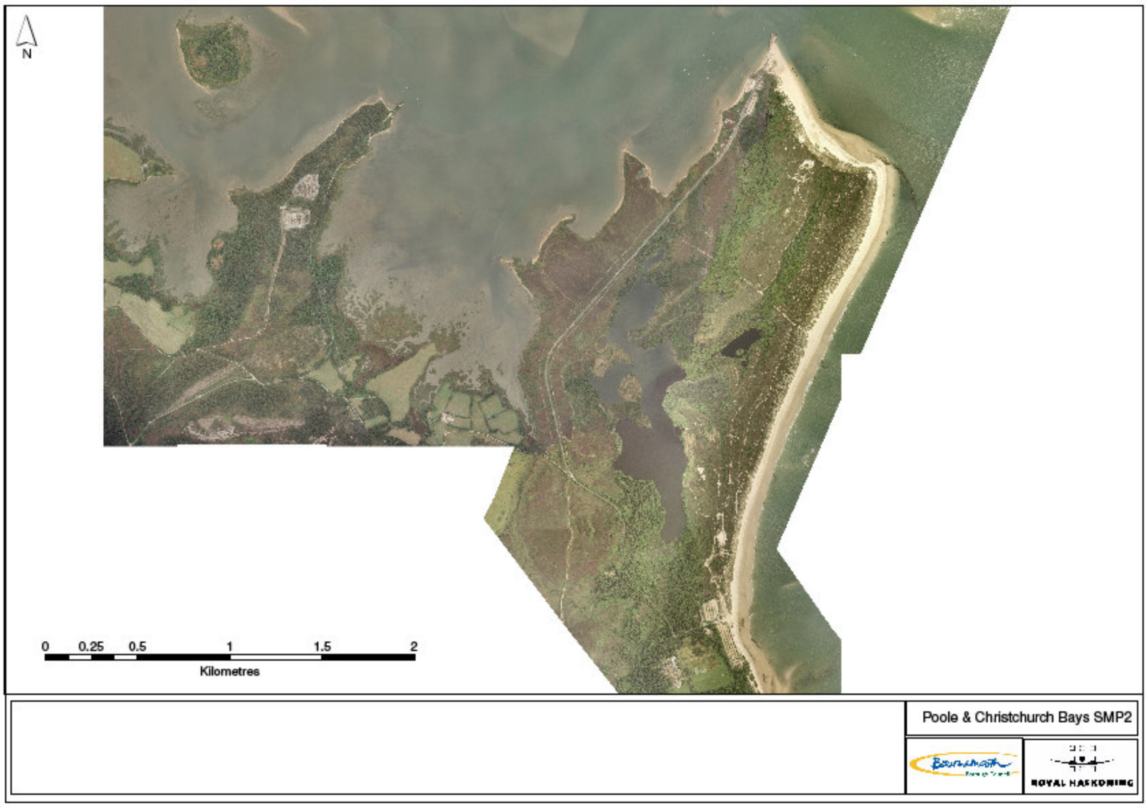

Figure 2.10 Aerial photograph of South Haven Peninsula (Studland)
(Source: Channel Coastal Observatory)

Sediments originating from the erosion of the tertiary cliffs in Poole Bay are a likely source for the historical accumulations at Studland. Accumulations occurred in the very recent Holocene (during the last 400 years) and the shoreline has moved seaward by approximately 1km. The most seaward of the dune ridges has formed since the 1950s. The present day sediment sources are also thought to include inputs from the erosion of cliffs and coastal slopes in the southern part of Studland Bay.

Summary: Although there are geomorphological similarities between the four spits, it is evident that there are also significant differences. Sandbanks and Hurst Spit lie very much along the larger natural bay shapes, formed by the harder geology in combination with the influence of the inlets. To a degree, Hurst Spit is more dependent on the erosion pressure on the Milford Cliffs, particularly at the root of the spit.

Mudeford Spit has developed in association with the slower erosion of Hengistbury Head and the supply of sediment around the head and the estuary. The Spit acts to deflect the estuary entrance. This dictates that the estuary's ebb dominated delta influences the shape of the coast to the east. Therefore it is not just the presence and influence of Hengistbury Head that needs to be considered when looking at the influences shaping the Christchurch Bay coast.

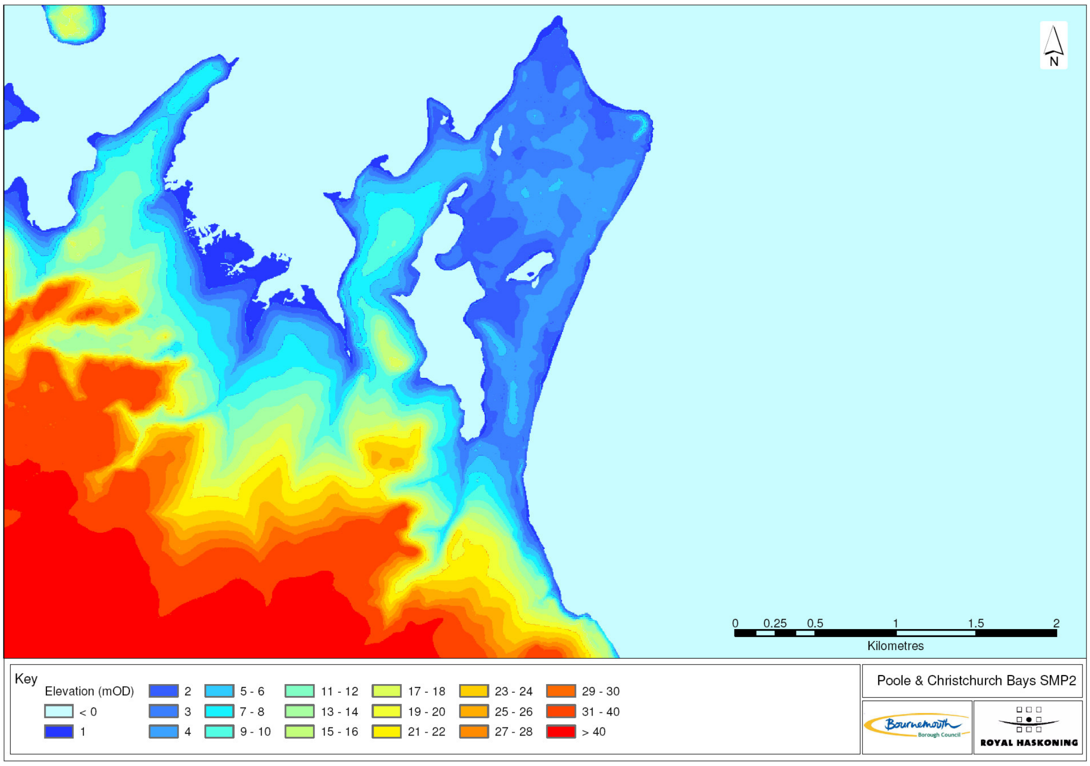

Figure 2.11 Studland Spit topography (derived from LiDAR)
(Source: Environment Agency)

The shoreline of Studland is a seaward advancement of the overall shape of Poole Bay; this has developed between the influence of Handfast Point and South Haven Point. The seaward advance has occurred due to the significant accretion of sand along this part of the SMP frontage during the recent Holocene. Its general morphological shape is dictated by the sedimentary processes at Poole Harbour entrance as apposed to it being influential on the shape or position of the mouth itself. Clearly at the local level there are strong interactions here.

The underlying behaviour of the spits are important to their management. Mudeford Spit acts most as a true spit while Hurst Spit and Sandbanks behave more as open coast with more local typical spit behaviour at their heads. Studland Haven Peninsula acts more as a morfa, (or deposition of sediment in the influence of an estuary).

Cliffs

There are a series of cliffed areas along the frontage. These are particularly important within the SMP review as they represent the most significant sediment source to the local beaches. In some cases they also represent both the most active zones of erosion as well as zones at most risk from erosion. They also tend to coincide with areas of high residential development and population density close to the active shoreline. In addition, much of the cliffed area within the SMP frontage is designated as a SSSI and is nationally important in supporting rare habitats, particularly along the actively eroding sections.

Groundwater and landslip tendencies (i.e. non-coastal processes) play a major role in the erosion of the cliffs, particularly within Christchurch Bay and at Swanage. Coastal processes however, act to remove much of the material that slumps to the toe of the cliffs. It is suggested that this effectively keeps the cliffs in a continued unstable state.

The important cliffed areas in terms of their actively eroding nature and contribution to sediment sources are:

- Beckton Bunny to Milford-on-Sea
- Chewton Bunny to Barton on Sea
- Canford Cliffs
- Solent Beach to Hengistbury Head
- Punfield Cove to Durlston Head

Figure 2.12 below shows the cliffs located along the Chewton Bunny to Barton on Sea frontage.

In addition to the above areas, there are active cliffs in the following areas:

- Naish Beach
- Highcliffe
- Christchurch
- Southborne
- Boscombe
- Bournemouth
- Poole
- Branksome
- Studland
- Handfast Point
- Ballard Cliff
- Swanage Bay
- Durlston Bay
- Durlston Head

These areas are discussed later (Section 2.6) in this report in relation to their recession rates and sediment supply potential.

Figure 2.12 aerial photography of the Chewton Bunny to Barton on Sea cliffs
(Source: Channel Coastal Observatory)

Beaches

The open coast frontage from Hurst Spit to Durlston Head can be termed a drift-aligned shoreline, in that the majority of incident wave energy approaches the shoreline from an oblique angle. This creates a strong pattern of littoral drift along the nearshore zone, parallel to the beaches, transporting sediment along-shore (generally from west to east) and this is readily observed in the deposition and distribution of sediment along the beaches of the SMP frontage. This is an important consideration, as drift-aligned coastlines are prone to experiencing 'knock-on' effects from management actions taken further along the shoreline, in the 'up-drift' direction.

Sand and shingle beaches are present along most of the 48km of open coast frontage. The only locations where sand or shingle beaches are truly absent are the seaward face of Mudeford Quay Spit (Haven House Spit) in Christchurch Bay, the area around the Handfast Point promontory and Old Harry Rocks and the Peveril Point promontory.

Most of the beaches display a relatively shallow profile and wide dissipative form, associated with an actively eroding and wave dominated coastline, particularly from Bournemouth eastwards. As such, the health of the beaches and their continued function as the frontline flood and erosion defence, as attenuators of wave energy is important to the overall SMP objectives.

2.4 Bathymetry

The entire bay from the Isle of Wight Needles to Durlston Head is quite shallow. SCOPAC (1999) identify the whole bay as being inside the 20mCD depth contour. Figure 2.13 shows both the nearshore and offshore bathymetry of the entire frontage.

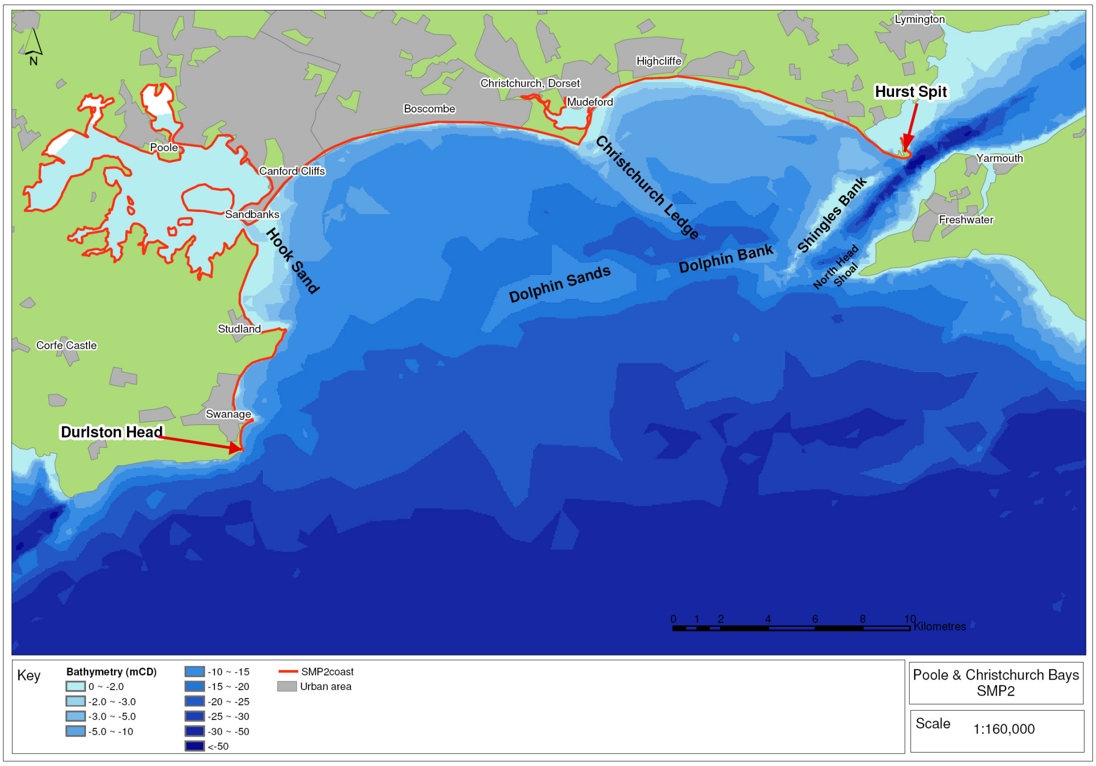

Figure 2.13 Nearshore and offshore bathymetry
(Source: Environment Agency)

Christchurch Bay is shallower than Poole Bay, the 10m depth contour for Poole Bay is between 0.5 ~ 1km offshore compared to 3 ~ 5km offshore for Christchurch Bay. Depth limitation to waves (the process of waves breaking, shoaling or generally losing their energy as they start to interact with the seabed) is therefore more pronounced in Christchurch Bay, despite its greater exposure to the south-westerly wave climate. A combination of reduced depth limitation and increased exposure to waves is most prominent at Hengistbury Head.

Important offshore features of the bathymetry include Christchurch Ledge, Dolphin Sand, Dolphin Bank, Shingles Bank and North Head Shoal in Christchurch Bay (see Figure 2.13 and 3.1) and Hook Sand in Poole Bay (see Figure 2.13). North Head Shoal is a component of the tidal delta system of the Solent. Dolphin Sand and Shingles Bank lie just to the south of Hurst Spit. Hook Sand is an important part of the sediment system in Poole and Studland Bays. The presence of all of these features is influential on the shoreline due to their wave refraction and sediment storage properties.

Shingle Bank is approximately 0mCD, and Dolphin Bank and Dolphin Sand form a barrier across Christchurch Bay at approximately 6 ~ 14mCD deep. Hook Sand extends south-east from Sandbanks approximately 2km and has a depth of 0 ~ 1mCD.

Studland Bay is much shallower than Swanage Bay, with the ~10mCD depth contour lying approximately 2.5km from the shore. In Swanage Bay the ~10mCD depth contour lies approximately 0.5km from the shore.

2.5 Hydrodynamics

This section describes the wider hydrodynamic conditions experienced across the SMP frontage, encompassing tides, water levels and wave climate.

2.5.1 Tides

Two tidal regimes exist in Sub-cell 5f, both having very distorted tide curves. Halcrow (1999) reported that there appears to be a split in the incoming tide at Hengistbury Head. Flood tide levels within the rest of Poole Bay west of Hengistbury Head occur slightly later.

In general across the SMP frontage, the low tide duration is very short compared to the high tide duration, and the tidal rise is longer than the fall. Poole Harbour shows a 'double' high tide characteristic, which results in a long period of standing water. This gives Poole Harbour a lagoon-like nature, and also has significant implications in tidal flood events as floodwaters can stay high for long periods.

The tendency for double high waters exists along the entire frontage but is more pronounced between Mudeford and Alum Chine. Spring tidal range at Hurst Spit is 2.6m and at Swanage it reduces to 1.5m. These variations in tidal range plus the asymmetry, which is exhibited between flood and ebb conditions, creates a complex pattern of tidal flow (Halcrow 1999).

SMP1 identifies that the main tidal streams are generally parallel to the coastline offshore and that, as might be anticipated, during the flood tide flow and currents are in an easterly direction. During the ebbing tide the flow is westwards offshore.

Tidal Curves

The tidal curve for Poole Harbour is shown in Figure 2.14. It demonstrates the distinctive double high water characteristic.

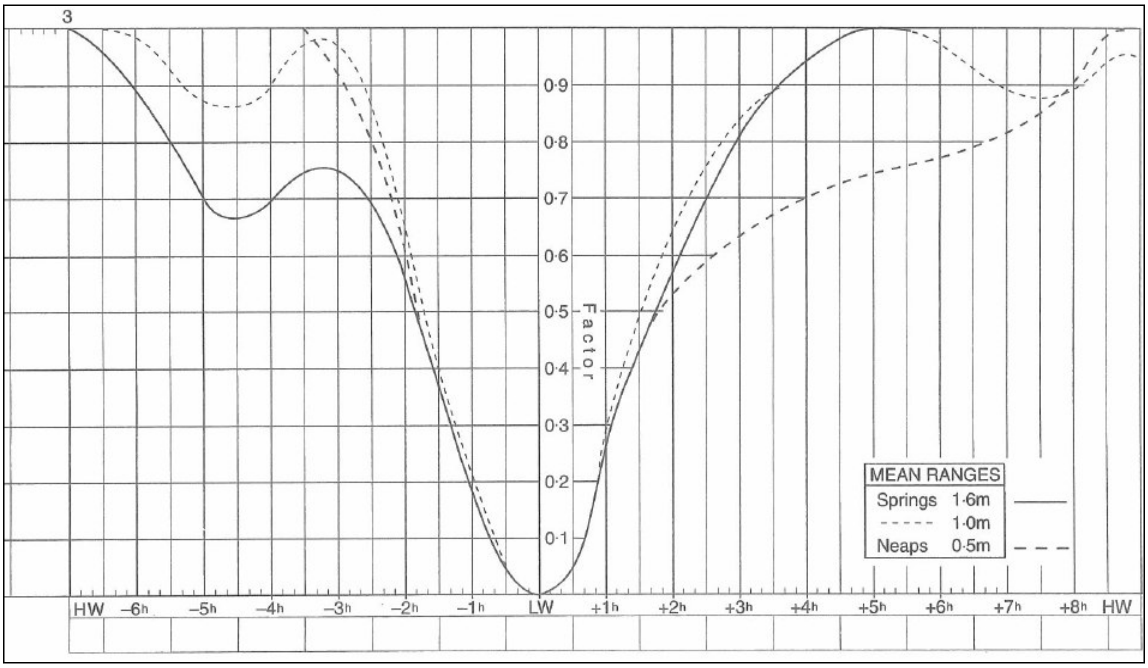

Figure 2.14 Tide curve for Poole Bay (Source: Admiralty Tide Tables 2008)

Tide Differences

Time differences at high and low water between specific locations along the SMP frontage and the two reference ports of Poole and Portsmouth are shown in Table 2.1, and height differences are shown in Table 2.2. (From Admiralty Tide Tables 2008).

Table 2.1 Tidal time differences between SMP locations and reference ports

Location	Reference Port	Time Difference (hhmm)			
		0000 1200	0600 1800	0500 1700	1100 2300
Swanage	Poole Harbour	-	-	-0045	-0055
Poole Harbour Entrance	Poole Harbour	-	-	-0025	-0010
Poole (Ro Ro Terminal)	Poole Harbour	-	-	-	-
Bournemouth	Portsmouth	-0240	+0055	-0050	-0030
Christchurch Entrance	Portsmouth	-0230	+0030	-0035	-0035
Christchurch Quay	Portsmouth	-0210	+0100	+0105	+0055
Hurst point	Portsmouth	-0115	-0005	-0030	-0025

Table 2.2 Tidal height differences between SMP locations and reference ports

Location	Reference Port	Mean Level	Height Difference (m)			
			MHWS	MHWN	MLWN	MLWS
Swanage	Poole Harbour		-0.2	-0.1	0.0	-0.1
Poole Harbour Entrance	Poole Harbour		0.0	0.0	0.0	0.0
Poole (RoRo Terminal)	Poole Harbour		-	-	-	-
Bournemouth	Portsmouth		-2.7	-2.2	-0.8	-0.3
Christchurch Entrance	Portsmouth		-2.9	-2.4	-1.2	-0.2
Christchurch Quay	Portsmouth		-2.9	-2.4	-1.0	0.0
Hurst Point	Portsmouth		-2.0	-1.5	-0.5	-0.1

From Admiralty Tide Tables 2008

MHWS Mean High Water Springs

MHWN Mean High Water Neaps

MLWS Mean Low Water Springs

MLWN Mean Low Water Neaps

2.5.2 Water Levels

The Report on Extreme Tide Levels (Environment Agency, 2003) predicts extreme still water levels based on tide gauge records. For this sub-cell, seven locations are included. These are shown in Table 2.3.

Table 2.3 Predicted extreme still water tide levels (2003)

Location	OS Grid Reference	MLWS	MHWS	Tidal Still Water Level (mOD) for Annual Exceedance Percentage (AEP)								
				100%	20%	10%	4%	2%	1%	0.5%	0.2%	0.1%
Swanage	SZ030786	-0.90	0.60	1.41	1.58	1.65	1.75	1.82	1.90	1.97	2.07	2.14
Sandbanks	SZ045876	-0.90*	0.80	1.39	1.56	1.63	1.73	1.80	1.88	1.95	2.05	2.12
Poole Terminal	SZ008897	-0.80	0.80	1.39	1.56	1.63	1.73	1.80	1.88	1.95	***2.05***	***2.12***
Bournemouth	SZ099905	-0.90	0.60	1.38	1.56	1.63	1.73	1.81	1.88	1.96	2.06	2.14
Hengistbury Head	SZ164903	-0.31	0.89	1.39	1.57	1.65	1.75	1.83	1.91	1.99	2.09	2.17
Christchurch Priory Quay	SZ158923	-0.11	0.89	1.39	1.57	1.65	1.75	1.83	1.91	1.99	***2.09***	***2.17***
Barton on Sea	SZ240920	-0.66*	0.93*	1.43	1.62	1.70	1.80	1.88	1.96	2.04	2.15	2.23
Return Period (years)				1	5	10	25	50	100	200	500	1000

MLWS and MHWS levels from Admiralty Tide Tables (* determined by linear interpolation)

Confidence Levels:
Coastal sites Sandbanks, Poole and Bournemouth have levels based on several years of site data and are high confidence. Other coastal sites have medium levels of confidence.

Poole Terminal and Christchurch Priory Quay are regarded as estuary locations and have medium confidence from 100% to 2% AEP, and low confidence from 1% to 0.1% AEP. Values in bold *italics* have a low degree of confidence.

Proudman Oceanographic Laboratory (POL) has recorded the ten highest and lowest surges since 1996, using a tide gauge located on Bournemouth Pier (SZ 0893 9053). These are shown in Table 2.4 and Table 2.5. Storm events, which have occurred recently during March 2008 and January 2009, are also likely to be associated with high surge records (actual values were not available at the time of writing).

Storm surges involve the temporary raising of sea level due to low atmospheric pressure and strong winds. Such events can be damaging when they coincide with high tide at the coast. The occurrence of these events may be altered in the future by changes in storminess (the number, location or strength of storms) and rising sea level. However, UKCIP (2002) state that there is no evidence from the two longest tide gauge records (Liverpool and Newlyn) for any long-term increase in storm surge statistics.

To assess future changes in storm surge height, simulations have been carried out using a model of atmospheric wind and pressure together with a POL United Kingdom shelf sea model. The changes simulated for a 50 year return period water level indicate that the largest rises in surge height would occur in south-east England, although there is a good deal of uncertainty in this modelling.

The UKCIP described how return periods may alter in the future. The general trend is one of the return periods for a given water level reducing (the water level will occur more frequently) or an alternative way to view this is that the water level of a given return period (e.g. a 1:50 year event) would be higher (Royal Haskoning 2004).

Table 2.4 Ten largest positive surges recorded at Bournemouth Pier

Date	Time (hh:mm)	Surge (m)
2nd December 2005	15:45	0.98
12th August 2000	02:00	0.98
30th October 2000	05:30	0.87
12th March 2006	05:45	0.85
1st April 1998	14:00	0.85
1st February 2001	03:15	0.8
6th March 2007	01:15	0.8
19th November 1996	08:30	0.79
1st January 1998	18:15	0.78
14th November 2002	03:45	0.77

Negative surges can also occur, effectively meaning tide heights are lower than those predicted in Admiralty Tide Tables. Negative surges generally occur under conditions opposite to those that cause positive surges (i.e. very high pressure, little or no wind).

Table 2.5 Ten largest negative surges recorded at Bournemouth Pier

Date	Time (hh:mm)	SURGE (m)
27th October 2002	16:30	-0.64
11th November 1999	05:30	-0.57
23rd January 2007	02:00	-0.55
7th December 2003	02:30	-0.52
6th November 2006	09:45	-0.52
23rd December 1999	00:45	-0.52
25th February 2005	12:15	-0.50
12th November 1999	05:45	-0.50
12th January 1998	12:15	-0.50
30th December 2004	01:00	-0.49

2.5.3 Wave Climate

The dominant wave direction is from the south to south-west, which corresponds with the direction of longest fetch and longer period swell waves originating in the Atlantic Ocean. Shorter period wind waves from the east and south-east are less influential in terms of geomorphological development along the frontage although significant storms do occur from these directions and can result in significant local impact.

The largest waves (and therefore greatest amount of wave energy) are received by Christchurch Bay and the easterly part of Poole Bay (Bournemouth eastwards). Offshore of Christchurch Bay receives more energy from swell waves than Poole Bay due to its greater exposure to the south-west, however its shallower bathymetry and the presence of the Christchurch Ledge dictates that the waves are more depth-limited than in Poole Bay. This means wave heights reaching the shoreline in Christchurch Bay are restricted and are similar to those in Poole Bay. Hengistbury Head demonstrates a combination of the least depth limitation and highest relative exposure to the dominant south south-west wave climate. Waves approaching from the south south-west undergo significant refraction and diffraction due to the presence of the headlands and (as previously discussed) this dictates the form and plan shape of all of the bays. Waves approaching from any angle also undergo significant attenuation due to the shallowness of the bay and the presence of an underwater trough and bar.

The bays continue to exhibit the need to adjust their shape to a point where sediment – wave energy equilibrium is reached and this is an important consideration in developing the SMP. Increased wave heights due to climate change and sea level rise will increase the pressure for the bays to continue to adjust their plan form. This dynamic response becomes increasingly enhanced from west to east.

The shoreline from the Branksome Chine area south to Durlston Head is more sheltered from the dominant south-westerly storms and faces mainly due east to south-east. The Isle of Purbeck, Studland Bay, Swanage Bay, Durlston Bay and the western part of Poole Bay are sheltered therefore from south-westerly waves. Their east facing nature does however make them more exposed to the less frequent east to south-easterly storms.

Waves in Poole and Christchurch Harbours are generated locally and are limited by the depth and very short fetch of the harbour. The largest waves occur along the northern side of Poole Harbour from local south-westerly storm events.

The CCO have been monitoring the wave climate along this SMP frontage using Waverider directional wave buoys at Milford (OS 427297E 90361N) since 1996 and Boscombe (OS 411413E 90302N) since 2003. The water depth at both the waverider buoy locations is approximately 10m. Additionally a Saab WaveRadar Rex gauge is located on Swanage Pier (50° 60.939' N 001° 19.4921' W).

Wave rose diagrams summarising annual wave activities for each of these locations are shown below. The diagrams show average seasonal wave conditions: January represents winter, April represents spring, July represents summer and October represents autumn.

The nearshore anchorage of the wave buoy at Boscombe Figure 2.15 means that offshore waves from the south-west appear inshore from a 180° direction, following refraction around the headlands.

Boscombe (2003 ~ present)

The Boscombe buoy is a Waverider MkIII buoy was first deployed 10 July 2003 by CCO. Wave directions prior to 2004 were excluded due to software problems. This buoy was replaced in December 2005.

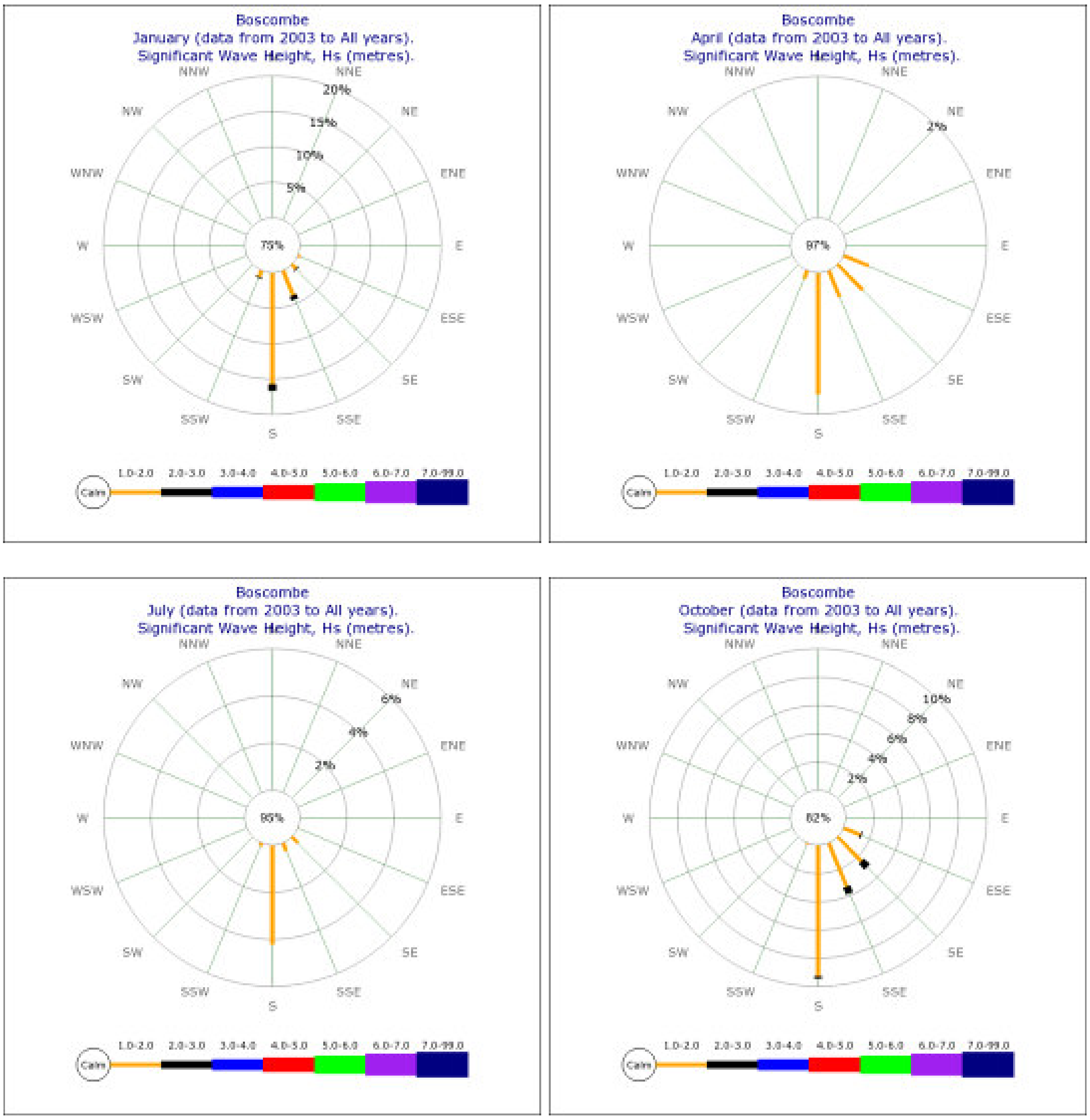

Figure 2.15 Waverider Buoy at Boscombe – 2003 to present

(Data courtesy of Channel Coast Observatory)

Milford (1996 ~ present)

A Waverider MkII buoy was deployed in May 1996, and after being badly damaged in October 2005 was replaced with a Waverider MkIII buoy on 17 November 2005.

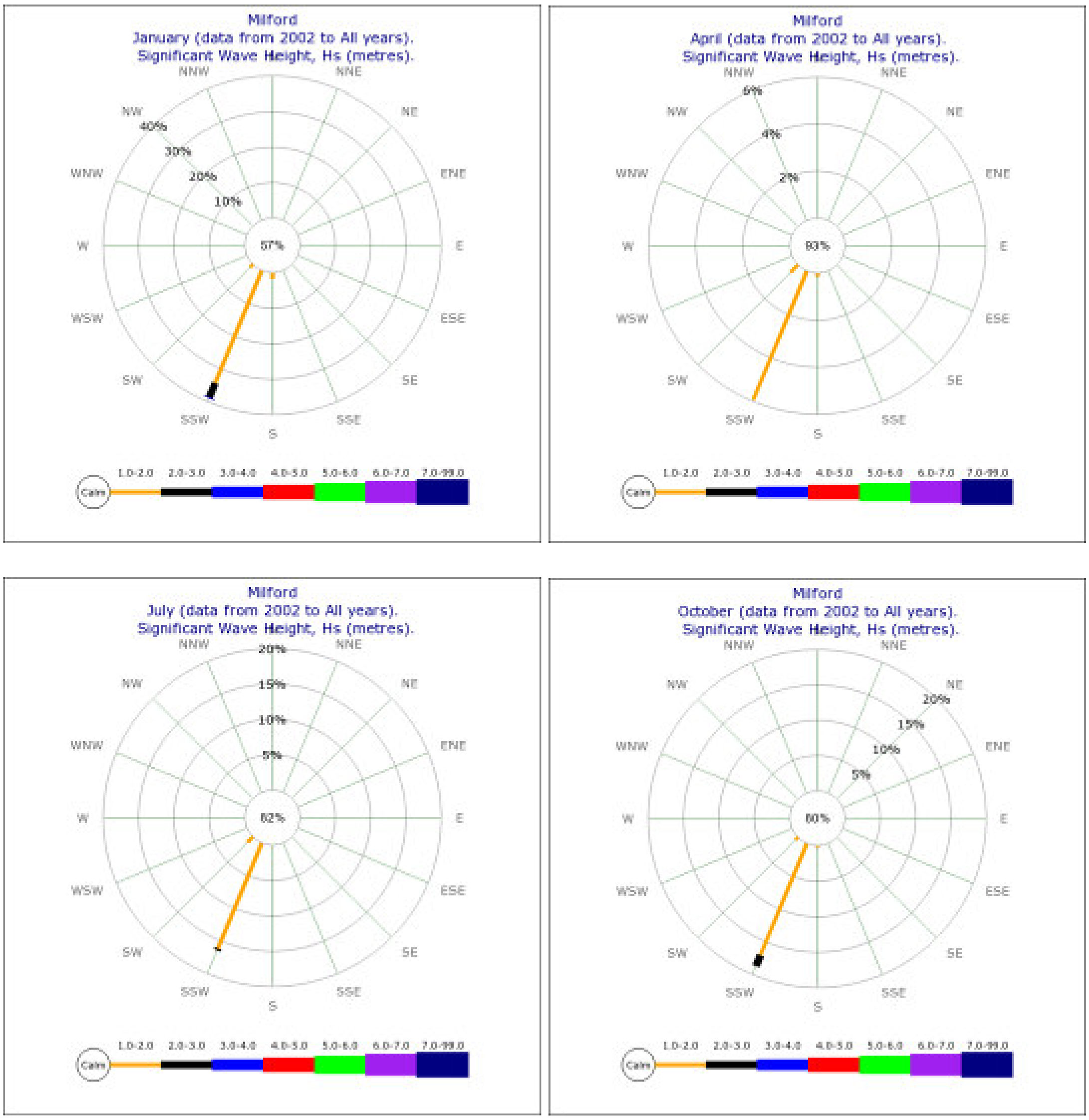

Figure 2.16 Waverider Buoy at Milford-on-Sea - 2002 to present

(Data courtesy of Channel Coast Observatory)

The overwhelming south to south-west approach of the wave climate at Milford-on-Sea can be noted from Figure 2.16.

Annual exceedance

Table 2.6 Annual wave climate exceedance values at Boscombe

(Data courtesy of Channel Coast Observatory)

Year	Annual H_s exceedance* (m)						Annual Maximum H_s	
	0.05%	0.5%	1%	2%	5%	10%	Date	A_{max}(m)
2003	2.74	2.17	1.95	1.53	1.19	0.98	14 Nov 2003 11:00	2.79
2004	2.98	2.28	1.96	1.69	1.30	1.02	08 Jan 2004 09:30	3.62
2005	2.62	1.81	1.59	1.40	1.11	0.90	02 Nov 2005 01:00	2.84
2006	2.82	2.24	2.03	1.82	1.47	1.17	29 Dec 2006 23:00	3.14
2007	2.94	2.07	1.84	1.63	1.33	1.07	18 Nov 2007 14:00	3.19

Table 2.6 above uses the significant wave height (the average of the highest one third of all recorded waves) to provide an indication of how often a certain size of wave is

exceeded during a calendar year (the example used here is Boscombe). For example, the last row of the table, showing 2007 data, indicates that for 10% of the year, waves exceeded 1.07m in height. In 2003, the 10% exceedance value was 0.98m. It can be seen that for each year, the 0.05% exceedance value fell between 2.6m and 3.0m.

The highest recorded H_s value during the five year record is 3.62m, recorded 8th January 2004. Maximum wave heights H_{max} recorded will exceed those H_s values given in each year, but generally the best indication of the type of conditions that need to be allowed for is given by H_s.

2.6 Sediment sources

Sediment sources have been defined by SCOPAC (1999) as cliff, offshore marine and fluvial sources. The key sources along the SMP frontage were identified as inputs from eroding cliffs along the Becton Bunny to Milford-on-Sea and Chewton Bunny to Barton on Sea frontages. Fluvial inputs are not a natural key source of sediment to the open coast frontage but they are influential within the harbours. Harbour dredging and beach replenishment activity makes some fluvial material available artificially to the open coast. It is very important to acknowledge the influence of artificially derived material along this coastline. Section 2.6.4 outlines beach recharge activities in Poole Bay.

2.6.1 Cliff Sources

Four areas of cliff were identified as sources of sediment by SCOPAC (1999). These are identified in Table 2.7.

Table 2.7 Cliff sources of sediment (Source: SCOPAC 1999)

Source	Approximate sediment supply (m^3/year)
Becton Bunny to Milford-on Sea	70,000
Chewton Bunny to Barton on Sea	60,000
Solent Beach to Hengistbury Head	8,000
Punfield Cove to Durlston Head	30,000

Becton Bunny to Milford-on-sea and Chewton Bunny to Barton on Sea are dependent on a complex landslide system providing sediment, rather than more direct marine erosion as at Punfield Cove to Durlston Head (although some complex landsliding occurs at Swanage).

Sediment supply from Solent Beach to Hengistbury Head is limited by the presence of the Long Groyne retaining sediment.

2.6.2 Sea Sources

Sea sources comprise of both offshore and coastal platform (beaches) sources. Shoreface depths range from between 5m and 10m deep. The sources are identified in Table 2.8, taken from the SCOPAC 1999 Research Project (Sediment Inputs to the Coastal System) with approximate quantities and size of sediment supplied to the coastal system.

Table 2.8 Sea sources of sediment (Source: SCOPAC 1999)

Source	Length (km)	Approximate quantity (m^3/year)	Type
Hurst Spit	1.0	300	Coarse
Hurst Spit to Milford-on-Sea	3.5	1,200	Fine
Milford-on-Sea to Hordle	1.2	6,000	Fine
Hordle to Barton on Sea	4.0	3,500	Fine
Barton on Sea to Chewton Bunny	1.2	12,000	Fine
Chewton Bunny to Hengistbury Head	4.8	5,000	Fine
Hengistbury Head to Double Dykes	1.5	6,000	Fine
Double Dykes to Bournemouth	7	4,500	Fine
Bournemouth to Handfast Point	10.5	25,000	Fine
Handfast Point to Punfield Cove	1.1	100	Coarse
Punfield Cove to Durlston Head	3	4,500	Fine

Other sources include Shingle Bank, Dolphin Sand and Dolphin Bank. Sediment is deposited on Hurst Spit, before being moved offshore by ebb currents. Gravels are deposited on Shingle Bank and sands deposited on Dolphin Sands and Dolphin Bank. The role of these sinks are not fully understood and although they are believed to periodically act as sources, it is not clear how much material may be mobilised during these periods.

2.6.3 River Sources

Four river catchments discharge into the sub cell, releasing mainly fine sediment. These are detailed in Table 2.9

Table 2.9 River catchment sources of sediment (Source: SCOPAC 1999)

Catchment	Quantity and type (m^3/year)	Discharge area
Hampshire Avon	2000 fine	Christchurch harbour
Dorset Stour	1300 fine	Christchurch harbour
Frome & Piddle	700 fine/ 100 coarse	Poole Harbour
Poole Harbour	100 fine	Poole Bay

River sediments are mainly trapped in Poole and Christchurch Harbours, although recharging activities using dredged sediment from these harbours can release sediment to the coastal system. In the case of Christchurch Harbour dredged material has been placed on the inside of the Mudeford Bank – some of this material then is mobilised and released to the open coast frontage through the Mudeford Run (Christchurch BC, 2004) There is also some redistribution of sediments in Poole Harbour.

Sediment inputs arising from erosion of the undefended cliffs within the SMP frontage are by far the most important natural sediment inputs to the whole SMP frontage.

2.6.4 Beach Recharge

The above three section identify naturally derived sources of sediment. A key consideration for this SMP review however, is the sediment made available by anthropogenic activity. Beach recharge introduces new material to the frontage, (as opposed to recycling and/or reprofiling which moves existing sediment around within a given sub-cell). Recharge actually represents the largest input of new material to the SMP frontage.

Recharge activities have been concentrated in Poole Bay (a recharge programme was also undertaken for Swanage). The first recharge took place in 1970 and the most recent in early 2009. Recharge occurring in Poole Bay benefits not just the frontages of Branksome Chine, Bournemouth, Boscombe, Southbourne and Hengistbury Head, but also Christchurch Bay beaches, as a significant proportion of material put on to the beaches in Poole Bay will eventually bypass the Long Groyne and be transported further east along the frontage, Table 2.10 below provides a summary of the recharge activities undertaken to date.

Table 2.10 Beach recharge derived sediment volumes 1970-2009
(Source: Harlow, BBC 2009)

Recharge Programme	Dates	Net volume placed on beach (m^3)
BIS1*	1970	84,500
BIS2	1974/75	654,200
BIS3	1988/90	1,147,362
BIS4	2006/08	1,668,828
Total to date (m^3)		3,554,890

BIS = Beach Improvement Scheme

2.7 Sediment transport

The SCOPAC Sediment Transport Study (2004) gives an excellent description of the current understanding of sediment transport mechanisms for each of the process units within the SMP frontage. A series of maps have been reproduced in Section 3 to aid the understanding of the reader in relation to the sediment transport pathways within each process unit. A more detailed description of the transport mechanisms is also contained within Section 3 for each of the process units.

Broadly speaking, sediment transport mechanisms across the SMP frontage are driven by wave energy. As the dominant direction of wave approach is south to south-west, dominant nearshore transport of sediment is from west to east, in common with much of the wider regional coast. This is mainly true for Poole and Christchurch Bays, however due to their orientation, for the bays of Durlston, Swanage and Studland, transport tends to be south to north, but again in response to south – south-westerly waves. There is also some east to west and north to south transport experienced in the vicinity of the harbour mouths and headlands. Estuarine inputs of sediment also add a layer of complexity at these locations.

As Harlow (2005) points out, estimating the direction of dominant littoral drift is fairly simplistic, as it generally correlates with the dominant wave climate (particularly where tidal range is small and currents are weak, as is the case within most of this SMP frontage). However estimating the amount of littoral drift is more complex as it is a product of many more factors, including wave height, wave period, nearshore bathymetry, particle size distribution, relative cohesiveness of beach and shoreface sediments, plus the influence of tides.

The picture of offshore sediment transport is complex and by its nature is less well understood than the nearshore littoral transport.

2.8 Coastal Monitoring

The SMP frontage for Poole and Christchurch is particularly well served in terms of coastal monitoring effort. The Regional Strategic Coastal Monitoring Programme for the South East, managed by the CCO, provides full coverage of the shoreline, including topographic beach profiles, bathymetry measurements, aerial photography, LiDAR and nearshore wave recorders. This monitoring programme has been running since 2002 and although the dataset is not yet long enough to give long-term trends, it does indicate short-term response. Additionally, it is very helpful in indicating how littoral drift and coastal protection structures contribute to the re-distribution and retention of sediment following the numerous recharge activities which have taken place.

The approximately 12km of beach forming the BBC frontage have been extensively monitored (beach profiles and particle size distribution) since 1974. Littoral drift surveys commenced in 1993. Since 2002, the original 33 profile lines which had covered the frontage and been surveyed twice yearly since 1974, were superseded by the 90 profiles which are now undertaken by the Regional Monitoring Programme, as described above. The BBC beach monitoring programme is probably the longest running such programme in the UK and as such provides an unprecedented observation of coastal morphological trends and associated performance of defences. At 35 years long, the programme almost encompasses two of the 18.6-year tidal nodal cycles and as such can be said to give an accurate and reliable observation on the medium to long-term trends along this part of the shoreline.

Long-term natural trends observed from the monitoring are masked somewhat by the recharge episodes that have taken place. However when allowing for this, it can be seen that the overall trend is of accretion following recharge, followed by gradual erosion and narrowing of the foreshore, particularly within Poole Bay and central Christchurch Bay.

3 PROCESS UNIT DIVISIONS

3.1 Explanation of Process Units

The SMP 5f sub-cell has been further divided into *process units*. Process units are independent of management considerations and are determined purely on whole coastal processes and not necessarily divided by features such as bays and headlands (although generally that is the case with sub-cell 5f). The six process units used for the review reflect those identified for SCOPAC's 2004 Sediment Transport Study. They have also been have been guided by those process units and boundaries identified in FutureCoast (Halcrow 2002). They also correspond to those used in the initial SMP study, with the exception that Durlston Bay was treated as a separate unit during SMP1. In this SMP Review it is an integrated part of the Swanage process unit, as it is now understood that there are offshore sediment transport mechanisms linking Swanage and Durlston Bays. Each process unit is discussed individually, working along the SMP frontage from east to west, using the following divisions:

- Hurst Spit to Hengistbury Head (Christchurch Bay)
- Christchurch Harbour
- Hengistbury Head to South Haven Point (Poole Bay)
- Poole Harbour
- South Haven Point to Handfast Point (Studland Bay)
- Handfast Point to Durlston Head (Swanage)

The four open coast process units are discussed below. The two enclosed harbour process units are discussed within the estuary processes report (Appendix C, Annexe II).

3.2 Hurst Spit to Hengistbury Head (Christchurch Bay)

3.2.1 Past Evolution

Christchurch Bay is believed to relatively young in geological terms. It is understood to still be adjusting itself to the breaching of the former chalk ridge that extended between the Isle of Wight and the Isle of Purbeck (Futurecoast 2002). This explains the tendency towards continued erosion and its adjustment to achieve sediment and wave energy equilibrium and a more mature plan-form. Research by Halcrow (1999) for SMP1 suggested that a landward transgression of a further 240m was required to provide a stable plan form, however this would be dependent on ideal conditions existing, so this must be treated with caution.

During the Holocene period, rising sea levels combed up coarse sand and gravel-sized sediments from the seabed to form land-based barriers that then continued to migrate shoreward in response to the sea levels increasing. The landward movement of these barriers became limited by the rising topography, leading to rapid erosion of the cliffs, which now form the backshore. Breaches in the barriers led to tidal inundation of the areas of low topography, forming Christchurch Harbour and Hurst Narrows.

The Shingles Bank was formed as part of the tidal exchange with the Western Solent, and is a major sink for gravels and coarse sand in the eastern part of Christchurch Bay derived from the drift of sediments eastwards towards Hurst Spit. Sediments are supplied from the Spit to the tidal channel, then flushed seawards and deposited on Shingles Bank.

Hurst Spit is a multi-recurved (see glossary) barrier spit of approximately 2km in length. It is considered to be quite a recent shingle feature resulting from nearshore processes, orientated at 130^{o}N and resting on a clay bench. At Hurst Point it recurves very sharply to the north / north-west and terminates with an active recurve aligned westwards. The general plan form of the spit seems to have been stable since the mid-eighteenth century. Three former recurves, which predate this period, exist to the west of the current position of the modern day feature.

Despite its recent morphological stability, records show that Hurst Spit has previously moved landwards by up to 80m in a single storm event and historically it has shown itself to be a dynamic geomorphological feature that has responded to the infrequent major storms by moving landward. However as an indication of its recent level of stability, Hurst Castle was built in 1544 and it has seemingly only been at risk from potential beach recession over the most recent 50 to 80 years (SCOPAC 2004). Most recent information from the Regional Monitoring Programme (CCO 2008) indicates a net erosional trend on the lower foreshore along the spit. Accretion is observed along the rear of the beach slope – this correlates with the sediment recycling exercises which have occurred during 2003, 2004, 2005 and 2008 and have mainly placed material along the rear of the slope.

In recent years the Spit has been subject to significant reprofiling, major shingle replenishment in 1996 and rock armour revetments have been built along part of the backshore. These interventions became necessary as the spit began to become starved of new sediment inputs, due to the ongoing expansion of coastal protection works throughout Poole and Christchurch Bays. This reinforces the view of a longer-scale reduction in sediment supply as the coast has developed. In effect, Hurst Spit has evolved more as part of the open coast, becoming elongated as Christchurch Bay's shape continues to deepen. Landward migration began to occur and breaching of the Spit (previously unrecorded) first occurred in 1954. Management practices have slowed this progression to an extent but not stopped it.

Mudeford Spit is a shingle barrier at the mouth of Christchurch Harbour and has been breached many times before being fixed from 1938 onwards. The location of the last breach in 1935 provides the location for the present day navigable entrance to Christchurch Harbour (Mudeford Run). The spit is primarily of a mixed sand and gravel composition. Finer sands have accumulated on top of the spit forming dunes and sandhills up to 7m in height (SCOPAC 2004). It currently extends approximately 900m in length, although historically it has been much longer and evidence shows it has been a dynamic and mobile feature.

The cliffs that back Christchurch Bay are very prone to landsliding, and are also easily eroded by the sea. Measures to limit or reduce erosion have been implemented since the mid-1880's and take the form of cliff drainage, seawalls and groynes. This has increased downdrift erosion to the east. It is estimated that up to 75% of the Christchurch Bay frontage is now defended – in spite of this it remains the most important source of sediment fro the SMP frontage.

Hengistbury Head was mined for ironstone during the 19th Century, causing significant erosion and an increased threat of breaching. The resulting increase in supply of sediment to the north-east contributed to the growth of Mudeford Spit. Iron ore from the Head itself was the initial target for mining activities, but following exhaustion of this ore, ironstone nodules were removed from the beach. This further removed protection from the toe of the Hengistbury Head cliffs. The historical morphology and consideration of breach risk at Hengistbury Head is considered in more detail in Annexe D of Appendix C, which provides a review of the risk and consequences of a breach at Double Dykes.

3.2.2 Physical Controls

Christchurch Bay displays a log spiral form. It has a wider and shallower foreshore than Poole Bay and this encourages shoaling and refraction of waves.

The presence of Hengistbury Head and Long Groyne helps to ‘anchor’ the shape of Christchurch Bay as it acts as a headland. Hengistbury Head is composed of ironstone nodules in a weaker clay deposit, which influences the development of the shore to both east and west. Christchurch Ledge, a remnant of a more seaward position of Hengistbury Head, dissipates larger waves entering Christchurch Bay.

Hengistbury Head is fronted by a shingle beach overlying sand, backed by Tertiary cliffs which contain layers of ironstone nodules. Long Groyne was constructed in 1938, and traps a significant proportion of shingle, creating a wide dissipative beach. Since the construction of Long Groyne, increased erosion to the north-east of the groyne along the seaward face of Mudeford Spit necessitated the construction of rock groynes along the length of the beach. More recent evidence from the Regional Monitoring Programme (CCO 2008), shows that accretion has occurred and the position of MHW has moved seaward in the first eight groyne compartments directly north east of Long Groyne. Interestingly, the first 5 compartments, which display accretion, have not received sediment from the recycling activities that have taken place during the period 2004 – 2008. This suggests sediment is received from the west (around the Long Groyne) or from offshore sources. It is also likely that erosion of the coastal slope is providing additional sediment to these accreting groyne compartments.

Hengistbury Head is an important feature in the coastline, necessary for the formation of Poole Bay, and sheltering Christchurch Harbour from wave action. Double Dykes is at threat from breaching and although this risk is very low (1% annual probability), if it occurred it would create a second tidal channel into Christchurch Harbour and separate Hengistbury Head from the mainland. Annexe D of this Appendix provides a review of the risk and consequences of breaching at the Double Dykes area of Hengistbury Head.

Other features significant in this area are Dolphin Bank and Shingles Bank, which act as sediment reserves and also refract and dissipate waves.

The eastern part of Christchurch Bay is sheltered from southerly and south-easterly and easterly waves by the western part of the Isle of Wight. This is influential on the stability and development of Hurst Spit, allowing sediment to be deposited. Hurst Spit is sheltered from wave activity by the presence of North Head Shoal.

3.2.3 Sediment Sources and Sinks

The beach sediment in Christchurch Bay was historically derived from the seabed, with very limited new offshore inputs available. There is limited input from fluvial sources via Christchurch Harbour. The Long Groyne at Hengistbury Head retains a significant amount of the eastward drift of sediment from Poole Bay, although as it is generally observed to be 'full' ongoing drift around the end of the structure must allow a reasonable amount of material to bypass this point.

In the past 50 years the amount of sediment available for long shore drift due to the recession of the Tertiary cliffs within Christchurch Bay has reduced. This is in part to the overall longer-term process of developing a stable bay shape but now also due to shore stabilisation and protection works. Despite this there are still important inputs to the nearshore system from the cliffed shoreline, particularly at Chewton Bunny and Becton Bunny. Drift rates are currently thought to be within the range of 5 – 20,000m^3a^{-1}.

Importantly, it should be noted that the cliffs from Becton Bunny to Milford-on-sea and Chewton Bunny to Barton on Sea are dependent on a complex landslide system providing sediment, rather than direct marine erosion due to waves and tides. Basic weathering of cliffs, from wind and rain, also contributes material to the frontage. Although these non-marine influences deliver much of the material to the beaches, coastal processes are integral in removing this material from the base of cliffs and transporting it along the frontage.

Sediment is lost from Christchurch Bay to the Western Solent, and offshore from Hurst Spit to be stored in the Shingles Bank. There is some storage of sediment on the spits at Christchurch Harbour. These spits are prone to periodic cycles of breaching and re-growth deflecting the harbour mouth to the north-east with sufficient sediment supply.

3.2.4 Sediment transport

Net sediment transport within Christchurch Bay is in an easterly direction, consistent with the direction of long-shore wave energy. SCOPAC (2004) determined that the direction of wave approach is more important than inshore wave heights in determining variations in the long-shore transport efficiency.

As the Christchurch Bay frontage runs east, the proportion of sand on the foreshore declines with more gravels present. The littoral drift supply to Hurst Spit is almost completely gravel.

There is limited sediment exchange at Christchurch Harbour mouth within the Mudeford Run. Around Hengistbury Head and Mudeford Spit there is some offshore transport of gravel and some onshore wave driven transport of sand and gravel. SCOPAC (2004) indicate that offshore transport mechanisms tend to move sand in a westerly direction, across Dolphin Bank, with accumulations at Dolphin Sand.

A north-easterly pathway brings gravels towards Hurst Spit with accumulations on the Shingles Bank. A counter-pathway heading south-west runs directly to the south-east of the Shingles Bank, driven by an estuarine derived currents from the Solent discharging around Hurst Spit.

A summary of these sediment transport pathways in Christchurch Bay is shown in Figure 3.1. (Taken from the SCOPAC sediment transport study (2004)).

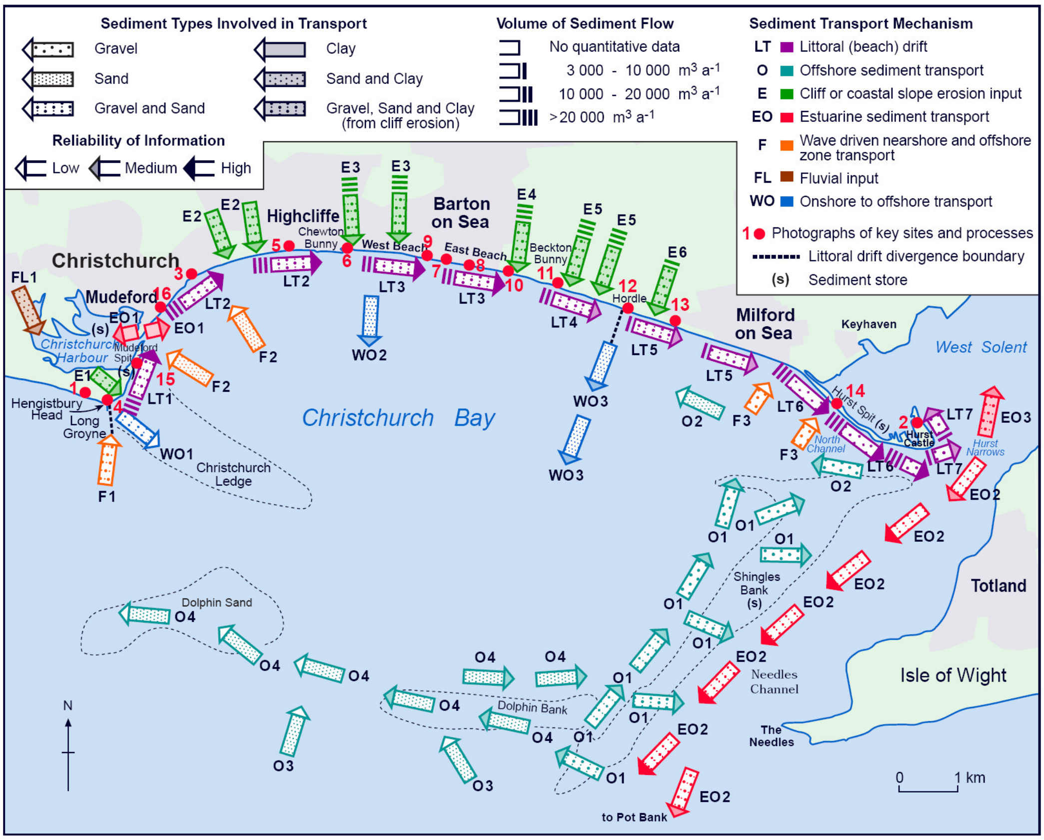

Figure 3.1 Sediment transport in Christchurch Bay

3.2.5 Future Shoreline Evolution

No active intervention

The unconstrained scenario (assumes no defences) provided in Futurecoast gives the following picture. Hurst Spit is likely to respond to sea level rise by rolling back, exposing the low-lying marshes and tidal flats which are currently on its sheltered lee side. Permanent breaching would be a low risk in the short to medium term. In the longer term breaching would become more likely. This would have implications in terms of the protected habitats behind, wave penetration into the Solent (increasing the energy dynamics within the estuary) and isolating Hurst Castle as an Island. The pace of this development would be strongly linked to the supply of sediment arriving via west to east littoral drift.

Central Christchurch Bay would experience recession of the cliffed areas, probably at a fairly rapid rate, due to mass sediment movement events. Material that initially formed talus slopes (slopes consisting of broken rock fragments, also referred to as scree slopes) would quite rapidly be removed and drawn into the nearshore system (feeding downdrift areas to the east – notably Hurst Spit).

Christchurch Harbour mouth and Mudeford Spit would most likely be dominated by a period of spit growth during the next century, both increasing its overall volume and pushing its distal end further to the north-east. In the even longer term, a cycle of breaching may occur again, as noted in the past. This would allow greater wave energy penetration into the harbour and reduce the natural protection to the Mudeford and Stanpit area.

With present management

Under a scenario where current management regimes remain (Hurst Spit CBY7 currently has a Hold The Line policy), Hurst Spit would be retained in place and breaching is likely to be avoided. This depends on continued availability of material for recharge of the Hurst Spit frontage and would dictate that the shelter provided to the western Solent and its intertidal areas would remain. Five of the seven Management Units in Christchurch Bay (CBY2, 3,4,6 & 7) currently have a Hold The Line policy. CBY1 & 2 currently has a policy of Retreat.

Continued efforts to reduce cliff toe erosion and groundwater related cliff instability within central Christchurch Bay are likely to be fairly successful in retaining the existing plan form shape of the Bay, however, reducing the erosion will reduce the inputs of sediment to the beaches. As such beach face erosion will increase and it is likely that in the long term, localised embayments will develop between the currently defended hard points.

Retaining present management of Mudeford Spit would effectively fix it in place; anchoring its distal end and preventing landward roll back. The Mudeford Run would remain in its current location and Mudeford Quay would remain in its present form.

Sensitivity to climate change exists along the frontage. Relative magnitude of sea level rises will influence the amount of reduction in depth limitation to waves that occurs.

3.3 Christchurch Harbour

This process unit is covered within the estuary process report, but the linkages with the open coast are briefly identified below.

Christchurch Harbour is the estuary of the Stour and Avon rivers, and is a wide and shallow lagoon. The volume and cross sectional area are very small, but appear to be in equilibrium. Its mouth is formed from two sand and gravel spits, with a narrow, maintained entrance. The spits are mobile, with a history of growth and breakthrough, although they are currently fixed by groynes.

There are extensive mudflats and saltmarshes although the upper parts of the estuary which have been reclaimed - this has limited the estuary volume. The estuary is ebb dominant, which helps keep the estuary clear of sediment deposition, and a maximum flow ratio is high enough to form a plume at all stages of the tide. This dictates a net movement of transport outside of the Harbour mouth through the Mudeford Run.

Christchurch Harbour is sheltered from the open sea by Hengistbury Head, with its lowest point, Double Dykes, at risk from breaching (this risk is low – around 1% annual probability). This would alter tidal flows in the estuary and the mouth of the estuary may try to relocate.

The ebb delta of the harbour acts to modify the coastal shape and transport of the coast locally to the east.

3.4 Hengistbury Head to Handfast Point (Poole Bay)

3.4.1 Past evolution

Poole Bay is a headland-controlled log spiral embayment, and is still adjusting to the erosion and breaching of the former Chalk ridge extending between the Isle of Purbeck and the Isle of Wight. Erosion of the soft Tertiary shoreline geology enabled the Bay to be formed by inundating the former basin of the Frome and Piddle rivers. This occurred over at least the last 8,000 years. Huge quantities sediments from the sandy Tertiary geology would have been released as the Bay was formed.

Sea bed sediments were then driven up by rising sea levels and were forced landwards to form barrier beaches comprised of non-cohesive sediments. A permanent breach in the western end of the barrier led to the creation of Poole Harbour.

The sandy promontory of the South Haven Peninsula (Studland) is a succession of dunes ridges and slacks that have accumulated on the southern spit of Poole Harbour's entrance. The sandy sediments originating from the erosion of the tertiary cliffs during the creation of Poole Bay are a likely source for the historical accumulations at Studland.

Studland Bay was formed as the dune ridges developed on Poole Harbour's southern spit. Saline lagoons developed, which became isolated from the sea. The older dune ridges are heavily vegetated, the oldest being developed by 1720, the next by 1840, and the last by 1900. The most seaward ridge formed in 1950's and is still developing.

3.4.2 Physical controls

The shape of Poole Bay is primarily determined by the Isle of Purbeck and Hengistbury Head. Handfast Point is formed from relatively resistant chalk, and softer materials each side have eroded away. The headland is also a primary control on Poole Bay as it shelters the eastern part of the Bay from the predominant south-westerly waves, and is regarded as relatively stable. This also drives the localised shore drift reversal at Branksome Chine, causing the development of the Sandbanks spit. The Sandbanks shoreline is further stabilised by the ebb delta at the mouth of Poole Harbour.

Reference to the first Shoreline Management Plan (Halcrow 1998) suggests that around 75% of the shoreline is defended within this process unit.

The low cliffs at Double Dykes present a possible threat of breaching, although studies have calculated this as only a 1% annual probability (NFDC, Halcrow 2004). If a breach occurred this would disconnect Hengistbury Head from the mainland and potentially redirect the River Avon to flow through the breach. It is unlikely that enough sediment would be available from local sources to seal any breach. However an enormous volume of sediment would need to be eroded and put into suspension (approximately 340,000m^3) for a full breach to occur (Halcrow, 2006).

Hengistbury Head is discussed in Section 3.3 above.

3.4.3 Sediment sources and sinks

Beach sediment in Poole Bay is derived from the sea bed during the Holocene sea-level rise, and fresh input is very limited. Potential sediment supplies exist in the cliffs of Poole Bay, but these are well-defended. Fluvial inputs are very small as sediments are deposited in Poole Harbour.

Sediment is generally transported alongshore from west to east. There is some transport offshore from the eastern end of the bay, and some movement of sediment around Hengistbury Head Long Groyne.

Present day sources also include sediment inputs from the erosion of cliffs and coastal slopes in the southern part of Studland Bay.

In the past the sediment budget of Poole Bay would have been sustained by cliff erosion. However, following almost complete coastal protection over the 20th Century, combined with the long term reduction in general erosion of the bay, it appears to have become completely closed to natural fresh sediment inputs with one exception. This exception is some continuing cliff erosion at Hengistbury Head and sediment inputs from the erosion of cliffs and coastal slopes in the southern part of Studland Bay.

Relatively little sediment is stored within the thin beaches or seabed deposits of the Bay. Exceptions are the large accumulations of Dolphin Sand (fed by Christchurch Bay) and Hook Sand and Studland Bay in the west.

As part of coastal defences along the Poole Bay frontage, periodic beach replenishment helps maintain beach levels in conjunction with timber and rock groynes. Some of this sediment has been supplied from dredging in Poole Harbour, some from licensed dredging areas, and has led to a wide beach in front of the eastern end of Hengistbury Head, where some accumulates west of the Long Groyne, the remainder bypassing the Head.

Recent observations taken from the Regional Monitoring Programme (CCO 2008), provide a picture of overall accretion within the Poole Bay process unit over the last 5 years. However this is very much linked to the beach re-nourishment activities which have been undertaken during the last 4 years (recharge has occurred during 2005, 2006 and 2007. If the trends are observed for the period 2007 to present (since the last recharge occurred) an erosional pattern is seen and general loss of sediment volume is observed across the entire frontage. This does tend to suggest that without recharge schemes going ahead, the overall pattern would be erosion, with steepening beaches and increasing net offshore movement of sediment. This helps to highlight that the coastal system has not yet reached natural equilibrium (refer to earlier point in Section 3.2.1) with the hydrodynamics continually acting to move the sediment away from the frontage.

3.4.4 Sediment transport

A summary of sediment transport in Poole Bay from the SCOPAC Sediment Transport Study (2004) is shown in Figure 3.2, and from Poole Bay to Handfast Point in Figure 3.3.

Much literature exists regarding sediment transport within Poole Bay. The SCOPAC Sediment Transport Study (2004) provides a good review of the literature and the following summary is adapted from that study.

Poole Bay operates as a partially enclosed sediment circulation system exporting sediment eastward toward Hengistbury Head and Christchurch Bay. It also transports some material south and south-west to the offshore seabed.

A well-established net eastwards drift operates throughout most of the bay and transports littoral sediments towards Hengistbury Head. Long Groyne retains significant amounts of material, but sand is also moved offshore and the remaining material drifts into Christchurch Bay. Volumes of material available for long-shore drift have reduced dramatically during the last 100 years due to the intense shoreline and cliff stabilisation and protection works. This general trend in reduced natural input has been interrupted by short-term gains due to beach replenishment activities. Drift is more complex along the Sandbanks peninsula and the littoral transport regime is affected by the presence of the East Looe tidal channel close inshore and the refraction of incoming waves over Hook Sand.

A well-defined south-west sand transport pathway operates across the offshore seabed of Poole Bay. It is possible that that some of this transported material supplies Hook Sand and that some is lost further offshore to the south.

Sandbanks Spit links with the coastal processes active in both Studland Bay and Poole Harbour. Sediment exchange occurs between these process units via the Harbour's ebb tidal delta (Hook Sand) but this appears to be a very complex system (see Figure 3.2).

The Hook Sand accumulations are important to the overall health of the Poole Bay shoreline. Although there maybe some new supply due to the offshore south-west pathway discussed above, it appears to be a mainly relict source. Hook Sand is currently very influential in attenuating wave energy before it reaches the vulnerable Sandbanks frontage. Any lowering in the elevation of this bathymetric feature could have series erosion and flood risk implications. This may be of concern considering the continued supply of material from Hook Sand into the Studland frontage. However observations suggesting erosion along the Studland frontage are also presented, so the picture remains a complex one. .

Poole Harbour Entrance to Hengistbury Head (Poole Bay): Sediment Transport

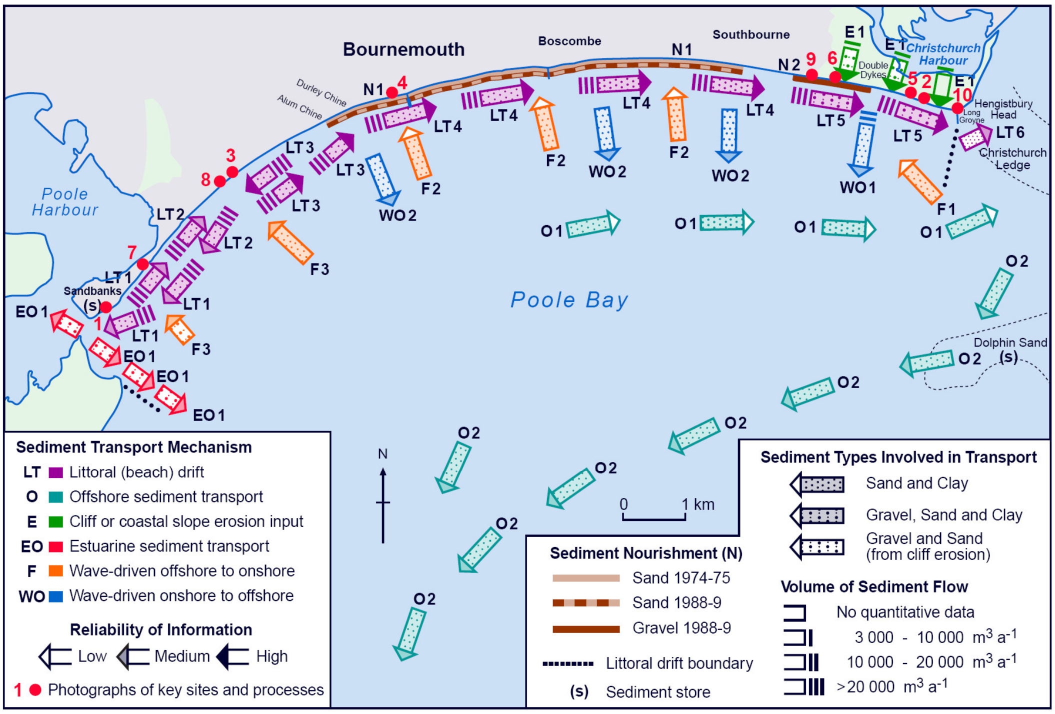

Figure 3.2 Sediment transport in Poole Bay (From the SCOPAC sediment transport study (2004)

3.4.5 Future Shoreline Evolution

No active intervention

An unconstrained scenario at Hengistbury Head would lead to relatively rapid erosion of the south-west facing shoreline and easterly transport of much of the material currently retained by Long Groyne, feeding Mudeford Spit, (encouraging its elongation) and central Christchurch Bay. Breaching at Double Dykes would become a more likely scenario in the medium to longer term. A new inlet to Christchurch Harbour would increase wave energy within it, however an ebb-dominated delta may well develop, which in time would provide some shelter to the new inlet from waves. A delta in this position may also partially arrest the west to east littoral drift of sediment, leading to significant accumulations originating from the central Poole Bay area. The risk of a breach occurring across the low-lying Double Dykes area due to high fluvial flows from within the Harbour has also been highlighted as a potential risk.

Central Poole Bay would experience increasing alongshore and offshore transport of material in response to rising sea levels. Although rising topography initially would hinder the landward movement of the shoreline, steepening shoreface and foreshore could re-establish a tendency toward cliff line recession. Recession rates would be high due to the soft geological nature of the frontage. This recession would provide fresh material to the beaches, predominantly to the east.

Sandbanks Spit would respond depending upon how much additional eroded material was transported to it from central Poole Bay. Additional material may allow it to extend in length and volume but this is not certain. It would however be likely to migrate landwards in response to rising sea levels.

With present management

Currently there is a hold the line policy for the majority of Poole Bay (Management Units PBY1 & PBY2, extending to Warren Hill). A retreat the line policy for the 'Landform' while holding the width of the intertidal area through 'limited intervention' was adopted for the Warren Hill to Long Groyne frontage.

Continued replenishment of Solent Beach should continue to reduce the rate of recession of the sea cliffs at Hengistbury Head. Adequate volumes of material will continue to be retained inside Long Groyne to maintain the width of the beaches. This should dictate that a wide foreshore of mixed sand and gravel is retained, providing dissipation of wave energy. Recession rates should reduce but they will not cease entirely.

Under the present management regime there would be little change at Double Dykes in the short to medium term, however in the long term, breaching remains a risk, particularly as the gabions and groynes become less effective in the face of rising sea levels.

Central Poole Bay should undergo no change in plan form under present management, however, as with so much of the overall SMP frontage, this is very dependent on the continued replenishment of the beaches.

Maintaining the current defences at Sandbanks will retain the spit in its current position and plan form. Most existing sediment within the spit is locked in by the current defence structures, but it will continue to feed a small amount of material both into the ebb tide delta and eastwards towards central Poole Bay.

3.5 Poole Harbour

This process unit is covered within the estuary process report, but some key points and linkages with the open coast are briefly identified below.

Poole Harbour is a major commercial port, handling up to 600,000 passengers on its RoRo ferry. It is also the UK's largest inshore oilfield and a designated Ramsar site, SSSI, SAC and SPA. A chain ferry links Sandbanks to South Haven Point and carries approximately 180,000 pedestrians and 800,000 vehicles per year.

Poole Harbour contains one large island, Brownsea Island, and several smaller ones, including Furzey Island and Green Island. Brownsea Island contains important examples of both the natural and historical environment. Brownsea Island is a very dominant feature within Poole Harbour and its proximity to the mouth of the Harbour links it to the sediment erosion and deposition behaviours observed there. Although Brownsea Island is dealt with physically as part of the Poole Harbour system, it would be treated as an independent location for the development of management policy in the final SMP document. Originating from the first SMP (and maintained within the Poole Harbour Strategy document), Brownsea Island is divided into 4 separate Policy sub-Units: PHB2a; PHB2b; PHB2c; PHB3.

3.5.1 Physical Controls

Poole Harbour is a large and shallow enclosed estuary with double sandy spits forming its mouth. It was formed by a breach in the barrier beaches created by the last Holocene sea level rise and acts as the estuary of the Frome and Piddle Rivers. The harbour has lagoon-like characteristics due to the double high water tidal regime.

The main channel of the estuary runs along the more developed northern side of the harbour, whereas the southern side is more natural, comprising extensive mudflats and saltmarshes.

3.5.2 Sediment

There is evidence of redistributed sediment within Poole Harbour as erosion takes place on undefended sections on the northern side, and deposition occurs near the river mouths. Although there is some transport of finer material out of the Harbour on the ebb tides (ABPmer 2009), it appears that the finer sands and sediments are mostly deposited within the Harbour along the creeks and on the mudflats and alluvial plain (SCOPAC 2004). There may be some coarse sand transported through the harbour mouth, this however, is likely to depend upon the availability of transportable sediment and it is likely to be limited to the relatively small quantities of coarser sediments delivered by the Frome and Piddle Rivers (SCOPAC 2004). The overall picture of natural sediment transport through the Harbour mouth is difficult to establish, as there is regular dredging of the main channel, and this has been used for recharging along the beaches of Poole Bay.

The last capital dredge took place between November 2005 and March 2006, when the Middle Ship and Swash Channels were dredged to 7.5m below chart datum and 1.8million m^3 was removed and redistributed along Poole Bay.

3.6 South Haven Point to Handfast Point (Studland Bay)

3.6.1 Past Evolution

Studland Bay occupies an 8km stretch of the SMP frontage and the wide sandy beach and dunes that exist there are thought to be geologically very recent, perhaps only forming in the last 500 years. Recent trends have seen erosion in the southern section of Studland Bay and accretion to the north. This agrees with the generally accepted south to north littoral drift along this frontage and supports the concept that the frontage is very strongly influenced by the harbour entrance and ebb tidal delta. Accretional trends north of Redend Point have established the largest area of sand dunes in central southern England. SCOPAC (2004) reports that these dunes have accumulated during a series of accretional periods. This implies cyclic or episodic sediment supply from offshore sources but also demonstrating the nature of this frontage as a morfa rather than as a typical spit.

Recent monitoring undertaken by Natural England at Studland indicates that the entire frontage has been eroding over the past few years and that the northern part of the frontage is no longer accreting (Caldow, 2009)

3.6.2 Physical controls

This unit effectively encompasses Studland Bay with South Haven Point marking its northern boundary and Handfast Point to the south. South Haven Point marks the southern side of the tidal inlet to Poole Harbour.

The Isle of Purbeck represents an important geological control as it provides significant shelter to the Studland shoreline from the prevailing south – south-west waves. This results in a generally low energy shoreline. Historical morphological trends along the Studland shoreline can be attributed to this low energy, refracted and diffracted wave climate originating from the south – south-west. However, Studland is fully exposed to the occasional storms that originate from an east – south-easterly direction and these storms can mobilise very large amounts of sediment during a single event.

Present day sea level rise and increasing storminess now represents a significant threat to the Studland frontage and recent erosion is thought to be due to increasing frequency of storm waves from the east – south-east.

3.6.3 Sediment sources and sinks

Both Studland Bay itself and the extensive dunes in the northern section represent a regional sediment sink. It is identified as a distinct sub-cell within the overall sediment transport mechanisms of Poole Bay and although these independent processes operating within Studland Bay mark it out as a separate unit for the purposes of this review, it is more widely regarded by coastal authorities as a regional sediment sink within the overall processes of Poole Bay (SCOPAC, 2004). The quantity of stored sediment is believed to be in the region of 25 to 50 million cubic metres (SCOPAC 2004).

Sediments originating from the erosion of the Tertiary cliffs in Poole Bay are a likely source for the historical accumulations. Present day sources also include sediment inputs from the erosion of cliffs and coastal slopes in the southern part of Studland Bay but these are not identified as very significant.

3.6.4 Sediment transport

It is believed that the majority of sand inputs to the Studland system can be attributed to onshore transport from the bed of Studland Bay (SCOPAC 2004). Net accretion appears to have continued to occur until the late 1990s.

A south-east directed tidal sediment transport pathway operates due to the tidal ebb dominance of Poole Harbour entrance. This is likely to have been primarily responsible for the delivery of sediment to the Studland frontage.

Redistributions of material occur at the shoreline and episodes of erosion have been observed in southern parts of Studland Bay and in Shell Bay. As sediment appears to be transported northward by the net littoral drift within the bay, this explains why the southern parts have tended to erode and also supports the assumption of Studland Bay as a sub-cell within the wider log spiral form of Poole Bay.

Figure 3.3 below taken from the 2004 SCOPAC Sediment Transport Study, gives a visual demonstration of the sediment transport pathways as they are believed to operate throughout Studland Bay and around South Haven Point.

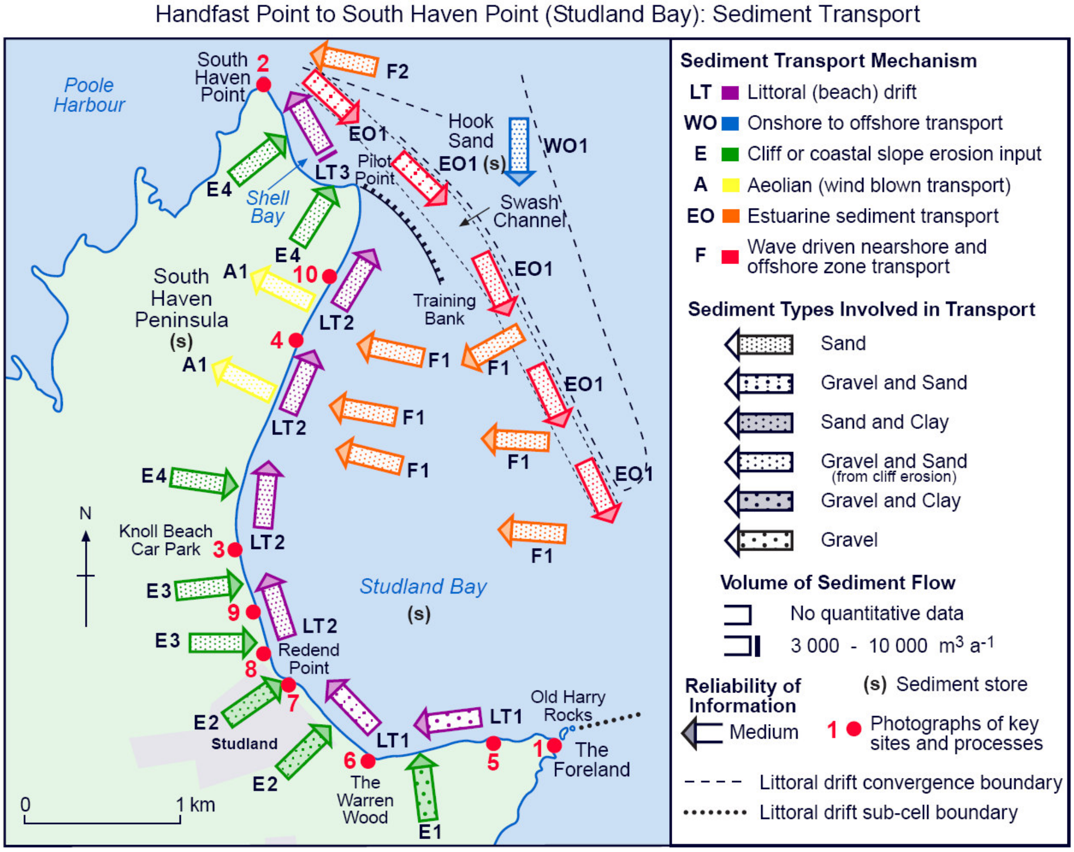

Figure 3.3 Sediment transport pathways in Studland Bay

3.6.5 Future Shoreline Evolution

No active intervention

Futurecoast predicts that the Studland frontage is likely to change from a growing dune system to an eroding one under an unconstrained scenario, due to the exhaustion of sediment supplies. Some accretion in the northern sector of Studland Bay would still be likely to occur, though at a gradually slowing rate. It is also theorized that active morphology along the central part of Poole Bay and the Sandbanks Spit would feed enough sediment into the offshore Hook Sand area to provide stability to the Studland frontage. This frontage is however also likely to show high sensitivity to climate change and the relative rate of sea level rise.

With present management

The Studland frontage is very much a naturally operating coastal system and as such, the WPM scenario differs little to the NAI scenario described above. Guidance provided by the current SMP gives a Selectively Hold The Line policy for the northern part of

Studland Bay (STU 3 & 4). Do Nothing and Retreat options are the long-term policies for the southern section (STU1 & 2 respectively).

3.7 Handfast Point to Durlston Head

3.7.1 Past evolution

The embayments between Handfast Point and Durlston Head have been formed by the erosion of softer material, while the erosion resistant areas formed headlands. Durlston Head and Peveril Point are limestone, while Ballard Point is chalk.

This section of east facing shoreline reflects the alternating east to west striking sedimentary strata of variable erosion resistance truncated by a north to south trending coastline (SCOPAC 2004). Both Durlston and Swanage Bays have eroded into less resistant sediments and are backed by active cliffs.

The overall shape of Swanage Bay appears to be continuing to evolve toward log spiral form.

3.7.2 Physical controls

This section of coastline is sheltered from the dominant south-westerly storms. The Isle of Purbeck is the dominant geological control offering shelter from the south – south-westerly waves. Durlston Head, Peveril Point and Handfast Point mark the boundaries of Durlston Bay and Swanage Bay. Ballard Point is a chalk headland in the northern section of Swanage Bay. This process unit is exposed to the less frequent and generally less severe easterly – south-easterly storms, however these are thought to be occurring more frequently.

There is reduced management intervention along this section of the coast due to the resistant nature of the coastline, however there are still seawalls and groynes in existence for around 25% of the frontage length, primarily in Swanage Bay, with a revetment present in Durlston Bay. There are complex landslips at Ballard Cliffs at the northern end of Swanage Bay. These cliffs are subject to active land sliding and the soft Wealden Beds of sands and clays are sensitive to rainfall intensity (higher intensity can promote higher pore water pressures within the cliffs). In addition their relatively soft composition makes them vulnerable to toe erosion, particularly under a scenario of rising sea levels and increased wave energy.

3.7.3 Sediment sources and sinks

Cliff erosion supplies sands and some flint gravels to Swanage Bay, whereas Durlston Bay receives clays and limestone boulders (SCOPAC 2004). Most inputs, however, are fine materials that become transported offshore in suspension so that only thin, narrow beaches occupy the bays and therefore limited littoral sediment drifts are observed along this section of coast. Beach sediments are derived from erosion material from the historical formation of the bays and therefore beach and bay sediments represent a finite resource.

There was some beach replenishment at Swanage in 2005. Swanage Bay is thought to act as a sink for limited amounts of sediment, these accumulations coming principally from the erosion of the local cliffs.

3.7.4 Sediment transport

There is very limited littoral sediment exchange between the bays, and beach volumes have decreased as sediment is transported offshore. There is thought to be a north-east to south-west offshore pathway which may transport some sediment generally from Swanage Bay to Durlston Bay.

Although some recent modelling studies have concluded that there is a net northward drift in Swanage Bay, observations do not support this. Generally the beaches are depleted, with only the gravel component increasing to the north. It is possible that the crucial inputs from the Wealden cliffs have reduced beyond a critical point following establishment of coast protection measures in Swanage Bay.

A summary of sediment transport in Swanage Bay from the SCOPAC sediment Transport Study (2004) is shown in Figure 3.4 below.

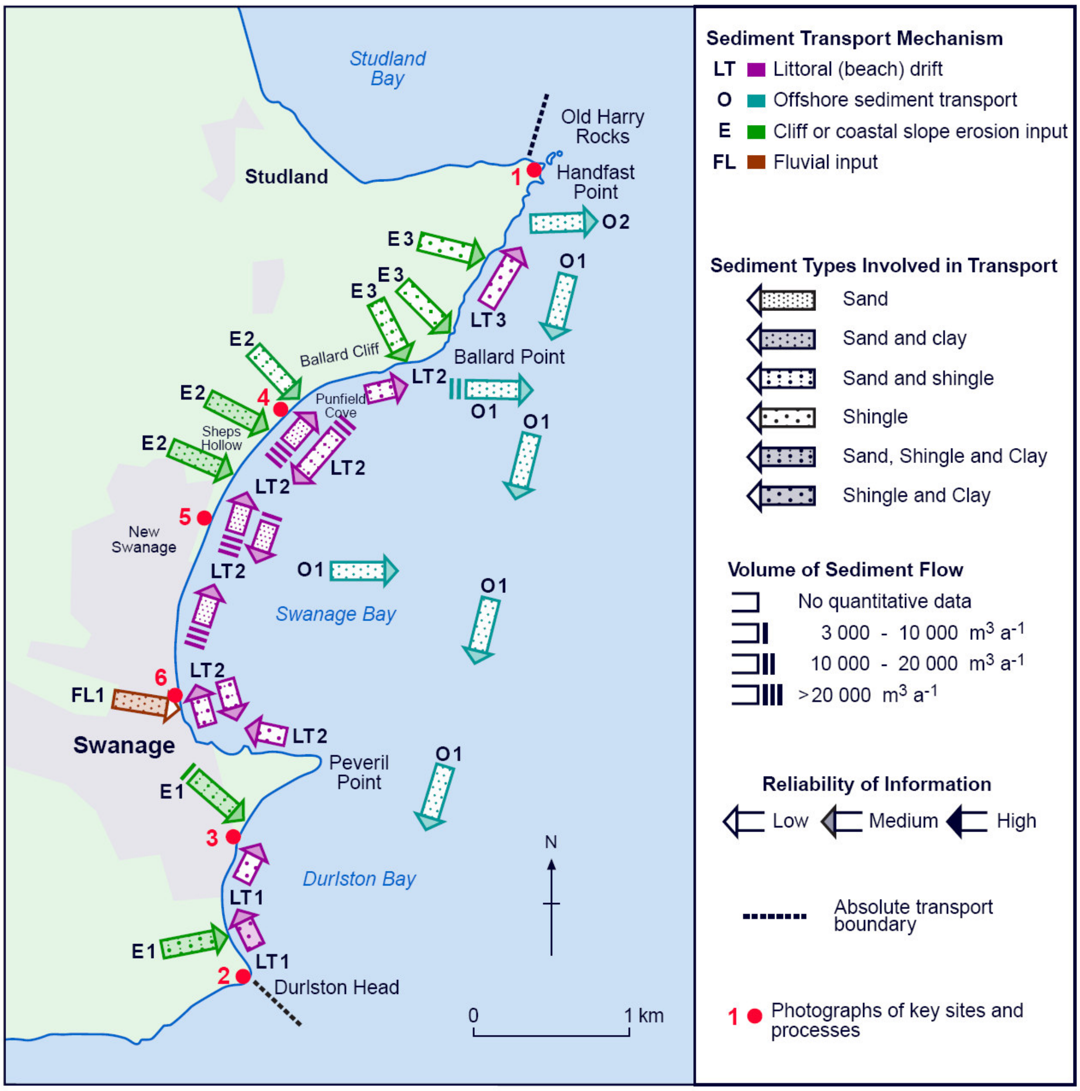

Figure 3.4: Sediment transport pathways in Swanage and Durlston Bays

3.7.5 Future Shoreline Evolution

No Active Intervention

Limited recession of the cliffs, particularly the chalk sections, would continue over the next 100 years. The resistant headlands within this process unit would change little within the same period. Much of the material would be in the form of boulders originating from mass failure events. As such it would be broken down slowly in-situ and would then predominantly be transported offshore. The rate of offshore transport would be likely to increase along the whole frontage as sea level rise accelerates toward the end of the century.

A No Active Intervention policy would have impacts upon erosion rates of the softer Wealden Beds, primarily through rising sea levels and increased wave energy impacts at the toe of the cliffs.

With present management

Current policy for this process unit includes the Management Units DUR1, 2 & 3, plus SWA1, 2, 3, 4 & 5. A combination of Hold The Line is used for the urban frontages of Durlston and Swanage together with Do Nothing policies for the cliffed areas.

With around 25% of the frontage defended within this process unit, around 75% of the frontage could be expected to continue to evolve as in the unconstrained scenario. Where defences are present, cliff recession will be slowed, but rising sea levels will lead to foreshore steepening in the longer term. Where defence sections end adjacent to the softer geology, some outflanking and undercutting of structures could occur.

Table 1.1 Reports and Studies

Id	Title	Author	Date produced	Geographic Coverage
1	Response of Shingle Barrier Beaches to Extreme Hydrodynamic Conditions	A. P. Bradbury	1998	
2	Swanage Coast Protection Scheme	Halcrow	Mar-2005	Swanage
3	Past & Future Cliffline movements between Barton on Sea & Milford-on-Sea, Christchurch Bay 2004	University of Southampton	Mar-2004	Barton on Sea to Milford-on-Sea
4	A study of the Reactivation of Landsliding at Barton-on Sea, Hampshire following the Stabilisation works in the 1960's - MSc dissertation	Phil Garvey/ Southampton University	Sep-2007	Barton on Sea
5	SCOPAC Sediment Inputs to the Coastal System - Summary document	Posford Duvivier	Mar-1999	Beachy Head to Dawlish Warren
6	New Forest Coastal Archaeological Resource	NFDC	Nov-1994	Hurst Spit to Calshot
7	SCOPAC Research Project: Preparing for the Impacts of Climate Change	SCOPAC	Nov-2001	Lyme Regis to Worthing
8	Dredging. Application for Marine Aggregate Extraction Licence Area 451 St Catherine's Environmental Statement	Other	Jun-1998	St Catherines Deep IOW
9	Barton Cliffs Vegetation & Restoration Trials (NFDC 1999)	NFDC	May-1999	Barton on Sea Undercliffs
10	Environmental Statement: Aggregate Production Licence Production West Channel (Area 465/1 & 465/2)	Other	Aug-1999	West Channel IOW
11	Sturt Pond - A report on the Environmental Condition of Sturt Pond	NFDC	Jun-2001	Sturt Pond
12	Naish Beach Coast Protection Scheme Preliminary Studies	NFDC	1996	Naish Beach
13	Barton on Sea Cliff Stabilisation 2002	NFDC	Oct-1994	Barton on Sea Undercliffs
14	Cliff Erosion in Christchurch Bay MSC	University of Southampton	May-1995	Christchurch Bay
15	Review of the Hampshire Coastline Volume I & II	HR Wallingford	Aug-1987	Hampshire
16	Poole Sea Defences Feasibility Study 2008	Other	Apr-2005	Poole

Id	Title	Author	Date produced	Geographic Coverage
				Harbour
17	Hengistbury Head Consequences of Breaching	Halcrow	Jun-2006	Hengistbury Head
18	Wareham Strategy Inception Report. October 2000	Halcrow	Oct-2006	Wareham & Estuaries
19	Swanage Coastal Flood Warning Procedures 2007	Halcrow	Feb-07	Swanage Bay
20	Purbeck District Strategic Flood Risk Assessment	Purbeck District Council	Jul-2007	Purbeck District
21	Fishermen's Jetty, Swanage.	Purbeck District Council	Oct-2007	Fishermens Jetty, Swanage
22	Mudeford & Stanpit Flood Risk Pre Feasibility Report	Royal Haskoning	Feb-2008	Mudeford & Stanpit
23	Poole Harbour Flood Model Review	EA Regional Office	Jul-2008	Poole Harbour
24	Mudeford & Stanpit Flood Risk Viability Report	EA	Sep-2008	Mudeford & Stanpit
25	Holes Bay Flood Risk Pre Feasibility Report	EA	Oct-2008	Holes Bay, Poole
26	Poole & Christchurch Bays Research Project 1980	Bournemouth Borough Council	May-1980	Poole & Christchurch Bays
27	Poole & Christchurch Bays Research Project 1980 Appendices	Bournemouth Borough Council	May-1980	Poole & Christchurch Bays
29	Hampshire Coast – Historical Changes on the Hampshire Coast 1870 to 1965	Other	Jul-1987	Hampshire Coast
30	Barton on Sea. Monitoring of Ground movement & Groundwater 1991 to 1997	NFDC	Jun-1998	Barton on Sea
31	Hurst Spit Stabilisation Scheme Dredging Area 406 Annual Reports	NFDC	1997, 1998, 1999	Hurst Spit
33	SCOPAC Research Project. Coastal Sediment Transport Study Volume 4 Highcliffe Castle to Swanage	SCOPAC	Sep-1991	Hurst Spit to Swanage
34	SCOPAC Sediment Transport Study Vol 1	SCOPAC	Sep-1991	Brighton - Lyme Regis
35	Marine Aggregate Evaluation of Shingles Bank Christchurch Bay (1992)	University of Southampton	Jun-1992	Shingles Bank, Christchurch Bay
36	SCOPAC Research Project: Sediment Inputs in the coastal system. Phase 3	SCOPAC	Jan-1999	All
37	Poole & Christchurch Bays Research Project Sediment Sampling & Analysis Reports	University of Southampton	1979-1988	Poole & Christchurch Bays
38	Durlston Bay Coastal Strategy Study	High-Point Rendel	Nov-2005	Durlston Bay
39	Durlston Bay coastal Strategy Study	Purbeck District	n/a	Durlston Bay

Id	Title	Author	Date produced	Geographic Coverage
		Council		
40	Strategic Monitoring of the Coastline Towards a Regional Approach (NFDC)	SCOPAC	N/A	South Coast
41	Peveril Point Options Appraisal Report	Dorset County Council	Feb-08	Peveril Point
42	Poole Harbour Flood Risk Pre Feasibility Report		In Progress	
44	South West - Report on Regional Extreme Tide Levels February 2003.	Royal Haskoning	2003	
45	Tidal Flood Zones Compliance Main Stage. December 2007			
46	Poole Harbour Approach Channel Deepening & Beneficial Use of Dredged Material.	Royal Haskoning	2004	Poole Harbour
47	Hengistbury Head – observations & questions relating to Halcrow's "Poole Bay & Harbour Strategy Study"	HenRA	2005	Poole Bay & Harbour
48	South-east Strategic Regional Coastal Monitoring Programme Annual Reports & Wave Reports	CCO	2008	
49	Middle Beach gabion sea defences condition assessment	(Royal Haskoning)	2001 - 2008	
50	Studland Bay Management Plan - Managed realignment commissioned by National Trust	(Halcrow)	2006	
51	Wessex Region - broad-spectrum risk assessment for all National Trust / Coastal Properties in the Wessex Region			
52	Poole Harbour. The vegetation of Poole Harbour	Brian Edwards	2004	
53	Barton on Sea. The Coastal Landslides at Barton on Sea Hampshire UK	HP Rendel	2002	
54	Report on analysis of cliff stability	NFDC	1991	
56	Poole & Christchurch Bays Research Project Sediment Sampling & Analysis	Southampton University	1986	
57	Swanage Beach Recharge Scheme	Halcrow	2005	
58	Purbeck District Council. Options Report			
59	Swanage Bay Beach Management Study	Halcrow	2000	
60	Swanage Beach Recharge Scheme Engineers Report and Beach Management Plan	Halcrow	2004	
61	Swanage Beach Recharge Scheme Environmental statement	Halcrow	2004	
63	Studland. Middle Beach Studland - condition assessment of the gabion sea defences	(Royal Haskoning)	2001 - 2008	

Table 1.2 Management Plans

ID	Title	Author	Date
117	New Forest SAC Management Plan	NFDC	2001
104	Dorset and East Devon Coast World heritage Site Management Plan	Other	2003
39	Hengistbury Head. Tackling Coastal Challenge. Dorset Rural Pathfinder Challenge 4: The breaching of Hengistbury Head	Dorset Coast Forum	2005
101	Poole Harbour Aquatic Management Plan	Dorset Coast Forum	2006
67	New Forest District Council Coastal Management Report (NFDC 1997)	NFDC	Apr-1997
109	Poole & Christchurch Bays SMP1	Halcrow	Mar-1999
103	Dorset Coast Strategy	Dorset Coast Forum	May-1999
113	Mudeford Quay Management Plan	Christchurch Borough Council	Apr-2000
114	Mudeford Sandbank Management Plan	Christchurch Borough Council	Mar-2001
128	Local Authority Local Plans	Christchurch Borough Council	Mar-2001
106	Poole Bay & Harbour Strategy Study	Other	Jun-2003
107	Hurst Spit Beach Management Plan	NFDC	Feb-2004
68	New Forest District Council Coastal Management Report (NFDC 2003)	NFDC	Feb-2005
105	Dorset Local Geodiversity Action Plan	Other	Feb-2005
110	Hengistbury Head Management Plan 2005	Bournemouth Borough Council	Jun-2005
126	Local Authority Local Plans	NFDC	Aug-2005
112	Christchurch Quay Management plan	Christchurch Borough Council	Dec-2005
125	Harbourside Management Plan	Borough of Poole	Jan-2006
121	The Dorset Stour Catchment Flood Management Plan	EA Area Office	Oct-2006
108	Purbeck District Strategic Flood Risk Assessment	Purbeck District Council	Jul-2007
127	Local Authority Local Plans	Bournemouth Borough Council	Jul-2007
41	Milford-on-Sea Action Plan – Parish Vision 2020 (Sept 2007)	Other	Sep-2007
118	Bournemouth, Christchurch, East Dorset & Salisbury SFRA	North Dorset District Council	Feb-2008
111	Christchurch Beaches & Hinterland Management Plan	Christchurch Borough Council	Apr-2008
31	Christchurch Harbour & Waterways Management Plan	Dorset Coast Forum	Jun-2008
83	Poole Harbour SFRA	Borough of Poole	Jul-2008
100	Christchurch Harbour & Waterways Management Plan	Dorset Coast Forum	N/a
84	Environmental Statement	Royal Haskoning	
1	Bournemouth Borough Council Leisure Services Seafront Strategy 2007 – 2011	Bournemouth Borough Council	2007
115	River Frome Water Level Management Plan	EA Regional Office	Dec-2006
99	Frome & Piddle Coastal Flood Management Plan		
102	Dorset Area Outstanding Natural Beauty Management Plan		
116	Water Framework Directive		
119	Brownsea Island Management Plan		
120	Coastal Habitat Management Plan (CHaMPS) for Poole Harbour		

Table 1.3 Strategy Reports

ID	Title	Author
26	South Wessex Coastal Defences Strategic Review	EA
97	Planning Policy Guidelines PPS25	Government
123	Christchurch Bay Strategy Study	NFDC
124	Poole Harbour SFRA	PBC
	Dredging in Christchurch Harbour – towards a sustainable solution (2004)	Christchurch Borough Council

Table 1.4 Data

ID	Title	Author
2	Bournemouth Conurbation tourism usage figures / economic impact figures (£'s) at beach / beach usage numbers	Bournemouth Seafront Office
3	Poole Bay. Wave conditions at west end of Poole Bay commissioned by Branksome Park, Canford Cliffs & District Residents Association	BPCCRA
9	Christchurch Harbour. Annual ornithological reports dating back to 1956	Christchurch Harbour Ornithological Group
93	Wessex - rare reptile & amphibian locations	The Herpetological Conservation Trust
96	Barton & Highcliffe, Coast Erosion - Geology of the Wessex Coast of Southern England	Ian West
51	Barton on Sea cliff movement (NFDC 1995 to present)	NFDC
32	Future Coast (2002)	Halcrow
4	LiDAR	CCO
5	Aerial ortho rectified photographs	CCO
6	Topographic data	CCO
7	Bathymetry	CCO
8	Wave data	CCO
10	Barton on Sea. Aerial photographs showing changes to the cliff top for the period 1950 – 1980	Cliff House Hotel
15	Event Report Coastal Flood Event 10th/11th March 2008 Wessex Area	EA
30	Wareham Meadows and Moors (15 Drawing Sheets) Land around Frome and Piddle	EA
34	Hengistbury Head – films & reports	HenRA / NFDC
35	Hengistbury Head – photographs of headland and low lying areas	HenRA / NFDC
36	Hengistbury Head – Sea breakthrough fact sheets 1,2 & 3 (Aug 05 to Nov 2007)	HenRA / NFDC
40	Hamworthy Park – photographs of flooding – Spring 2008	Lake Residents Association
43	National Trust. Plans of tenanted and franchised property/businesses. Details of NT infrastructure and Studland Bay amenities	National Trust
48	National Flood & Coastal Defence Database (current)	EA
53	Barton on Sea Piezometer Data (NFDC 1991 to Present)	NFDC
54	Barton on Sea Rain Gauge Data (NFDC 1999 to present|)	NFDC

Table 1.5 Mapping

ID	Title	Author
22	Poole Harbour Strategy Tidal Flood Risk Mapping Final Summary Results Report July 2003	EA
23	Areas Benefiting from Defences Flood Risk Mapping. 2008	EA
25	South Coast Tidal Flood Risk Mapping Summary Results Report March 2003 Final Report. SUPERSEDED by Tidal Flood Zones Compliance Main Stage. December 2007	EA
47	National Coastal Erosion Risk Mapping (current)	NCERM website
13	Wareham Tide Banks Topographic Survey March 2004 and July 2005	EA

Additional References

Caldow, Richard, (Natural England) 2009 – Personal communication -