

Channel Coastal Observatory
National Oceanography Centre
European Way
Southampton
SO14 3ZH

Tel: +44 (0)23 8059 8469
Fax: +44 (0)23 8059 6320
e-mail: samantha.cope@noc.soton.ac.uk
Website: www.channelcoast.org

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Authors: **Cope, S.N and Wilkinson, C.**

Approved By: **Bradbury, A.P.**

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SCOPAC Sediment Stores & Sinks Study

Channel Coastal Observatory

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1. Introduction

1.1 Background

Hard engineering measures implemented in the 19th and 20th centuries have in some cases led to erosion of beaches throughout the SCOPAC region. For densely populated locations, on-going beach management works using soft engineering approaches is essential to prevent flooding and erosion.

Approximately 21% of the beaches along the SCOPAC coastline undergo beach management in the form of recycling, replenishment or sediment bypassing to maintain the standard of protection. These soft engineering approaches have been in practice since the 1970's in England. In the majority of cases these practices are considered more environmentally friendly than hard engineering solutions.

Sediment recycling and bypassing are often more efficient management options for maintaining beach levels compared with beach replenishment. Using these beach management options, the re-use of sediment is relatively low in cost and can be implemented quickly as sediment is transported a shorter distance and is often kept within the same sediment cell. Still, this form of beach management is reliant on a store of sediment accretion large enough to be recycled updrift or bypassed downdrift. Where this is not possible, or a substantial amount of sediment is needed to rebuild a beach, sediment replenishment is required.

Sediment replenishment is more costly as it involves transporting sediment for long distances, often from offshore dredging areas and sometimes inland quarries. In addition, the sediment may not be a true replica of the native beach material, resulting in poor beach performance, particularly where finer fractions are present.

More recently, in order for Local Authorities and the Environment Agency to be eligible for capital FDGiA to undertake beach recycling works, an approved 5 year Beach Management Plan (BMP) is required (Dornbusch and Cargo, 2010). A BMP details the engineering approaches required to manage the site, which often include beach recycling and replenishment. The identification of active beach and offshore sediment stores in this project will inform the production of BMPs and could allow new 'untapped' sediment resources across the SCOPAC region to be used, closer to the site of beach depletion. This project quantifies areas of sediment accretion on the beaches and presents changes in area of offshore shoals with a view to the possibility of operating authorities using locally sourced material to continue management activities whilst saving costs.

1.2 Project Aims and Objectives

The primary aim of the project is to identify sediment stores and sinks across the SCOPAC region for future recycling operations, as there are large cost savings to be had by using locally sourced material for beach management activities.

The project presents sediment accretion and erosion for beaches, ebb deltas, landward sinks and offshore shoals using best available data. The main focus of the report is on the active sediment stores, particularly those areas undergoing large changes in volume or area.

More specifically the project:

- Defines sediment stores and sinks (drawing on the SCOPAC Sediment Transport Study)
- Maps the location of beach and ebb deltas stores; landward sinks and offshore sediment stores and sinks
- Estimates historical and existing volumes of the beach and ebb delta stores
- Maps historical evolution (area change) of the offshore stores and sinks and landward sinks
- Documents any known sediment extractions and depositions from sediment recycling and replenishment logs
- Summarises environmental protection laws

1.3 Study Area

The area investigated within this report is the SCOPAC coastline, which covers an area of the south coast of England: from Lyme Regis in the west to Shoreham-by-Sea in the east, including the Isle of Wight (Figure 1.1). The coastline is approximately 780km long, and consists of various geological and morphological features. These include beaches, spits, barrier beaches, cusped forelands, estuaries, saltmarshes, cliffs, and landslide complexes.

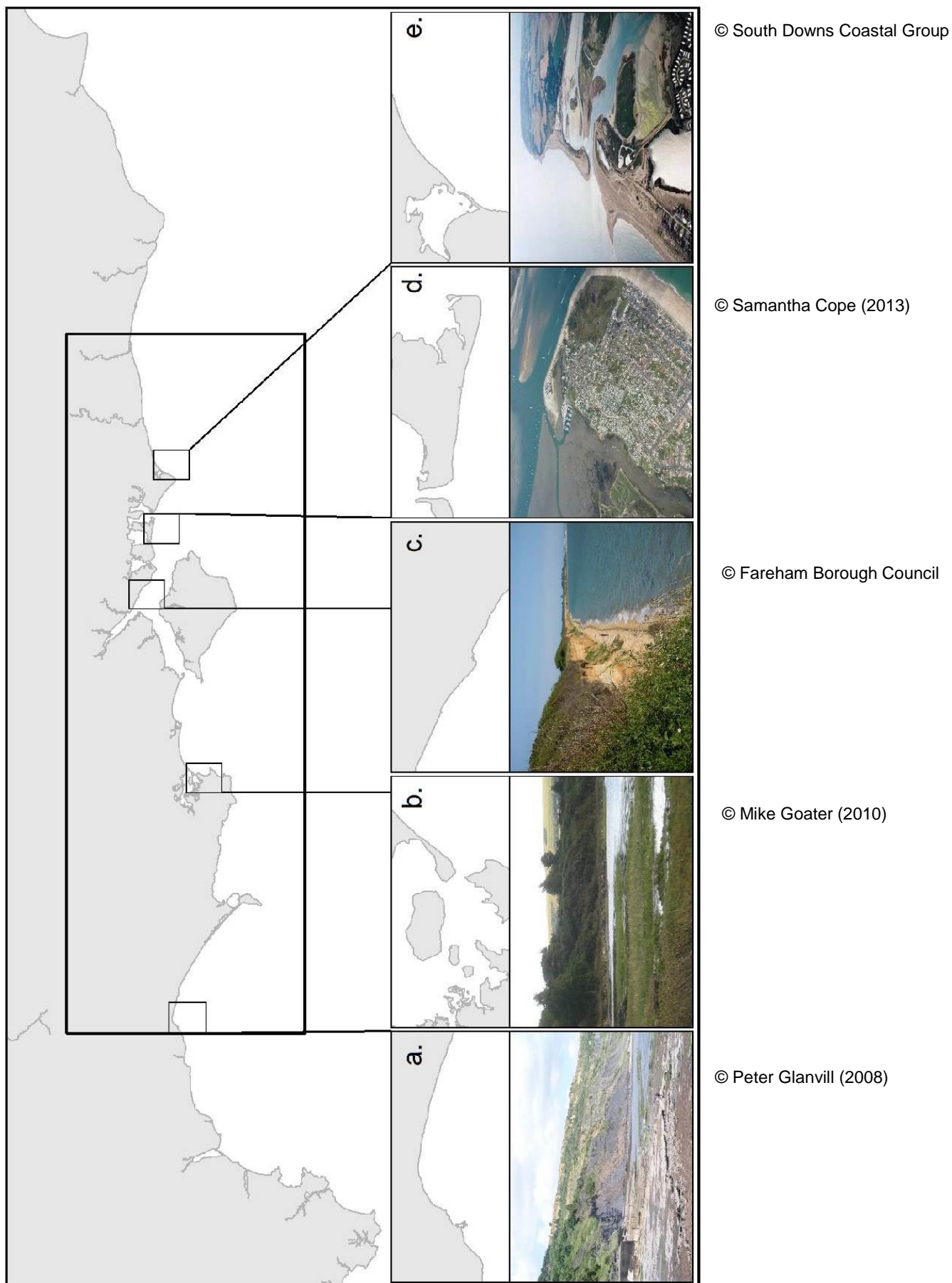


Figure 1.1: Location of Study Site on the south coast of England, and example coastal features: a. Lyme Regis, b. Poole Harbour, c. Solent Breezes, d. Hayling Island and e. Pagham Harbour

1.4 Sediment Stores and Sinks

Coastal change is taking place continuously through the transport and deposition of sediment around the coastline, dictated by wave direction and currents. These transport systems are interrupted by major coastal headlands and estuaries, creating sediment cells. Each sediment cell comprises sediment inputs (i.e. eroding cliffs), sediment throughputs in the form of longshore drift, sediment stores (i.e. beaches and inter-tidal habitats) and sediment outputs (offshore sediment sinks) (Carter *et al*, 2004).

1.4.1 Definition of Beach Stores & Sinks

Beach stores are most commonly found at headlands at downdrift extents of bays, or at convergence locations of littoral drift. Beach stores are defined in this report as accretionary features which are active within the sediment budget. Sediment may be transported to or from the beach both alongshore or cross shore. Beach sinks are defined in this report as relict features above Mean High Water Springs, deposited throughout the Holocene and no longer active within the sediment budget (e.g. Browndown or Sinah Warren). The majority of beaches along the SCOPAC coastline are beach stores rather than sinks.

1.4.2 Definition of Offshore Stores & Sinks

Offshore shoals which exchange sediment with adjacent beaches or estuaries are termed stores in this report. An example of this is the Shingles Bank in Christchurch Bay which is still very much an active shoal, and is effectively the ebb delta of the western Solent. On the contrary, offshore sinks are defined in this report as relict deposits, no longer interacting with the wave base.

1.5 Beach Recycling and Replenishment

The CIRIA Beach Management Manual (2010) notes that beach recycling is particularly suited to shingle beaches where the volume of material to be recycled is less than 80,000 m³ per year. The longshore transport rates on mixed sand and shingle beaches or wide sand beaches are much higher, resulting in larger quantities of sediment needing to be transported to balance the system. This presents practical difficulties when transporting the sediment by land based methods which may not prove cost effective. A larger replenishment of sediment from seaborne plant, combined with control structures may be more cost-effective for highly dynamic beaches.

The following information on beach recycling, replenishment and sediment bypassing has been taken from the CIRIA Beach Management Manual (2010).

1.5.1 Beach Recycling

Beach recycling generally involves extracting sediment from a downdrift accumulation and transporting it updrift to the site of erosion, within the same sediment cell. This may involve the use of

land or seaborne techniques depending on access, tidal range, beach levels and the quantity of sediment.

Beach stores are used most commonly for recycling events and are often located at the downdrift end of a sediment cell (e.g. a headland or the tip of a spit, such as East Head) against a hard structure (e.g. Hengistbury long groyne) or where sediment converges to form cusped forelands (e.g. Browdown).

An example of regular beach recycling in the SCOPAC region is at Hurst Spit in the West Solent, where approximately 5,000m³/year on average is extracted from North Point and deposited updrift onto the main body of the spit (New Forest District Council, 2012).

There is one example found in the SCOPAC region of cross shore sediment recycling where sand is removed from the accreting dunes at Cakeham and placed on the foreshore.

The CIRIA Beach Management Manual (2010) notes that the cost of recycling operations for shingle will vary from less than £1.50/m³ to £20/m³ (2008 prices). The Manual also recommends monitoring of beach volume and sediment volume extracted and deposited to avoid excessive beach recycling which can result in downdrift erosion.

1.5.2 Beach Replenishment

Beach replenishment or recharge involves the addition of imported, new sediment to the sediment cell to increase beach volume. The material is usually sand to shingle in size range and is obtained from offshore sources, brought to the site using seaborne techniques. There is also the possibility of using inland sources such as quarried materials.

An example of beach replenishment in the SCOPAC region is at Poole Bay, where 3,554,900m³ of sediment has been deposited in 4 phases between 1970 and 2008 (Harlow, 2009).

1.5.3 Sediment Bypassing

Sediment bypassing involves transporting sediment from an updrift accumulation, usually as a result of sediment accretion against a hard structure (e.g. a breakwater), to a downdrift area of erosion. Fixed plant, floating plant or land based equipment can be used.

An example of sediment bypassing in the SCOPAC region is at Shoreham-by-Sea, where approximately 8,500m³/year of gravel has been deposited downdrift of the harbour mouth (Arun District Council, 2006).

1.5.4 Beneficial use of sediments

Another source of sediment for increasing the volume of beaches is from dredging of harbours or navigational channels. It is now a requirement that potential beneficial uses of such sediments are sought, thereby retaining sediment within the system rather than disposing of it offshore.

In general, maintenance dredging from harbour mouths or navigational channels produces a finer grade of sediment which cannot be used for beach recycling, however, capital dredging yields gravel and sand in addition to the finer fractions. An example of beneficial use of sediment on a beach in the SCOPAC region is at Bournemouth and Swanage beaches where 65,000m³ was deposited from the Poole Harbour channel and at Lee-on-the-Solent where 308,000m³ of gravel was deposited from the capital dredge at Southampton Water in 1996.

2. Environmental Protection Laws

There are a multitude of licences, consents and permissions covering the coastal and marine zone which require consideration before beach management works or marine aggregate dredging can take place (Figure 2.1).

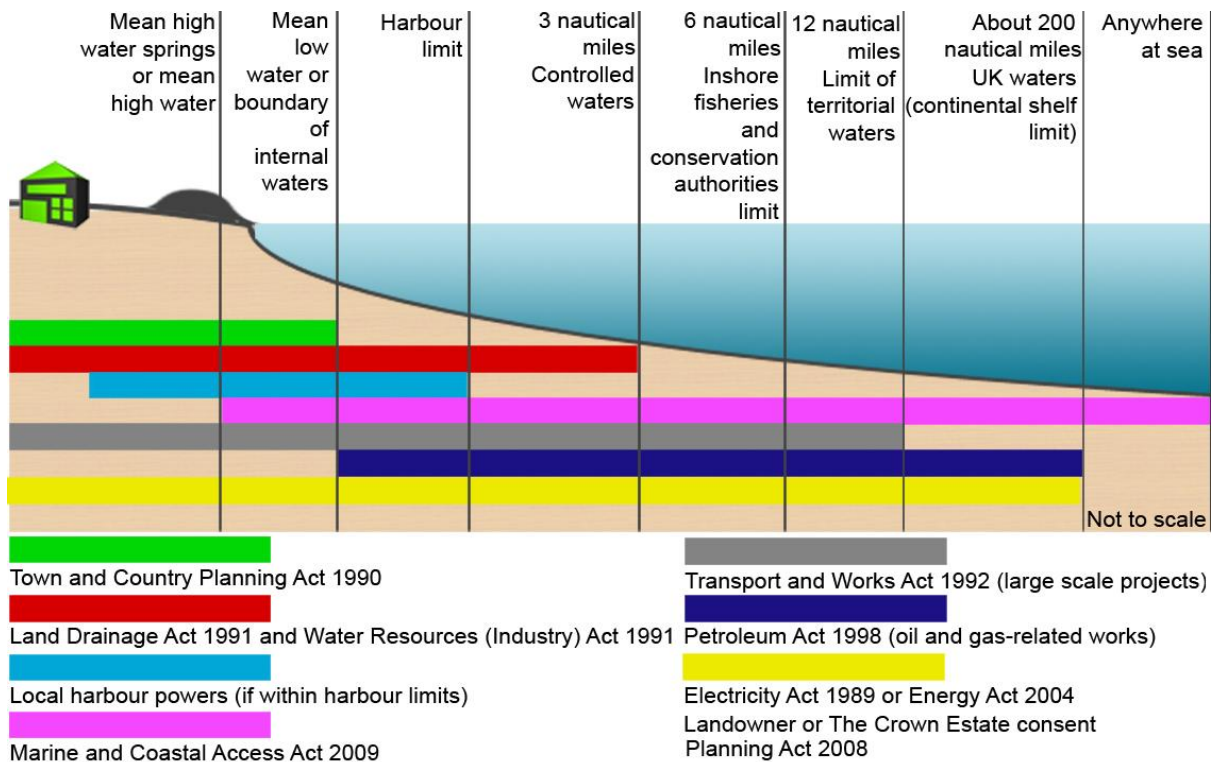


Figure 2.1: Geographical extent of each of legislation (MMO)

Historically, the three main pieces of legislation relating to beach management and/or aggregate dredging were:

- Planning Acts: Where beach management works extend down to the Mean Low Water mark.
- Part 2 of the Coastal Protection Act (1949): Where beach management works extend below the Mean High Water Spring mark.
- Part 2 of the Food and Environment Protection Act (1985): Where sediment is deposited below the Mean High Water Spring mark for capital or maintenance works.

The Solent Forum Marine and Coastal Consents Guide (March 2012) provides the most up to date information on licences, consents and permissions and reflects the changes that have taken place since the introduction of the Marine and Coastal Access Act (2009). It notes that since the, “marine licensing system under the Marine and Coastal Access Act (2009) came into force in April 2011.... the two main types of development consent required for coastal or marine works are planning permission for infrastructure to the boundary jurisdiction of the local planning authority (LPA) (generally above the Mean Low Water Mark (MLWM)) and a Marine Licence for works below Mean High Water Springs

(MHWS). The two systems work independently of each other and are administered by local planning authorities and the Marine Management Organisation (MMO) respectively.” The MMO now provide a single point of contact for Part 2 of the Coastal Protection Act (1949) and Part 2 of the Food and Environment Protection Act (1985) under the Marine Licence.

The following table illustrates which licences, consents and permissions are required for offshore, capital and maintenance dredging and foreshore recharge. These are summarised further in the Solent Forum Marine and Coastal Consents Guide (March 2012).

Table 2.1: Coastal Consents Works and Development Matrix (Solent Forum Guide, 2012)

	Marine Licence	Planning Permission	Harbour Works Licence	Landowner Consent	Flood Defence Consent	Environmental Permitting	Notes
Dredging - Offshore, capital and maintenance	X		X	X	X		Low risk maintenance dredging is exempt from requiring a Marine Licence until April 2014. See section 2 of this Solent Forum Guide for more information.
Foreshore recharge	X	X	X	X	X	X	In practice the permissions and licences required for recharge works are made on a case by case/site by site basis, often at the discretion of the local planning authority.

In addition to the licences, consents and permissions listed in **Error! Reference source not found.**, the following lists other considerations summarised in the Consent Guide:

Consents

- Harbour works
- Landowner consent
- Wildlife Licence
- Site of Special Scientific Interest Works Notification
- Flood Defence Consent and Flood Risk Assessment

Assessments

- Environmental Impact Assessment
- Habitats Regulations Assessment and Appropriate Assessment
- Water Framework Directive Assessment

Designations

- Conservation Areas
- Protected Wreck Sites
- Areas of Outstanding Natural Beauty
- National Park
- Marine Protected Areas
- Sites of Special Scientific Interest (SSSI)
- National Nature Reserves
- European Marine Sites

Other considerations

- Land and Seabed Ownership
- Byelaws

In addition to the Solent Forum Marine and Coastal Consents Guide (March 2012), the following publications provide further detail on environmental regulations:

- CIRIA (2010) *Beach Management Manual* 2nd edition
- Marine Management Organisation (2011) *Marine licensing guidance 8: Environmental Impact Assessment*.
- Newell, R.C. and Woodcock, T.A. (Eds.) (2013) *Aggregate Dredging and the Marine Environment: an overview of recent research and current industry practice*. The Crown Estate.
- The Crown Estate and BMAPA (2014) *Marine Aggregate Dredging and the Coastline: A Guidance Note*.

3. Results

This section provides a brief, descriptive analysis of the mapping produced across the SCOPAC region highlighting the:

- Beach stores
- Ebb tidal delta stores
- Landward sinks
- Offshore stores and sinks

3.1 Beach Stores

Volume calculations as well as four sets of maps have been produced as part of the analysis for the beach stores:

- Difference plots (Appendix B)

Difference plots have been created for the SCOPAC region showing changes in beach elevation over three different epochs: 2003-2012 (10 year difference plot), 2003-2007 (earliest 5 year difference plot) and 2007-2012 (most recent 5 year difference plot).

- Beach recycling and replenishment logs (Appendix C)

The location and volume of the beach recycling and replenishment activities are presented for each frontage for the earliest and most recent epoch.

- Difference plots excluding recycling and replenishment events (Appendix D)

All sediment erosion was removed from the difference plots, leaving sediment accretion only. To remove any management activities, a blanking file was created in the ArcGIS leaving only those areas of sediment accumulation which have not been directly managed by recycling or replenishment events in the past. The management activities were depicted on the maps as a single line.

- Final beach stores (Appendix E)

More detailed maps of the major beach stores were produced and annotated with the sediment accretion volume.

All of the beach store analysis was undertaken for the Shoreline Management Plan (SMP) management units.

3.1.1 Beach Volume Calculations

Before difference models were created, the volume of each DTM was extracted per management unit to quantify beach volume. The volume was extracted above MLWS for each location, creating a standard contour (mOD) at this level and calculating all sediment above. The earliest DTM volume was subtracted from the most recent to give a volume of sediment difference per management unit. This was carried out before any data was removed due to management. Table 3.1 gives an example of the data for Poole Bay. It can be seen that the volume of each management unit is at its lowest in 2003. The volume increases significantly in 2007 and then appears to drop again in 2012 in all management units apart from PBY2. This can be seen in the differences, where the difference between 2007 and 2012 shows negative values (i.e. erosion of the management unit).

Table 3.1: Volume of sediment including management: Poole Bay

	Management Unit	DTM Volume 2003 (m ³)	DTM Volume 2007 (m ³)	DTM Volume 2012 (m ³)	Difference (m ³) 2003-2007	Difference (m ³) 2007-2012	Difference (m ³) 2003-2012
5f	PBY1a	391,000	571,000	555,000	180,000	-15,000	165,000
	PBY1b	617,000	1,221,000	1,156,000	605,000	-65,000	540,000
	PBY2	106,000	184,000	186,000	79,000	2,000	81,000
	PBY3	83,000	111,000	109,000	28,000	-2,000	26,000

A record of the management carried out per management unit was included in the spreadsheet in order to quantify the effect of management on the beach over the three epochs studied. A visual representation of this data can be found in Appendix C. Table 3.2 shows the example for Poole Bay where the majority of replenished sediment was deposited on the beach between 2003 and 2007, with a top up of sediment from 2008-2012 in the centre of Poole Bay (PBY1b and PBY2) only.

Table 3.2: Volume of sediment deposition/extraction on beach: Poole Bay

	Management Unit	2003 - 2007		2008 - 2012		2003 - 2012	
		Deposition (m ³)	Extraction (m ³)	Deposition (m ³)	Extraction (m ³)	Deposition (m ³)	Extraction (m ³)
5f	PBY1a	522,950	0	0	0	522,950	0
	PBY1b	1,341,030	0	153,928	0	1,494,958	0
	PBY2	127,397	0	74,192	0	246,589	0
	PBY3	0	0	0	0	0	0

The volume of sediment deposited on the beach was then removed from the overall beach volume extracted from the DTM's (Table 3.1). It can be seen that, by applying this method to Poole Bay, the net effect is that the entire beach frontage suffers from erosion (Table 3.3). The exception to this pattern occurs in PBY3 at the eastern extent of the bay, which shows slight accretion over a 10 year time period and from 2003-2007, with only a small quantity of sediment loss between 2007 and 2012. This can be attributed to the process of longshore drift, transporting the replenished sediment towards Hengistbury Head at the east of the unit.

Table 3.3: Volume of sediment on beach with all management removed: Poole Bay

	Management Unit	DTM Volume 2003 (m ³)	DTM Volume 2007 (m ³)	DTM Volume 2012 (m ³)	Difference (m ³) 2003-2007	Difference (m ³) 2007-2012	Difference (m ³) 2003-2012
5f	PBY1a	391,000	48,000	92,000	-343,000	-15,000	-358,000
	PBY1b	616,000	-120,000	-339,000	-736,000	-219,000	-955,000
	PBY2	106,000	12,000	-60,000	-94,000	-72,000	-166,000
	PBY3	83,000	111,000	109,000	28,000	-2,000	26,000

If any sediment had been extracted from the beach (e.g. in Christchurch Bay), this quantity was added back in to the beach volume to provide a better representation of beach volumes excluding management.

The full table containing all management unit sediment volumes, management volumes of extraction and deposition and the final volume excluding any management can be found in Appendix F.

Analysis of the results is split down in to 9 stretches of coastline (map A.9 in Appendix A) as follows:

3.1.2 Lyme Regis to Portland Bill beach maps

- **Difference plot maps (Appendix B.1)**

Given that the South-West Regional Coastal Monitoring Programme did not begin until 2006, difference models for this region show only the final 5 year epoch; 2007-2012.

The Charmouth to Lyme Regis map shows a large area of accretion in MU5-5: this is due to a landslide event in 2008, contributing 165,600m³ of sediment to the beach. Over this 5 year period there appears to be a trend towards pockets of erosion in the east and accretion to the west at Seatown, West Cliff and West Bay, indicating net westerly longshore drift. It is not possible to know whether this is a long term trend of beach elevation change as there is no other data available for comparison.

Chesil Beach shows some accretion at the back of the barrier and at Chiswell, while the front face of the barrier beach shows an eroding frontage.

- **Beach recycling and replenishment logs (Appendix C.1)**

There has been very little management along this stretch of coastline. In 2003-2007 Lyme Regis beach was replenished with 52,000m³ sediment imported from France and a source off the Isle of Wight. A small quantity of sediment recycling occurred at West Bay from 2008-2012, where sediment was extracted from the front of the beach and placed at the back.

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.1 and E.1)**

The main beach stores identified between 2007-2012 can be found at:

- MU5_5: Charmouth (165,600m³ accretion)
- MU4: West of Seatown (78,900m³ accretion)
- MU5_3: West Bay (82,700m³ accretion)
- MU2: Chiswell, Chesil Beach (97,900m³ accretion)

Volumes for each of these sites were calculated over the earliest to most recent time period available, and can be found in Appendix E.1.

3.1.3 Portland Bill to Durlston Head beach maps

- **Difference plot maps (Appendix B.2)**

Large extents of this frontage are composed of steep cliffs which fall directly in to the sea, therefore there is very little beach analysis carried out. The few beaches that are located along this frontage are pocket beaches situated between rock outcrops.

Weymouth Bay (CPU5a – CPU5c) shows accretion in the southern extent of the bay over all three epochs, however in the central and northern extents of the bay the trend varies over time, attributed to management activities.

At Ringstead Bay (CPU6g), Durdle Door (CPU7b) and Worbarrow Bay (CPU10d) the beaches all show accretion in the east of the bay over the earliest time period and the 10 year epoch, however during the 2007-2012 epoch the accretion switches to the west of each bay, with erosion occurring in the east. This is consistent over all three sites.

- **Beach recycling and replenishment logs (Appendix C.2)**

Recycling has been carried out on Preston Beach, Weymouth (CPU5b and CPU5c) over both epochs. The deposition was located in the same position on the beach in both epochs, with extraction being carried out over a wider area in 2003-2007 than 2008-2012. The logs from 2003-2007 do not contain the volume of sediment moved between the sites. No other recycling events were recorded over this stretch of coastline.

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.2 & E.2)**

The main beach stores identified between 2003-2012 can be found at:

CPU7b: Durdle Door (9,100m³ accretion)

CPU10d: Worbarrow Bay (10,200m³ accretion)

Volumes for each of these sites were calculated over the earliest to most recent time period available, and can be found in Appendix E.2.

3.1.4 Durlston Head to Hengistbury Head maps

- **Difference plot maps (Appendix B.3)**

This area of coastline consists of many sandy beaches, and includes Poole Harbour. The beach at Swanage can be seen to be accreting over the 10 year epoch and also significant accretion can be seen between 2003 and 2007. This is, however, attributed to 224,000 m³ of replenishment. The beach shows consistent beach lowering over its entire length between 2007 and 2012 as the replenished sediment erodes.

Studland Bay shows a consistent pattern of accretion of sediment in the north (STU3 and STU4), with small isolated areas of erosion in the south of the bay (STU2).

Only a small area within Poole Harbour is surveyed as part of the South-east Regional Coastal Monitoring Programme, and therefore the rest of the site is not included in this study. The area which is surveyed within the harbour shows very little to no change over the 10 year period of study given the sheltered environment.

The beach fronting Poole Bay (Poole and Bournemouth) shows large quantities of sediment accretion over the 10 year epoch and first 5 year epoch. This is attributed to 2.2 million m³ of sediment deposition throughout the bay. PB1a shows a small amount of accretion around Sandbanks, followed directly to the east by an area of erosion at Shore Road. This is consistent over all three epochs. However further to the east the bay shows large quantities of sediment accretion along the

full length to Hengistbury Head. This pattern is consistent over a 10 year epoch and for the first 5 year period. Between 2007 and 2012 however, there is switch to dominant erosion along the frontage with small areas of accretion around Bournemouth Pier (PBY1b) and within PBY2.

- **Beach recycling and replenishment logs (Appendix C.3)**

The coastline between Durlston and Hengistbury Head contains one of the most managed stretches of beach in the SCOPAC region. The majority of management carried out here is in the form of large scale replenishment events rather than localised recycling events. Swanage Bay had a 224,000m³ replenishment between 2003-2007, while the entire frontage between Poole Harbour Entrance and Double Dykes, Bournemouth has benefitted over the same time period from 1.98 million m³. Management Units PBY1b and PBY2 were also replenished by 228,120 m³ between 2008-2012. Studland Bay and a short length of coastline in front of Hengistbury Head are the only areas unaffected by any direct management. It should be noted that Hengistbury Head indirectly benefits from the replenishment in Poole Bay, given the direction of longshore drift from west to east.

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.3 & E.3)**

The main beach stores identified between 2003-2012 can be found at:

STU3 & STU4: Studland and Shell Bay (269,000m³ accretion)

PBY3: Hengistbury Head (78,200m³ accretion)

Volumes for each of these sites were calculated over the earliest to most recent time period available, and can be found in Appendix E.3.

3.1.5 Hengistbury Head to Hurst Spit (Christchurch Bay) beach maps

- **Difference plot maps (Appendix B.4)**

This stretch of coastline appears to be dynamic in terms of sediment movement, as each epoch shows a slightly different trend. It is however, a heavily managed frontage with a high number of recycling and renourishment events (see extraction and deposition details below).

Mudford Spit (CBY1) shows very little sediment erosion or accretion over the three epochs studied, apart from at the hinge in the south where accretion is identified in 2003-2007 and erosion in 2007-2012.

CBY2 shows an accretionary trend over 10 years in the centre of the management unit, with erosion to the west. Over the first 5 year epoch the west of the unit show accretion, with the same location

showing erosion in the last 5 year epoch. The sediment appears to move within this management unit at this location.

Very little change can be seen within cells CBY3 and CBY4, but CBY5 shows a strong erosion trend over all three epochs studied.

In general, Hurst Spit (CBY7) displays erosion on the seaward side with the back of the spit showing sediment accretion over both 2003-2012 and 2007-2012, as the spit overwashes or is managed. Two main areas of sediment accretion can be found along CBY7 in all three epochs; these being at the west of the management unit, behind the rock revetment, and also to the west of Hurst Castle at the eastern end of the unit. LYM1 shows sections of erosion and accretion as sediment pulses towards the tip of the spit at North Point. North Point displays erosion for all three epochs, attributed to a total of 17,000 m³ of material removed over 10 years.

- **Beach recycling and replenishment logs (Appendix C.4)**

Management in this area is focussed at either end of the bay. Large frequency, small volume recycling events are carried out in CBY2 over both epochs. In 2003-2007 material was moved along the beach, and in 2008-2012 sediment was taken from the harbour entrance ebb delta. Recycling has also taken place on Mudeford Spit (CBY1) in order to stabilise the beach and protect the beach huts.

Hurst Spit (CBY7) is an actively managed spit. Sediment is extracted from North Point (LYM1) where it accretes through longshore transport, and is re-deposited on the rear face of the spit in order to increase the cross-sectional area. Even with sediment deposition in CBY7, the spit displays a general trend of erosion.

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.4 & E.4)**

The main beach stores identified between 2003-2012 can be found at:

CBY2: Friar's Cliff (34,200m³ accretion)

The volume for this site was calculated over the earliest to most recent time period available, and can be found in Appendix E.4.

3.1.6 Hurst Spit to Southampton Water beach maps

- **Difference plot maps (Appendix B.5)**

Given the large extent of inter-tidal habitat, a vast proportion of this frontage is surveyed using remote sensing techniques. The majority of the difference plots created for this frontage were made using

lidar data. Given the sheltered nature of the frontage, there are no significant large areas of accretion, however small pulses of sediment can be identified in LYM7 along Warren Farm spit. There is also a small build-up of sediment at the eastern extent of LYM10, adjacent to Lepe Country Park and at the hinge of Calshot Spit (LYM14). The hinge section of Calshot Spit shows accretion on the beach over both the 10 year epoch and the 2003-2007 epoch. However in 2007-2012 the same area shows slight erosion, thought to be a result of the sediment moving along the spit. Given the dominance of inter-tidal habitat and the built up nature of the Southampton Water and the port, no analysis has been carried out along the estuary frontage.

- **Beach recycling and replenishment logs (Appendix C.5)**

There have been no recorded management events for the beaches along this frontage in the last 10 years. The majority of the frontage is privately owned and the local authorities are unlikely to hold any records of any private works carried out.

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.5 & E5)**

The main beach stores identified between 2003-2012 can be found at:

CBY7 & LYM1: Hurst Spit & North Point (35,600m³ accretion)

LYM14: Calshot Spit (25,200m³ accretion)

Volumes for each of these sites were calculated over the earliest to most recent time period available, and can be found in Appendix E.5.

3.1.7 Southampton Water to Portsmouth Harbour Entrance beach maps

- **Difference plot maps (Appendix B.6)**

Between NET1 – NET6, very little change can be seen given the sheltered, muddy nature of the shoreline. Management unit CPU14 shows erosion in the centre of the unit over all three epochs, with accretion to the west on Hook Spit. Along the rest of this section of coastline there does not appear to be any particular trend, with accretion and erosion varying in location and time. The main exception to this can be seen within CPU11, where large areas of accretion occur in front of Browdown over all three epochs, and also at Gilkicker Point from 2003-2012 and 2007-2012.

- **Beach recycling and replenishment logs (Appendix C.6)**

There have been no recycling events along this frontage. A large replenishment scheme was undertaken within CPU12 (Lee-on-Solent) in 1997. Although this was carried out before the 10 year

study period, it was considered significant in size (300,000m³) and has therefore been included in the sediment logs.

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.6 & E.6)**

The main beach stores identified between 2003-2012 can be found at:

CPU11: Browndown (51,600m³ accretion)

The volume for this site was calculated over the earliest to most recent time period available, and can be found in Appendix E.6.

3.1.8 Portsmouth Harbour Entrance to Selsey Bill beach maps

- **Difference plot maps (Appendix B.7)**

This stretch of coastline is heavily managed given the flood and erosion risk to property and increased exposure to swell waves further east along the frontage. Three harbours are located within the area; Portsmouth, Langstone and Chichester Harbours. All three harbours have dynamic coastal processes in operation around the harbour entrances, requiring sediment recycling and hard engineering schemes to hold the beach in position.

There is a small build-up of sediment along the frontage at CPU9 which is recycled back updrift. The Portsea Island frontage (CPU8) shows a consistent trend over all three epochs with the beach to the west of South Parade Pier accreting in all three epochs, although eroding directly in front of the Pyramids Swimming Pool over the 10 year and the 2003-2007 epoch. Eastney Beach is continuously accreting, with a trend towards erosion at the entrance to Langstone Harbour, exacerbated by sediment extraction for recycling purposes. There are pulses of sediment moving north along Eastney Spit.

The opposite side of Langstone Harbour shows a large area of accretion at Gunner Point with a strong site of erosion at CPU7, suggesting sediment is moving west towards the harbour from this location. There are also pulses of sediment moving north along the spit.

Similar to Portsea Island, the frontage of Hayling Island shows a constant trend between all time periods studied. The western end of CPU6 shows erosion, whereas Eastoke appears to be accreting sediment over the past 10 years. This is in fact attributed to sediment recycling from west to east. The entrance to Chichester Harbour shows erosion over both the 10 year period and 2007-2012. There is however a site of sediment accretion at the tip of Black Point spit.

East Head spit located in Management Unit CPU5, continues to rotate clockwise into Chichester Harbour and in general is accreting at the tip of the spit over the three epochs. An additional difference plot was produced using lidar data, thereby providing a wider coverage of the foreshore. Sediment is recycled from the tip of the spit to the proximal end in order to maintain the cross-sectional area at The Hinge. In addition, sediment continues to accrete at Cakeham, requiring removal from the back of the beach onto the foreshore.

Within unit CPU4 the beach is accreting at the back with some erosion at the front of the beach. This is consistent over the three epochs studied. In 2003-2007 management unit CPU3 shows a strong trend of erosion over the full length. However in the other two epochs there is a large quantity of accretion in front of the Bunn Leisure caravan park attributed to a private replenishment carried out in 2011.

- **Beach recycling and replenishment logs (Appendix C.7)**

This frontage is frequently managed by sediment recycling and renourishment events, focused in particular along Hayling Island. Sediment is extracted from the west of the island and deposited at Eastoke in both epochs (2003-2007 and 2008-2012). Sediment from dredging of the harbours is also placed on the beach at this location. The total amount of sediment deposition at Eastoke is 305,000 m³ over the 10 year period.

Small local recycling events have been carried out at Portsmouth (CPU8 and CPU9), however not to the same scale as on Hayling Island.

East Head and Cakeham (CPU5) have had consistent management events over the 10 year time period. The majority of this is carried out at Cakeham and can be considered as regrading of the beach rather than recycling, as wind-blown sediment is removed from behind the beach huts back to the front of the beach. A small recycling event was carried out at East Head spit in both epochs, where sediment was extracted from the tip of the spit and placed on The Hinge.

There have been two replenishment schemes in CPU3, as well as a small volume recycling event. Approximately 26,000 m³ of sediment was deposited at the eastern end of CPU3 in 2012. A large private beach replenishment was also carried out at Bunn Leisure caravan site in 2011. Approximately 350,000m³ sediment was placed on the beach, alongside 25,000m³ from a recycling event, in order to stabilise the beach prior to the Medmerry managed re-alignment scheme.

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.7 & E.7)**

The main beach stores identified between 2003-2012 can be found at:

CPU9: Portsmouth (22,200m³ accretion)

CPU8: Southsea (196,600m³ accretion)

CPU7: Sinah Common (248,000m³ accretion) including Gunner Point (198,000 m³ accretion)

CPU6: Black Point Spit (46,700m³ accretion)

CPU5: East Head Spit (797,100m³ accretion)

CPU4: Bracklesham Bay (192,700m³ accretion)

Volumes for each of these sites were calculated over the earliest to most recent time period available, and can be found in Appendix E.7.

3.1.9 Selsey Bill to Shoreham-by-Sea beach maps

- **Difference plot maps (Appendix B.8)**

Selsey Bill (western end of MU1) shows a large amount of erosion over the 10 year time period, and also 2003-2007. From 2007 to 2012 however, there is significantly less erosion. The eastern extent of MU1/MU2 shows slight accretion for all epochs. The beach within management units MU2 and MU2a consist of Church Norton spit and the entrance to Pagham harbour. The spit shows consistently large volumes of sediment accretion over all epochs. In comparison, Pagham spit, directly behind Church Norton spit shows significant erosion over all three epochs even though it underwent 30,000 m³ of sediment deposition between 2008 and 2012.

There is consistent sediment build up to the east of MU3 in all three epochs.

The coastline fronting Bognor Regis (MU4) is not covered by any data sources for 2003 or 2007; therefore no data comparison can be carried out for this site.

Elmer displays similar erosion and accretion patterns for all three epochs with a consistently substantial amount of erosion behind the breakwaters at the eastern end of MU5.

At MU6, there is consistent erosion at Atherington with accretion to the east for the 10 year epoch and the 2003 – 2007 epoch. The small area of erosion at the east of MU6 at the estuary of the River Arun can be attributed to the extraction of approximately 4,000 m³ of sediment. However in 2007-2012 the opposite is true, with accretion in the central section of the management unit.

At MU7 and MU8a, the beach is accreting over the 10 year period (2003 – 2012) and last 5 year epoch (2007-2012). In the first epoch (2003 – 2007) the beach underwent erosion even though there

were minor sediment deposition events from recycling of 4140 m³ in MU7 and 24,261 m³ in MU8a. The erosion to the far east of MU8a in the first epoch can be attributed to a minor sediment extraction of 4092 m³.

MU8b displays a pattern of an eroding foreshore and accreting beach crest over the 10 year epoch and first epoch (2003-2007). There is a noticeable area of erosion directly to the east of Worthing Pier for these two epochs with a switch to accretion at the far eastern end of the unit, possibly attributed to sediment deposition of 11,268 m³ from recycling works in the first epoch. The latter epoch (2007-2012) displays predominantly accretion along the whole unit.

In MU9a, the beach between South Lancing and Shoreham-by-sea underwent a major sediment replenishment of 274,664 m³ in the first epoch which explains the dominance of accretion along the whole unit for the 10 year epoch (2003 – 2012) and the first epoch (2003 – 2007) and then erosion in the last epoch (2007 – 2012). South Lancing displays a dominant trend of accretion for these epochs even though the beach underwent 9,800 m³ of sediment extraction in the first epoch (2003-2007). The beach at Shoreham-by-Sea to the far east of MU9a consistently displays accretion, even with 70,087m³ of extraction between 2003–2007 and 40,257m³ between 2007-2012 as it is the end of the sediment sub-cell.

- **Beach recycling and replenishment logs (Appendix C.8)**

The majority of coastal management along this coastline took place in the first epoch from 2003-2007. Approximately 75,000m³ sediment was extracted from MU9a (South Lancing) and moved west to be deposited in MU8b. There was a major replenishment scheme of 274,664 m³ in MU9a (South Lancing to Shoreham-by-sea) in the first epoch. There were also sediment deposition events from recycling of 4140 m³ in MU7 and 24,261 m³ in MU8a in the first epoch and minor sediment extraction of 4092 m³ in MU8a. There has been no deposition in these locations since 2007, although 40,258 m³ of sediment was extracted from MU9a in both epochs and moved east, outside the study area.

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.8 & E.8)**

The main beach stores identified between 2003-2012 can be found at:

MU1 & MU2: West Selsey (243,400m³ accretion)

MU2 & MU2a: Pagham Harbour (835,200m³ accretion)

MU9a: Shoreham-by-Sea (503,300m³ accretion)

Volumes for each of these sites were calculated over the earliest to most recent time period available, and can be found in Appendix E.8.

3.1.10 Isle of Wight beach maps

- **Difference plot maps (Appendix B.9)**

The majority of difference plots created for the Isle of Wight were made using topographic beach survey data. However, where the coastline is cliffed with little or no access to beaches, lidar data was used.

East of Cowes there is little beach change until Ryde. RYD4 shows a small amount of erosion at the estuary of Wootton Creek. However, the main site of sediment accretion in this area is shown at Ryde Sands (RYD5) where the majority of sediment accretion can be seen extending out to sea alongside the pier for all three epochs. Approximately 6600 m³ of sediment was extracted from RYD5 and deposited at Seagrove (RYD8). RYD9 shows the only other large sediment accretion event on this coastline, with sediment accretion over the 10 year epoch and 2007-2012 but with little change from 2003-2007. The majority of coastline around Bembridge (RYD 12) is cliffed with a rocky foreshore and therefore no data was collected.

Sandown Bay shows significant variation in sediment over the length and over the different epochs (SAN2 – SAN8). While 2003-2007 shows large areas of accretion, particularly in SAN2 and SAN5, the same trend is not found over 2007-2012 or 2003-2012. The majority of the frontage is eroding over the 2007-2012 period, while from 2003 to 2012 there is a variation, with the centre of the beach showing erosion and the front and back showing accretion. From Sandown Bay to Reeth Bay (VEN5) no data was collected. Reeth Bay shows a consistent pattern of sediment erosion over all three epochs, with small pockets of accretions over 2003-2007 and 2007-2012. No data was collected to the west of this site apart from Freshwater Bay (FRE2 and FRE4). FRE2 shows erosion over the 10 year period and 2007-2012, however in 2003-2007 the bay appears to be accreting along the entire length. FRE2 is an enclosed beach, and therefore the sediment appears to be moving within the unit only. Accretion is found at the east of the bay in 2003-2007 and the west in 2007-2012, with no notable pattern over 10 years.

Along the north coast of the island to the west of Cowes there is very little noticeable change, with the only areas showing a variation in accretion/erosion being Totland Bay and Alum Bay (TOT2 and TOT3). TOT2 shows accretion to the south of the bay and erosion around the central section of the unit. As only one epoch of data was available for analysis however, there is no way of knowing if this is a constant trend over 10 years. A similar pattern is found in TOT3, where sediment is eroding in the centre of the bay and accreting to the west: this is found in all three epochs for this location. Data within Colwell Bay (TOT4) could only be sourced for 2007-2012. This data shows very little change over the time period, with a small quantity of sediment accretion found in the west of the bay. Although there is no significant change in beach elevation along the rest of the North Isle of Wight coastline, it can be seen that there are some small pockets of accretion and erosion within cell NEW9

between 2007-2012, with NEW8 showing erosion at the back of the beach and accretion towards the seaward extent of the beach.

- **Beach recycling and replenishment logs (Appendix C.9)**

The majority of the Isle of Wight is unmanaged. Most sites show very little sediment loss; especially on the north of the island which is sheltered from the strongest waves. There has been only one recycling event over the 10 year study period. This was carried out at Ryde in 2003-2007, where ~6,600m³ sediment was extracted from the outer extents of Ryde Sands (RYD5) and deposited on the beach within RYD8 (Seagrove Bay).

- **Final beach store maps, excluding recycling and replenishment events (Appendix D.9 & E.9)**

The main beach stores identified between 2003-2012 can be found at:

RYD5: Ryde Sands (304,300m³ accretion)

SAN1 – SAN6: Sandown (309,900m³ accretion)

The volume for this site was calculated over the earliest to most recent time period available, and can be found in Appendix E.9.

3.2 Ebb Tidal Delta stores

Area calculations (Table 3.4) as well as two sets of maps have been produced as part of the analysis for the ebb tidal delta stores.

Table 3.4: Area of accretion (m²) of ebb tidal deltas

Location	Year (Difference Plots)	Area of Accretion (m ²)
Christchurch	2006 – 2010	96,000
Langstone	2004 – 2011	339,000
Chichester	2004 – 2011	620,000
Pagham	2004 – 2008	66,000

- Difference plot map (Map A in Appendix G)

Difference plots have been created for the ebb deltas across the SCOPAC region showing changes in elevation from the earliest to the most recent available survey.

- Final ebb delta store map (Map B in Appendix G)

The erosion was then removed from the difference plots to produce final maps demonstrating accretion only and therefore the ebb tidal delta stores.

3.2.1 Poole Harbour

Only an approximate area change could be calculated from digitizing the 1960's and 2005 Admiralty Charts for Poole Harbour (see Section A.4.2), as bathymetry and lidar data were unavailable to the project. Map A demonstrates an increase in area to the east and erosion to the west of Hook Sands.

3.2.2 Christchurch Harbour

Map A demonstrates an area of accretion to the west and erosion to the east of the ebb delta at Christchurch Harbour. The area of accretion depicted in Map B is 96,000 m² between 2006 and 2010.

3.2.3 Langstone Harbour

There has been a mixture of sediment accretion and erosion on the Langstone Harbour ebb delta with what appears to be a shift of the offshore channel position towards the east between 2004 -2011 (Map A). The large volume of sediment accretion at Gunner Point and erosion immediately to the east is noted in Section 3.1.8.

The Langstone Harbour ebb delta has increased in area by 339,000 m² between 2004 – 2011 (Table 3.4 and Map B).

3.2.4 Chichester Harbour

The ebb delta at Chichester Harbour appears to be eroding more in the central section between 2004 and 2011 and accreting on the foreshore at East Head and between Cakeham and East Wittering (Map A). The area of sediment accretion has been 620,000 m² in 7 years, mostly on the foreshore (Table 3.4 and Map B).

3.2.5 Pagham Harbour

The ebb delta at Pagham Harbour is displaying accretion at the tip of the spit and erosion at the flanks between 2004 and 2008 (Map A). The area of sediment accretion has been 66,000 m² in 4 years, mostly on the foreshore (Table 3.4 and Map B).

3.3 Landward sinks

The main coastal sediment sinks are relict sediment deposits from the Holocene transgression. The features were mapped from aerial photography across the SCOPAC coastline.

- Sites of landward sinks (Map A in Appendix H)

The location of the landward sinks is mapped in Map A, Appendix H. Spits were also digitised within the landward sink analysis in order to identify their location. No area change analysis was undertaken in this section as they were covered in the beach analysis.

- Change in area of landward sinks (Map B in Appendix H)

A constant, loss and gain analysis was carried out on the three main sites, with the results shown in Map B, Appendix H. Data was not available for all years for all sites, therefore Sinah Common has a long time period of change analysis whereas Studland has only a 3 year change analysis.

Each digitised area is shown in table 3.5 below.

Table 3.5: Area of sediment per year (m²)

Location	Area per year (m ²)				
	1946	1986	1994	2005	2008
Sinah Common	915,000	909,000	921,000	935,000	928,000
Browndown	No Data	517,000	496,000	509,000	508,000
Studland	No Data			2,288,000	2,286,000

Browndown was not covered by available aerial photography in 1946, whereas Studland was not covered by any dataset until 2005. The table shows that Studland has the largest overall area (approximately 2,286,000 m²) however it is not possible to get a long term comparison of data as there is only 3 years between the datasets. Browndown is the smallest site, with an area of approximately 500,000m². The cusplate foreland at Sinah Common has been steadily increasing over time given the large area of sediment accretion at Gunner Point (79,500m²). Still there has been erosion to the east since 1946.

There is a possibility that some of the area change is due to errors attributed to the method. In some cases there may be a slight offset in the georectification of historical aerial photography. Similarly there could be slight variations in the position of the back of landward sinks where perhaps no change has actually occurred. This may be due to the variation in density of vegetation through which the exact position of the back of beach cannot be identified. However these will be only small errors in comparison to the areas of sediment calculated from this method.

The constant, loss and gain analysis shows how the area of each site has changed over time, from each consecutive year to the baseline (Map B in Appendix H). Table H.1 shows the results of this analysis. As expected there is greater change over the longest time period than other time periods.

At Browndown the area of loss between 1986-2008 is greater than the area of gain. However the quantity of gain from 1994-2008 is greater than the area of loss. At Studland the area of loss between 2005-2008 is greater than the area of gain. In all cases and for all sites the constant area stays significantly higher than either loss or gain.

3.4 Offshore Stores and Sinks

Two sets of maps were produced as part of the analysis for the offshore stores and sinks:

- **Initial tranche of digitised shoals: constant, loss and gain analysis (Appendix I.2 & I.3)**

Admiralty tide charts from 1950-1960 and 2004/2005 were digitised to identify potential locations of offshore shoals. A difference plot of the area was then undertaken to produce constant, loss and gain maps in Appendix I.2. Sediment type could not be distinguished from the Admiralty Charts, therefore swath bathymetry mapping and other data sources were used to identify between rock and sediment (Section A.4.3). Any areas of rock were removed from the dataset, leaving the sedimentary shoals only (maps in Appendix I.3).

- **Sedimentary stores and sinks (Appendix I.4)**

Any erosion was removed from the maps in Appendix I.3 to show sites of constant sediment and sediment gain only (see maps in Appendix I.4).

The offshore shoals analysis was split in to four sections to match the extent of the Admiralty Chart data. In addition, area calculations can be found in Appendix I.6.

3.4.1 Lyme Regis to Portland Bill (Appendix I.2.1, I.3.1 & I.4.1)

There are no offshore shoals between -20mCD and +0.5mCD were identified for this location.

3.4.2 Portland Bill to Christchurch Bay (Appendix I.2.2, I.3.2 & I.4.2)

- **Initial tranche of digitised shoals: constant, loss and gain analysis (Appendix I.2.2 & I.3.2)**

Between Portland Bill and Durlston Head there are two offshore sedimentary shoals: The Shambles and Adamant Shoal. The Shambles Bank has undergone substantial erosion since the 1960's, whilst the Adamant Shoal appears to be more stable in comparison.

Hook Sands, the ebb delta of Poole Harbour, is discussed in Section 3.2.1. In addition, historical Admiralty Charts for years 1853, 1878, 1891, 1902, 1912, 1923 and 1925 were digitized for the ebb delta (Map B in Appendix I.1). In general it would appear the ebb delta has remained relatively stable over the past 160 years, although the swash channel is further east compared with the earlier charts.

The foreshore of Mundeford Spit at Christchurch Harbour is covered by the analysis and shows that the majority of the spit has remained constant in area, with accretion towards the land over time.

Dolphin Bank in Christchurch Bay has undergone minor accretion since the 1950's whilst Dolphin Sand in Poole Bay appears to have eroded completely. As can be identified from Figure I.5, this is, however, a factor of the method applied, whereby not all depth contours are shown on the Admiralty Charts.

- **Sedimentary stores and sinks (Appendix I.4.2)**

The main offshore stores and sinks identified between 1960-2005 can be found at:

Shambles Bank (416,900m² accretion with 383,700m² of constant area)

Dolphin Bank (79,300m² accretion with 1,518 of constant area)

The majority of the Dolphin Bank shows a constant area, whereas the Shambles Bank appears more dynamic with accretion to the landward extent of the shoal and erosion to the south (seaward) side.

3.4.3 Christchurch Bay to Selsey Bill (Appendix I.2.3, I.3.3 & I.4.3)

- **Initial tranche of digitised shoals: constant, loss and gain analysis (Appendix I.2.3 & I.3.3)**

In Christchurch Bay, the Shingles Bank has remained relatively stable since the 1950's, with some sediment accretion on the north side adjacent to Hurst Spit and to the west of the bank.

In the West Solent, the Solent Bank and the small shoal off Calshot Spit has completely disappeared since the 1960's.

To the north of the Isle of Wight the Brambles Bank appears to have accreted.

North-east of the Isle of Wight, the Ryde Middle Bank has remained relatively stable whilst the Sturbridge Shoal has undergone more erosion.

The two large shoals (New Grounds and Princess Shoal) off the east side of the Isle of Wight have remained relatively stable over the time period, whilst the large shoal at St Catherine's Deep, off of the south-east side of the Isle of Wight has undergone a substantial amount of accretion. The St Catherine's Deep shoal is at a depth of -20m CD.

The ebb delta at the mouth of Langstone Harbour appears to have undergone an increase in area on the outer edge in particular. This can also be seen in the ebb delta maps (Appendix G).

The ebb delta at Chichester Harbour entrance appears to have eroded substantially in the centre and on the outer edge, whilst the foreshore along the East Head to East Wittering beach has remained stable with accretion on the seaward edge.

The large offshore shoal at Medmerry Bank has undergone substantial erosion since the 1960's to its northern extent, while the central section of the bank has remained constant.

- **Sedimentary stores and sinks (Appendix I.4.3)**

The main offshore stores and sinks identified between 1960-2005 can be found at:

Shingles Bank (880,600m² accretion with 5,660,900m² of constant area)
Bramble Bank (706,000m² accretion with 475,200m² of constant area)
Ryde Middle Bank (146,000m² accretion with 2,151,000m² of constant area)
New Grounds (947,500m² accretion with 10,773,200m² of constant area)
Princess Bank (182,200m² accretion with 2,585,800m² of constant area)
Medmerry Bank (75,300m² accretion with 6,379,000m² of constant area)
Pullar Bank (382,900m² accretion with 1,018,000m² of constant area)
St Catherine's Deep (9,769,900m² accretion with 4,467,500m² of constant area)

The main site of accretion is found within St. Catherine's Deep area, where the shoal has changed shape and size significantly since the 1960's.

3.4.4 Selsey Bill to Shoreham-by-Sea (Appendix I.2.4, I.3.4 & I.4.4)

- **Initial tranche of digitised shoals: constant, loss and gain analysis (Appendix I.2.4 & I.3.4)**

There are similar amounts of accretion and erosion on the shoals situated off of Selsey Bill (Pullar Bank, Middle Ground and the Outer Owers).

The shoal to the west of Foul Ground, and Foul Ground shoals appears to have eroded substantially.

- **Sedimentary stores and sinks (Appendix I.4.4)**

The main offshore stores and sinks identified between 1960-2005 can be found at:

Pullar Bank (382,900m² accretion with 1,018,000m² of constant area)
Middle Ground (145,700m² accretion with 804,400m² of constant area)
Outer Owers (1,066,700 m² accretion with 2,226,000m² of constant area)

4. SCOPAC wide stores and sinks

The results were collated to show final stores and sinks across the SCOPAC region for larger sediment cells (Appendix J). The maps present the following findings:

- Beaches

Beach accretion is shown for the earliest to most recent epoch with management practices removed. To avoid exaggeration of accretion on the beaches no outline was added in the GIS. The scale of the larger mapping does not lend itself well to presenting the beach stores. However, the detail can be found in Appendix E.

- Ebb tidal deltas

Ebb tidal delta accretion is shown for the earliest to most recent epoch.

- Landward sinks

Constant areas and areas of gain in sediment for earliest to most recent available data.

- Offshore shoals

Constant areas and areas of gain in sediment are shown for earliest to most recent available data.

4.1.1 Lyme Regis to Portland Bill (Appendix J.1)

There has been very little management along this stretch of coastline. The main beach stores identified between 2007-2012 can be found at:

- MU5_5: Charmouth (165,600m³ accretion)
- MU4: West of Seatown (78,900m³ accretion)
- MU5_3: West Bay (82,700m³ accretion)
- MU2: Chiswell, Chesil Beach (97,900m³ accretion)

There are no ebb deltas to report on along this section of coastline.

The landward sink at Studland has remained relatively stable since 2005 with an approximate area of 2,286,000 m².

There are no offshore shoals between -20mCD and +0.5mCD identified for this location.

4.1.2 Portland Bill to Christchurch Bay (Appendix J.2)

The stretch of coastline between Portland Bill and Durlston Head has very little beach management given the dominance of cliffs, whilst the beaches in Poole and Christchurch Bays are heavily managed. As a result of the ongoing beach management there are very few beach stores in the region. The beach stores identified between 2003-2012 can be found at:

- CPU7b: Durdle Door (9,100m³ accretion)*
- CPU10d: Worbarrow Bay (10,200m³ accretion) *
- STU3 & STU4: Studland and Shell Bay (269,000m³ accretion)
- PBY3: Hengistbury Head (78,200m³ accretion)
- CBY2: Friar's Cliff (34,200m³ accretion)

The ebb delta at Christchurch Harbour has accreted by 96,000 m² between 2006-2010.

The landward sink at Browdown has remained relatively stable since 1986. The cusped foreland has suffered some erosion on the seaward edge. The landward sink at Sinah Common has accreted by 110,000m² between 1946 – 2008 given the large area of sediment accretion at Gunner Point.

The main offshore stores and sinks identified between 1960-2005 can be found at:

- Shambles Bank (416,900m² accretion with 383,700m² of constant area)
- Dolphin Bank (79,300m² accretion with 1,518,600m² of constant area)

4.1.3 Christchurch Bay to Selsey Bill including the Isle of Wight (Appendix J.3)

The north Solent coastline is heavily managed. The main beach stores identified between 2003-2012 are as follows, the majority of which are in the east Solent:

- CBY7 & LYM1: Hurst Spit & North Point (35,600m³ accretion)
- LYM14: Calshot Spit (25,200m³ accretion)
- CPU11: Browdown (51,600m³ accretion)
- CPU9: Portsmouth (22,200m³ accretion)
- CPU8: Southsea (196,600m³ accretion)
- CPU7: Sinah Common (248,000m³ accretion) including Gunner Point (198,000 m³ accretion)
- CPU6: Black Point Spit (46,700m³ accretion)
- CPU5: East Head Spit (797,100m³ accretion)
- CPU4: Bracklesham Bay (192,700m³ accretion)
- RYD5: Ryde Sands (304,300m³ accretion)
- SAN1 – SAN6: Sandown (309,900m³ accretion)

* Over the past decade, both CPU7b and CPU10d have undergone net accretion towards the east. However, when analysing the two 5 year epochs, both beaches have experienced a reversal in sediment transport direction.

The ebb delta at Langstone Harbour has accreted by 339,000m² between 2004 – 2011 whilst the ebb delta at Chichester Harbour has accreted by 620,000m² in the same time period.

The main offshore stores and sinks identified between 1960-2005 can be found at:

Shingles Bank (880,600m² accretion with 5,660,900m² of constant area)
Bramble Bank (706,000m² accretion with 475,200m² of constant area)
Ryde Middle Bank (146,000m² accretion with 2,151,000m² of constant area)
New Grounds (947,500m² accretion with 10,773,200m² of constant area)
Princess Bank (182,200m² accretion with 2,585,800m² of constant area)
Medmerry Bank (75,300m² accretion with 6,379,000m² of constant area)
Pullar Bank (382,900m² accretion with 1,018,000m² of constant area)
St Catherine's Deep (9,769,900m² accretion with 4,467,500m² of constant area)

The main site of accretion is found within St. Catherine's Deep area, where the shoal has changed shape and size significantly since the 1960's.

4.1.4 Selsey Bill to Shoreham-by-Sea (Appendix J.4)

The main beach stores can be found at:

MU1 & MU2: West Selsey (243,400m³ accretion)
MU2 & MU2a: Pagham Harbour (835,200m³ accretion)
MU9a: Shoreham-by-Sea (503,300m³ accretion)

The ebb delta at Pagham Harbour has accreted by 66,000m² between 2006-2010.

The main offshore stores and sinks identified between 1960-2005 can be found at:

Pullar Bank (382,900m² accretion with 1,018,000m² of constant area)
Middle Ground (145,700m² accretion with 804,400m² of constant area)
Outer Owers (1,066,700 m² accretion with 2,226,000m² of constant area)

A flythrough collating all of the above information was produced as part of the final project outputs and can be downloaded from the SCOPAC website (www.scopac.org.uk).

5. Conclusions

A range of data and GIS techniques have been used to map the location and change in volume/area of stores and sinks across the SCOPAC region for the beaches, ebb deltas, landward sinks and offshore shoals. The outputs from the project will inform future coastal management works, in particular, the production of Beach Management Plans and sediment recycling and bypassing operations.

The project has highlighted the extent of the beach management works along built-up stretches of the SCOPAC coastline and the importance of logging these events, along with continued monitoring of sediment accretion and erosion. It is unknown whether all records of management have been received and are included in the report however, continuation of this approach will enable more cost-effective, localised beach management within the same sediment cell in the future.

Ongoing beach monitoring is essential, particularly on managed beaches as longshore drift may change direction (CIRIA Beach Management Manual, 2010) or a storm may remove large quantities of sediment from the system. This can occur on a seasonal or annual timescale. The value of the data captured by the National Network of Regional Coastal Monitoring Programmes is apparent throughout the project, particularly the 5 year beach difference plots which not only graphically show changes in net sediment movement but quantify fluctuating beach volumes. Best available data in the form of Admiralty Tide Charts were used for mapping the offshore shoals. As more swath bathymetry data is captured through the monitoring programmes, the extent, location and classification of the offshore shoals into rock or sediment will become increasingly accurate. In addition, with continued lidar and bathymetric survey data collection, the ebb delta difference plots will become more valuable as the time series increases.

The final year of analysis for this project was 2013. In light of the recent storms to hit the SCOPAC region in the winter of 2013/2014, a report was produced by the Channel Coastal Observatory (April 2014). The report analyses the return period of the storms and presents difference plots and volume changes for the beaches which underwent a post-storm survey. The storm and beach analysis is put into context by comparing the results with previous years. The report can be downloaded from the SCOPAC website (www.scopac.org.uk).

6. Recommendations

1. Continue to analyse the five year baseline difference plots for the beaches across the SCOPAC region to monitor long term changes and variability of volume.
2. Engineers should continue to submit recycling and replenishment logs to the Plymouth Coastal Observatory and the Channel Coastal Observatory.
3. The recycling and replenishment maps should be updated every 5 years to complement the beach changes recorded from the baseline survey difference plots.
4. Continue the classification of rock and/or sediment from the swath bathymetry data collected through the National Network of Regional Coastal Monitoring Programmes.
5. Continue to use a combination of bathymetric and lidar surveys for ebb-delta difference modelling to monitor changes in area.

7. Abbreviations

BGS	British Geological Survey
CCO	Channel Coastal Observatory
CIRIA	Construction Industry Research and Information Association
DTM	Digital Terrain Model
FDGiA	Flood Defence Grant in Aid
m (CD)	metres (Chart Datum)
MLWS	Mean Low Water Springs
m (OD)	metres (Ordnance Datum)
NOC	National Oceanography Centre
OS	Ordnance Survey
SCOPAC	Standing Conference on the Problems Associated with the Coastline
SMP	Shoreline Management Plan
UKHO	United Kingdom Hydrographic Office

8. Glossary

Accretion	An increase in the quantity of sediment found on a beach, in either volume or elevation
Bathymetry	Is the topography of the seabed e.g. as shown on Admiralty charts. Bathymetry is typically measured from a vessel with an echosounder, which sends a sound beam through the water and measures the time taken for the sound to reflect from the seabed and return to the vessel. The depth readings must be corrected for the tide at the time the measurements are taken.
Epoch	A length of time over which the study takes place; e.g. the three epochs: 2003-2007, 2007-2012 and 2003-2012.
Erosion	A loss in the quantity of sediment found on a beach, in either volume or elevation.
Fathoms	A unit used to measure the depth of water on Admiralty Charts pre-1990. 1 fathom = 1.8 metres.
Lidar	Lidar measures surface topography by sending a laser beam from an aircraft to measure the time taken for the laser beam to reflect off the surface and return to the aircraft. Measurements can be taken over a swath typically up to ~1km wide in a single pass of the aircraft.
Management Unit	A length of shoreline with similar characteristics in terms of coastal processes and assets at risk that can be managed efficiently and sustainability. Originally used in the first round of Shoreline Management Plans.
Photogrammetry	A method of obtaining reliable information (e.g. elevation/position) of objects/sites through the use of aerial photography.
Recycling	Sediment moved from one location to another within the same sediment cell.
Replenishment	Sediment brought in from a location outside of a sediment cell to be used for replenishment of a beach.
Sinks	Sinks are defined in this report as relict features no longer active within the sediment budget.
Stores	Stores are defined in this report as accretionary features which are active within the sediment budget.
Swath bathymetry	Measures the topography of the seabed using a swath of sound beams (in contrast to a single beam echo sounder which sends only one sound beam into the water), hence measuring a swath of sea bed typically 3 times the water depth. Swath bathymetry sensors are often referred to as multibeam sonars, and can achieve 100% seafloor coverage.

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