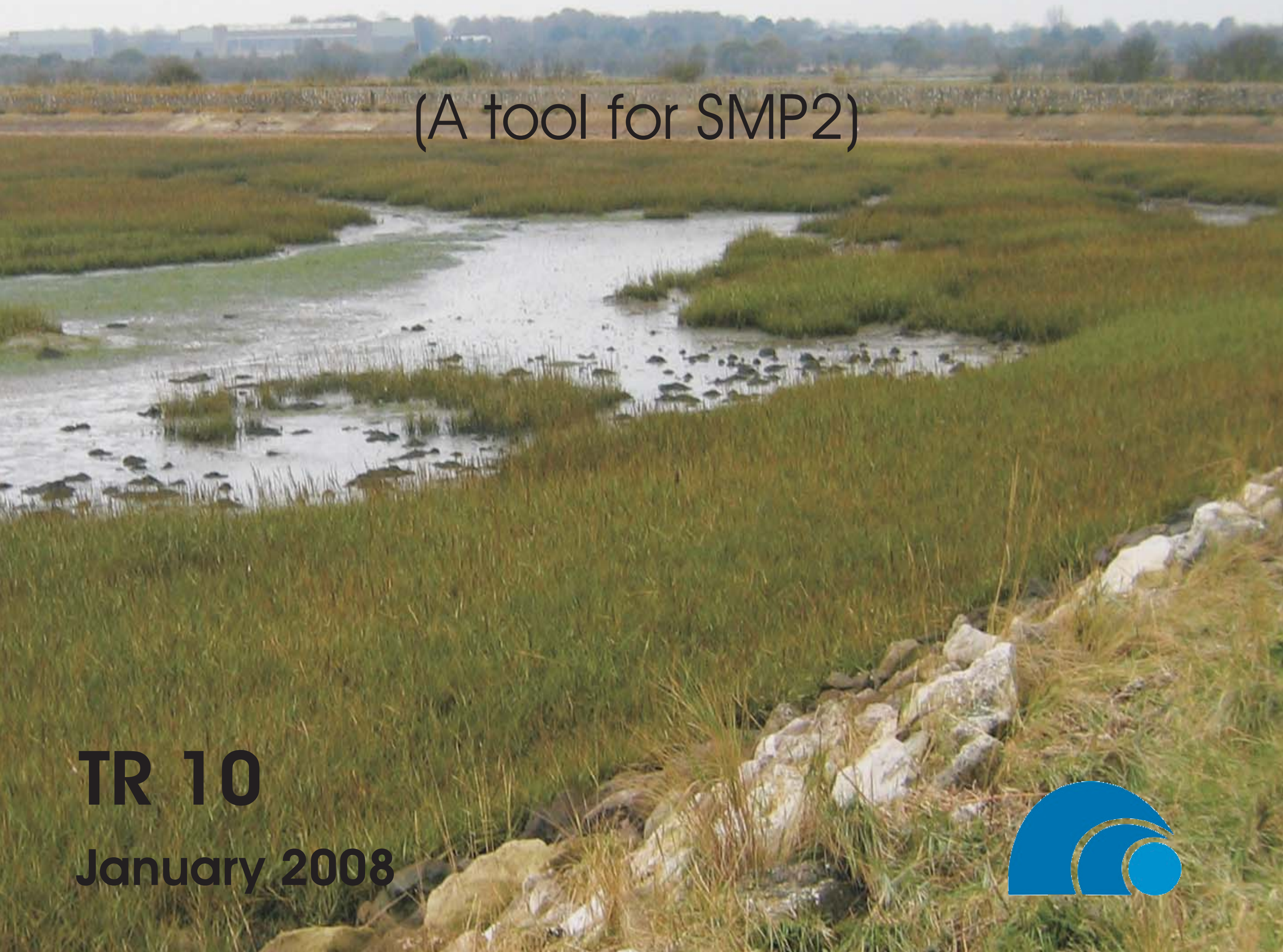
Channel Coastal Observatory

SOLENT DYNAMIC COAST PROJECT

Main Report

(A tool for SMP2)



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Solent Dynamic Coast Project: *Main report*

A tool for SMP2

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Please note that the Solent Dynamic Coast project is purely a desktop study, focusing on inter-tidal habitats, designed to inform the North Solent Shoreline Management Plan (SMP). It is essentially a precursor to the SMP Appropriate Assessment.

The main objective of the project was to quantify inter-tidal loss and identify potential for re-creation at a strategic level across the north Solent. In doing so, a method was devised based on approximate benefit-cost calculations to categorise potential inter-tidal habitat creation sites into possible managed re-alignment sites, possible abandonment sites (No Active Intervention) and possible hold the line sites. The project was able to estimate a balance of inter-tidal loss versus the potential for inter-tidal gain. The requirement for replacement EU designated freshwater habitat was also quantified.

The work was undertaken by the key statutory authorities. However, this study did not involve any decision making on the part of any statutory authority. The options suggested in this study are there to facilitate future debate and decision making as part of the SMP process. No landowners or wider stakeholders were consulted as part of the project. Detailed discussions will be required with landowners before any site management changes. These views will be sought as part of the SMP process. The SMP process will integrate all aspects of sustainable development, social, economic as well as environmental, prior to any final decisions on coastal management being made. The basis of the framework applied in the Solent Dynamic Coast project was therefore technical and does not reflect a formal proposal to change the management.

Please visit http://www.defra.gov.uk/environ/fcd/policy/smp.htm for DEFRA guidance on SMPs and http://www.nfdc.gov.uk/index.cfm?articleid=6554 for more information on the North Solent SMP.

Executive Summary

The Solent Dynamic Coast Project (SDCP) was conducted to inform development of the 2nd round Shoreline Management Plan (SMP 2) in order to comply with the requirements of the European Union Habitats and Birds Directives. The focus was on mudflat and saltmarsh habitats as these form the largest expanse of coastal habitats across the north Solent that are immediately under threat from climate change and coastal management decisions. The consequent effect to coastal grazing marsh was also considered. The main objectives were to;

- quantify the amount of inter-tidal coastal squeeze over the next 100 years that requires replacement habitat
- identify sites where inter-tidal habitat creation is physically possible
- quantify the amount of inter-tidal habitat creation sites that could potentially offset inter-tidal coastal squeeze over the next 100 years
- undertake preliminary ranking and assessment of the feasibility of conducting managed re-alignment relative to other impacting variables
- develop a region-wide framework of potential inter-tidal habitat mitigation and compensation sites

The majority of defences in the north Solent are fronted and backed by European designations, such as Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). Maintaining or improving these defences, must comply with European environmental legislation. Certain flood defence schemes have been delayed for over two years because replacement inter-tidal habitat could not be found to offset the projected coastal squeeze, resulting from the operational works.

As a result, the SDCP was initiated on behalf of the operating authorities within the north Solent region. The project covered the area between Hurst Spit, Hampshire and Pagham Harbour, West Sussex. The project verified mudflat and saltmarsh loss calculated by the Solent Coastal Habitat Management Plan (CHaMP, 2003) using a robust methodology of historical aerial photography interpretation (HPI) and analysis of topographic and tidal elevation data. Predicted changes to existing inter-tidal habitat across the north Solent, regardless of defences or environmental designations, was estimated to be +60 hectares (ha) for mudflat and -812 ha for saltmarsh over the next 100 years. Inter-tidal coastal squeeze resulting from maintenance of all existing defences (causing coastal squeeze) across the north Solent over the next 100 years was estimated to be approximately 5 ha of mudflat coastal squeeze and 495 - 595 ha of saltmarsh coastal squeeze. This predicted 500 - 600 ha loss provides a worse case scenario, as not all defences will be maintained.

Potential habitat creation sites across the north Solent were identified using topographic and tidal elevation data. A total potential of 3883 ha were identified. Once buildings, landfill and sites smaller than 0.5 ha were removed there were 2025 ha to be assessed further. In order to assess the viability of the potential sites (2025 ha), local coastal managers were interviewed using a questionnaire based on Government economics and environmental criteria devised by the Environment Agency (EA), Natural England (NE) and the Channel Coastal Observatory (CCO). The questionnaire categorised the sites into preferred options for, hold the line, managed re-alignment or no active intervention (abandonment)* for time epochs 0-19, 20-49, 50-100 and 100 years+.

* References to abandonment are only relevant in the context of the SDCP. The EA intend to implement a policy of withdrawal of maintenance from un-economic defences in due course.

Of the 2025 ha of potential habitat creation sites, only 552 ha were considered suitable to offset the 500 - 600 ha projected loss. Key potential habitat creation sites were West Northney, Medmerry, Gillies, Farlington Marshes, North Common, Lymington Reedbeds, Pagham South, Saltgrass Lane, Stoke, Nutbourne, and West Wittering. Of the 552 ha, 135 ha counts as mitigation because the key sites are within an existing SPA. There may be a shortfall of inter-tidal habitat creation sites in the north Solent over the next 100 years unless abandonment sites (686 ha) can be used as mitigation or compensation to offset future damaging schemes. Hold the line sites (787 ha) may require further future assessment if resources are made available to re-align them. Approximately 79 ha of designated freshwater sites were identified as requiring replacement habitat as a result of potential managed re-alignment. A further 328 ha of freshwater sites would also be lost due to potential abandonment without any clear means to replace it.

The SDCP approach was innovative and has not been applied elsewhere in the U.K. The mixture of scientific data and input by local coastal managers has produced guidance for inter-tidal habitat creation that will feed into the North Solent Shoreline Management Plan (SMP). Findings are based on current environmental policies, which lack clarity and are frequently open to ambiguous interpretation. The set of rules applied to rank potential inter-tidal habitat creation sites into time epochs for potential re-alignment or abandonment was based on a suite of assumptions that are subject to change. The parallel Isle of Wight Mitigation Study (which in addition to inter-tidal habitats, assessed other coastal Biodiversity Action Plan habitats), and the SDCP will inform the EA Southern Region Habitat Creation Programme (RHCP).

The work has been undertaken by the key statutory authorities. However, this study has not involved any decision making on the part of any statutory authority. The options suggested in this study are there to facilitate future debate and decision making as part of the SMP process. No landowners or wider stakeholders have been consulted as part of the project. These views will be sought as part of the SMP process. The SMP process will integrate all aspects of sustainable development, social, economic as well as environmental, prior to any final decisions on coastal management being made.

Contents

1. Introduction

The Solent Dynamic Coast Project (SDCP) provides technical advice to the North Solent Shoreline Management Plan (SMP) on meeting the requirements of the EU Habitats Directive 92/43/EEC and EU Birds Directive 79/409/EEC. ***The work has been undertaken by the key statutory authorities. However, this study has not involved any decision making on the part of any statutory authority. The options suggested in this study are there to facilitate future debate and decision making as part of the SMP process. No landowners or wider stakeholders have been consulted as part of the project. These views will be sought as part of the SMP process. The SMP process will integrate all aspects of sustainable development, social, economic as well as environmental, prior to any final decisions on coastal management being made.***

The study aims to provide a strategic approach to compensating for inter-tidal coastal squeeze caused by essential flood defences, and will form the basis of the North Solent SMP's Appropriate Assessment (AA). The AA will need to show that coastal management policies are adopted that allow sufficient mitigation or compensation to generate new inter-tidal habitat to offset that lost to coastal squeeze. Where replacement habitat causes loss to landward designated habitats then there may be a knock-on requirement for replacement freshwater habitats.

1.1 Background

The first round of SMPs was produced before statutory obligations to protect the natural coastline were fully realised. With better understanding of the implications of climate change there is now an increasing trend away from coastal defence towards risk management and planning for a "sustainable" coastline. As a consequence, managed re-alignment is becoming a more environmentally and economically accepted option. Coastal managers have, however, been limited when identifying suitable sites for mitigation or compensation of coastal habitats due to lack of research into viable areas.

In an attempt to deliver the European Union (EU) Habitats and Birds Directives for SMPs and Coastal Defence Strategy Studies (CDSs), the Solent Coastal Habitat Management Plan (CHaMP, 2003) included an assessment of mudflat and saltmarsh change. It predicted between 730 to 830 ha of inter-tidal habitat loss over the next 100 years for the north Solent and Isle of Wight. The Solent CHaMP (2003) also identified potential inter-tidal habitat creation sites using a coarse resolution approach based on the 5 metre OD contour line. However, more detailed analysis of the potential sites was required to advise the second round SMPs.

The latest SMP guidance recommends that Operating Authorities (OAs) plan for a dynamic coast where it may not be sustainable to maintain habitats in their current locations. In carrying out flood and coastal defence functions, OAs should seek to further nature conservation and contribute to meeting environmental objectives, including biodiversity targets set under the EU Habitats and Birds Directives, Ramsar Convention and DEFRA High Level Target 4 (DEFRA, 2006). Requirements include managed re-alignment for mitigation and compensation, in order to maintain favourable conservation status, and a coherent network of coastal habitats.

As a consequence, the Isle of Wight (IOW) Mitigation Study (which in addition to inter-tidal habitats assessed other coastal Biodiversity Action Plan habitats) was instigated. The SDCP was also initiated for the north Solent, to provide a strategic approach to meeting the requirements of the Habitats and Birds Directive by identifying and investigating suitable sites for inter-tidal habitat creation to offset losses from damaging schemes. Findings from both studies will inform the second round SMP's, CDSs and the EA Southern Region Habitat Creation Programme (RHCP).

1.2 Rationale

The multitude of environmental designations and targets has created added pressure for coastal managers in the north Solent. The area supports important ecological systems, which are protected by multiple international, European and national nature conservation designations. Maintaining and upgrading sea defences in the face of climate change is becoming less sustainable. At the same time, inter-tidal habitat loss is a huge problem, particularly in the north Solent, with saltmarsh losses as high as 83% in Langstone Harbour since the 1940's. This loss of inter-tidal habitat is cause for concern from both an environmental and sea defence point of view.

The north Solent comprises 354 kilometres of highly developed coastline, including open coast, harbours and rivers. Approximately 283 km are protected from flooding or coastal erosion (Figure 1.1). The majority of these defences are fronted by designated inter-tidal Natura 2000 sites, which have reduced significantly in area since the 1950's when most of these defences were built. Due to the reduction in fronting inter-tidal area, significant defence upgrade is required to provide an adequate level of protection, especially in the face of climate change. However, if a defence is to be upgraded, this study has found that approximately 178 km of defence length will require replacement inter-tidal habitat to offset the future coastal squeeze[*] to the fronting designated Special Area of Conservation (SAC) or Special Protection Area (SPA) (Natura 2000 sites) (Figure 1.2). This is so that favourable conservation status is maintained. Of the defences causing inter-tidal coastal squeeze (178 km), over half will come to the end of their residual life within the next 20 years (Figure 1.3).

Implementation of flood defence schemes that result in coastal squeeze to Natura 2000 sites have been delayed around the north Solent because of the difficulty in securing replacement habitat under the Habitats and Birds Directives. Schemes such as Eastoke and Selsmore in the East Solent were delayed for over two years because replacement inter-tidal habitat could not be found. Only 0.5 ha was required for Eastoke and 5 ha for Selsmore. In an effort to resolve the issue, the EA, NE and DEFRA agreed that if funds were put aside for replacement habitat then the Eastoke scheme could proceed. Securing and implementing replacement habitat to offset the Selsmore scheme is still ongoing.

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[*] Coastal squeeze definition used in the SDCP: where a sea defence inhibits rollback of designated inter-tidal habitats

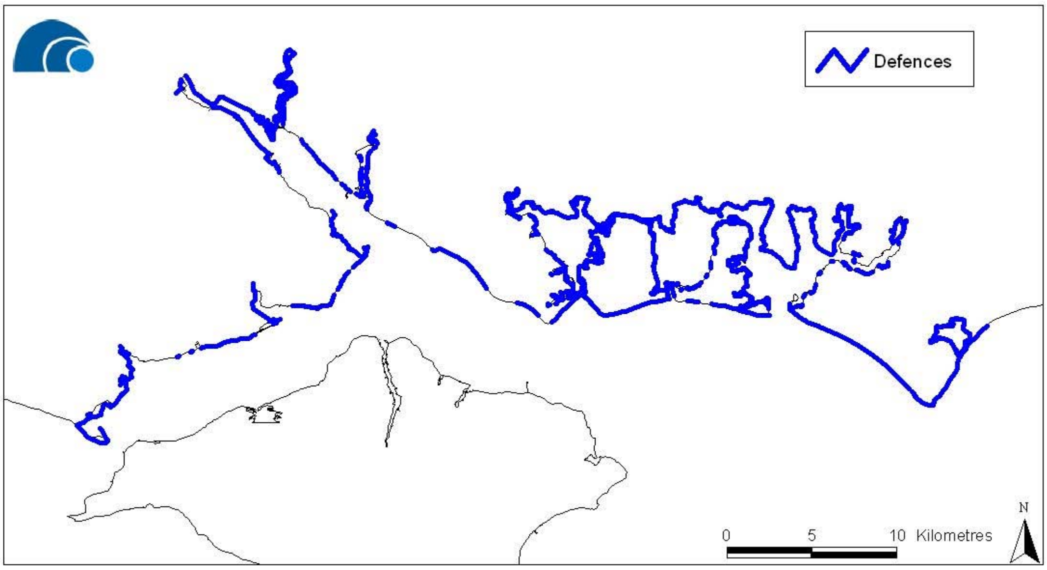


Figure 1.1: Defences across the north Solent

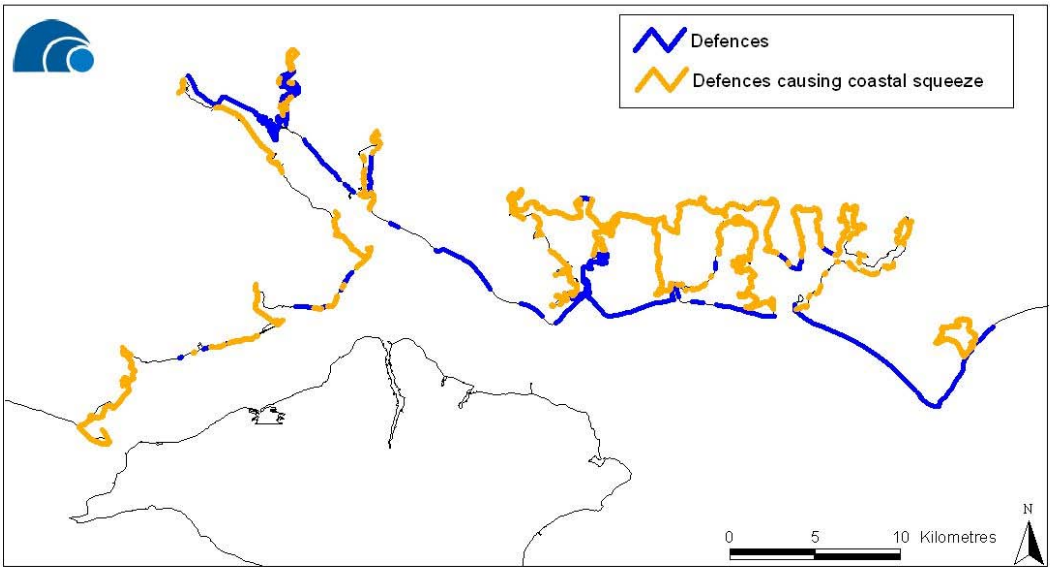


Figure 1.2: Defences across the north Solent causing coastal squeeze

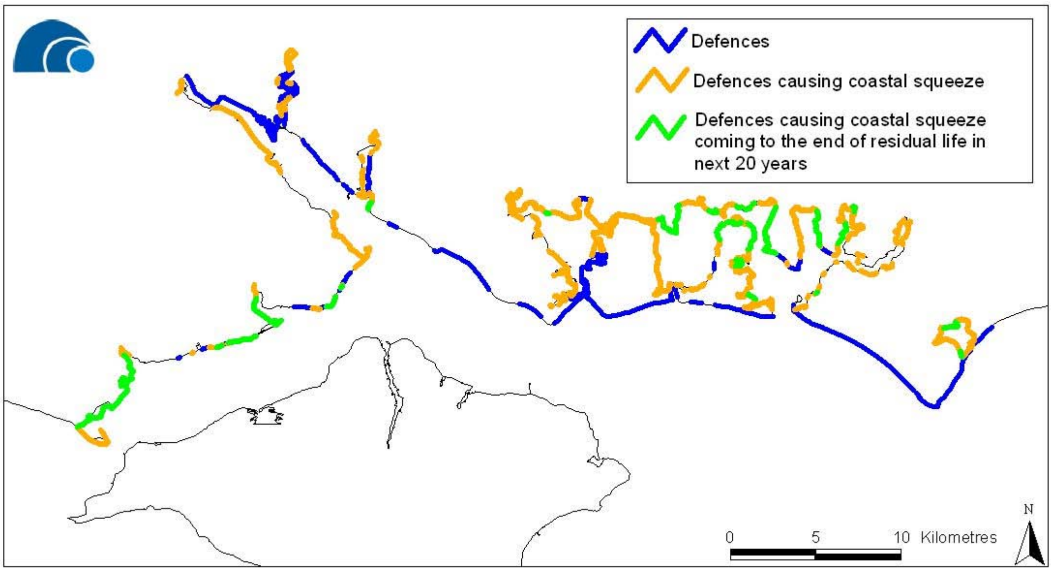


Figure 1.3: Defences across the north Solent, causing coastal squeeze, that are coming to the end of their residual life in the next 20 years

There are a number of barriers to implementing managed re-alignment for habitat creation in the north Solent. The administrative arrangements in the north Solent are more complicated than elsewhere in that the majority of sea defences are maintained by local authorities (LAs) and private landowners, rather then by the Environment Agency (EA). It is estimated that one third of the sea defences that cause coastal squeeze across the north Solent are privately maintained. In addition, approximately two thirds of the hinterland is privately owned. Accordingly, an OA which maintains a defence may not own the hinterland. This creates two problems;

- offsetting coastal squeeze for private landowners when they upgrade their defences
- Dealing with multiple key stakeholders when re-aligning a site.

Very few managed re-alignments have taken place in the north Solent because of complicated administrative arrangements and the fact the north Solent is a highly developed residential area that is a popular recreational and tourist attraction. There are, therefore, few habitat creation opportunities that may be implemented. The largest re-alignment was at Thornham Point in Chichester Harbour, in 1996. The 6.5 ha site was acquired by Chichester Harbour Conservancy when the landowner went bankrupt. The site was ideal as no inner bunds or ditching work was required; it was non-designated and a natural breach had already formed. This site was not actively breached to provide compensation for a damaging scheme. The site is now a designated Site of Importance for Nature Conservation (SINC) and hosts saltmarsh and grazing marsh. In addition, 25 ha of un-designated land were purchased at Chidham, Chichester Harbour for three times the cost of agricultural land. Secondary bunds were built and when replacement habitat is required to offset a damaging scheme, the existing defences will be breached. These opportunities are rare in the north Solent and in the case of Chidham, took three years to secure.

1.3 Project aims and objectives

The overall aim of the project is to “Inform the North Solent SMP so that it may meet requirements under the EU Habitats and Birds Directive for inter-tidal habitats, allowing a more dynamic coastline to be achieved, where coastal wildlife habitats can adapt to sea level rise whilst protecting people and property.”

More specifically, the objectives are:

- To clarify legal drivers and liabilities to provide information to planning authorities on the need to preserve inter-tidal habitat creation sites for their purpose.

- To provide information on inter-tidal habitat loss and replacement coastal habitat creation sites over 0 – 100 years that is agreed on a north Solent wide basis.

- To provide strong recommendations for the North Solent SMP and CDSs.

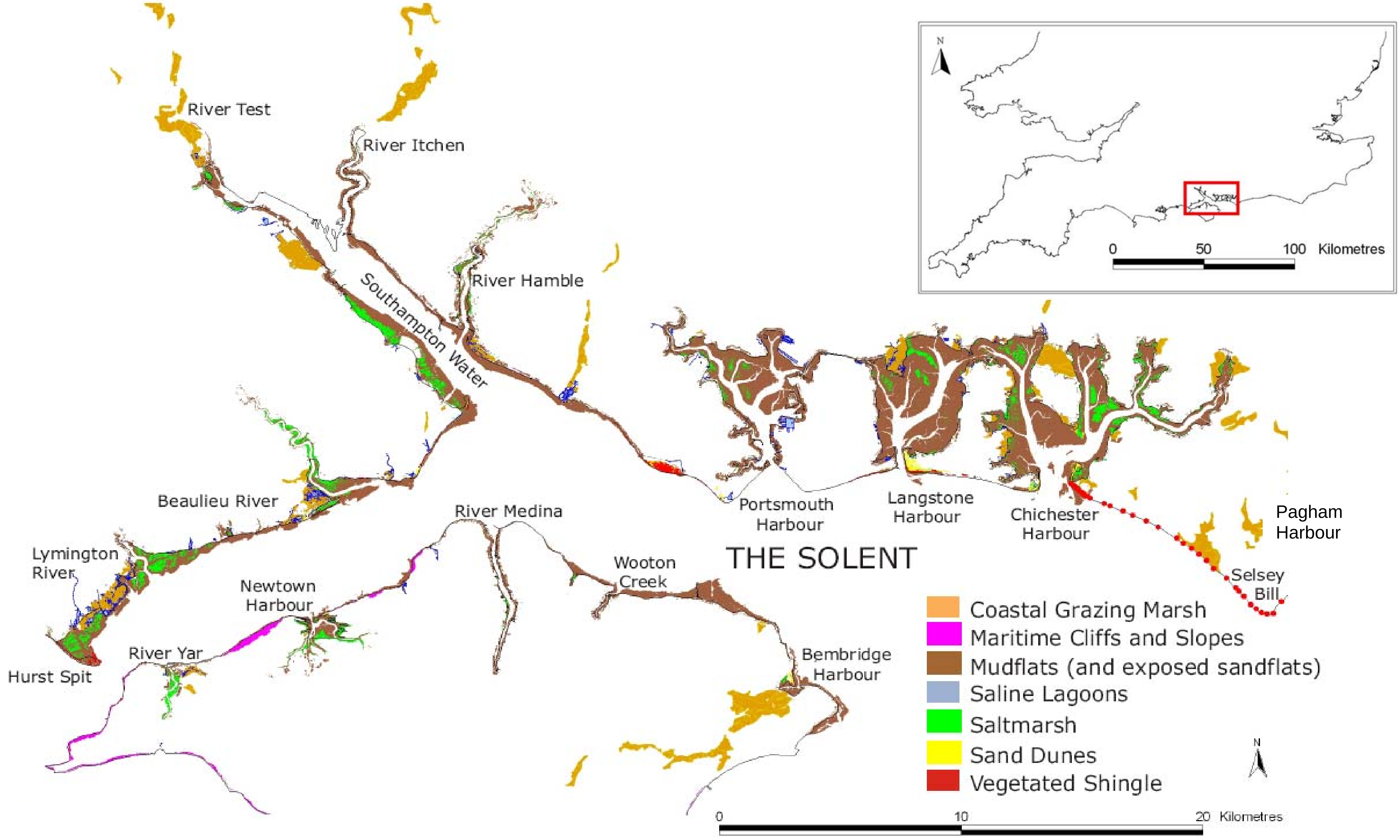
Recommendations from the SDCP and IOW Mitigation Study will also feed into the EA RHCP.

The main focus of the study was to identify potential inter-tidal mitigation and compensation sites as these form the largest expanse of deteriorating coastal habitats across the north Solent. Those habitats, such as coastal grazing marsh, that may be lost to inter-tidal habitat creation through potential managed re-alignment or abandonment of sea defences were also identified. Although estimates were made of the amount of freshwater site compensation, the potential for relocating these was not investigated. The EA RHCP will identify potential freshwater replacement sites.

1.4 Study area

The study area covers the north Solent between Hurst Spit, Hampshire and Pagham Harbour, West Sussex (Figure 1.4). The coastal fringes are floristically diverse with a large proportion fronted by inter-tidal habitats and to a lesser degree backed by coastal grazing marsh, saline and brackish lagoons. Vegetated shingle beaches are relatively prominent on the larger, more stable systems with very few sand dune systems and maritime cliffs and slopes.

Analysis was undertaken at three spatial scales: north Solent wide, European designations (Figure 1.5 and 1.6) and geographical units (Figure 1.7).



Hampshire coastal strip (2001) and harbours (2002) from aerial photography interpretation courtesy of Environment Agency/Channel Coastal Observatory; Hampshire/IOW rivers and Chichester Harbour (2003) from CASI courtesy of Environment Agency Science Group Technology for English Nature; East Head to Selsey Bill (1999) from Vegetated Shingle Project courtesy of English Nature, West Sussex County Council, Environment Agency, Arun District Council, Chichester District Council and SCOPAC; Coastal and Floodplain Grazing Marsh (1993) from Environment Agency (in partnership with English Nature) Coastal and Floodplain Grazing Marsh Inventory for England (2004) courtesy of Environment Agency's National Centre for Environmental Data and Surveillance.

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Figure 1.4: Coastal Biodiversity Action Plan habitats across the Solent

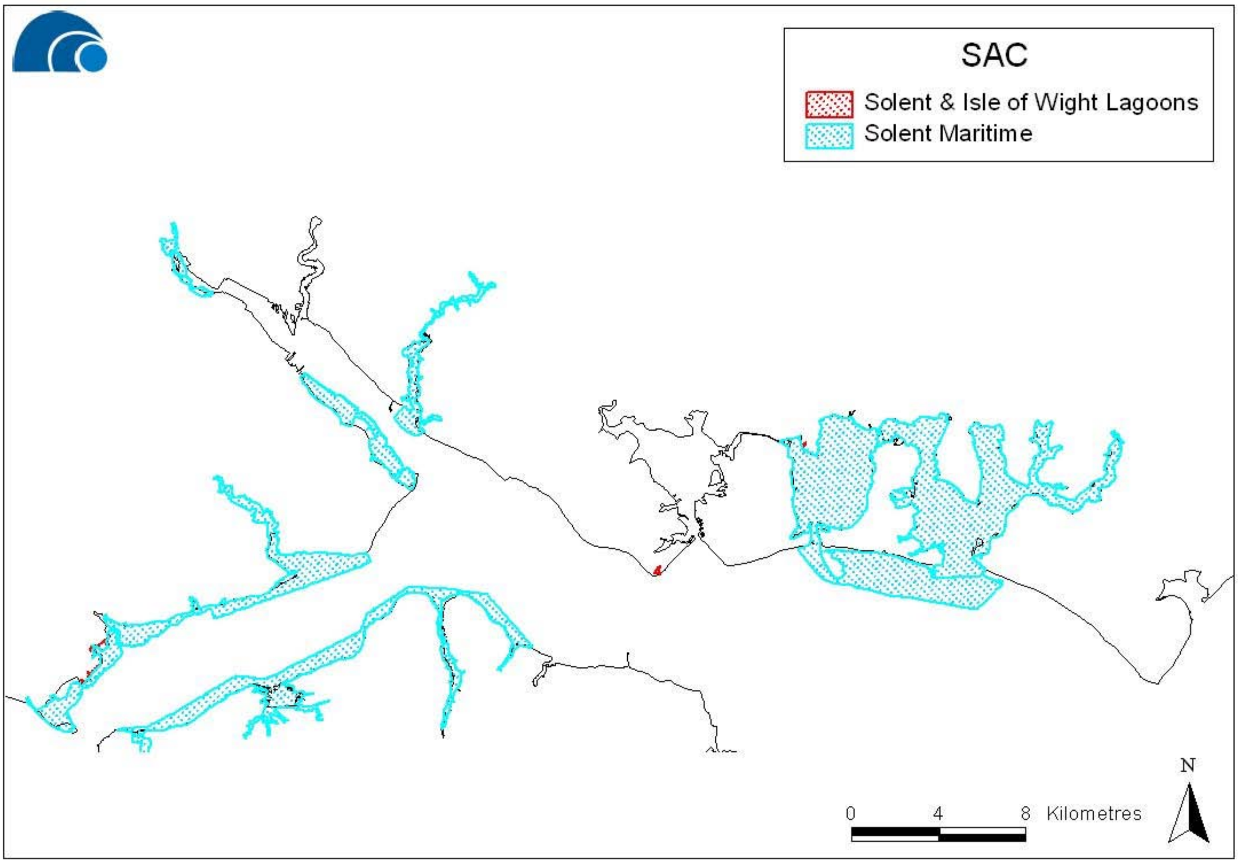


Figure 1.5: Solent SACs

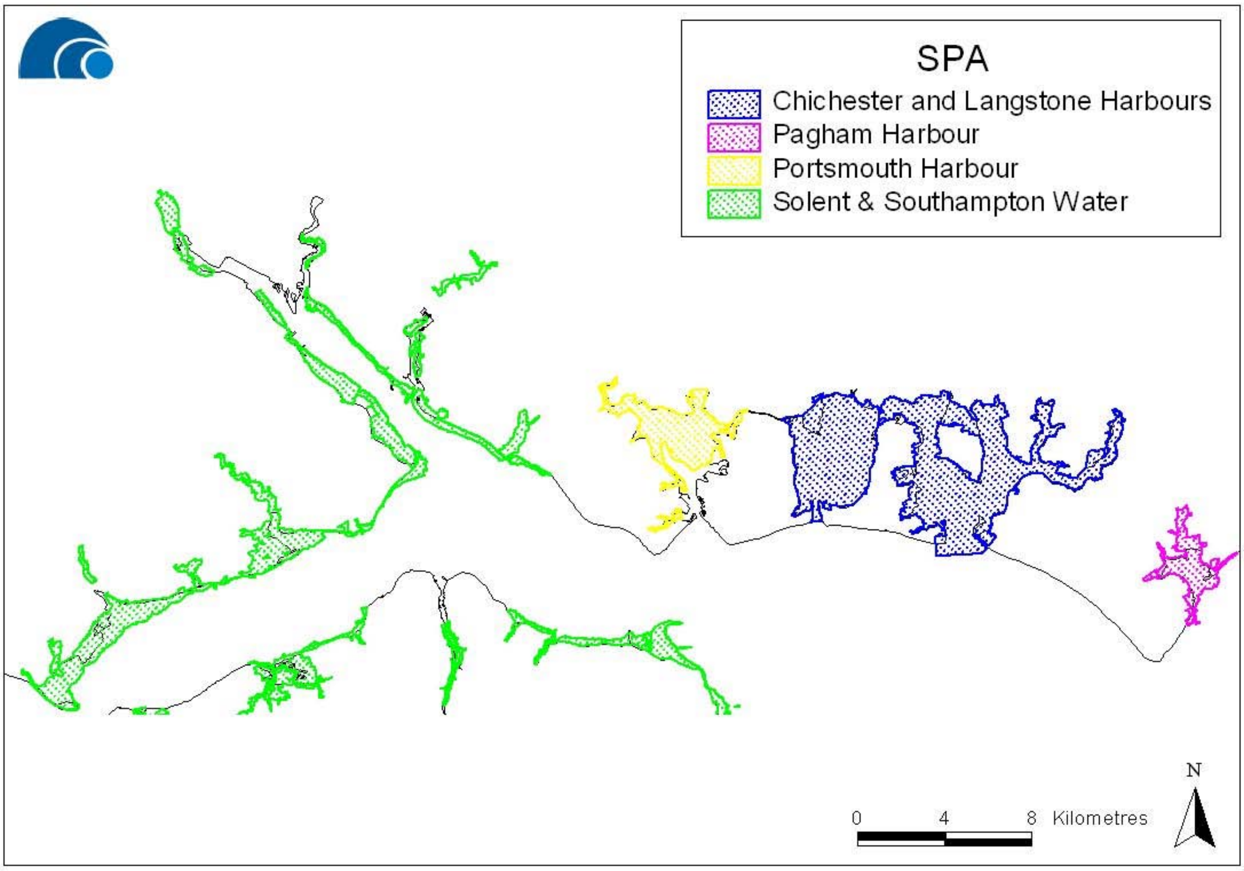


Figure 1.6: North Solent SPAs

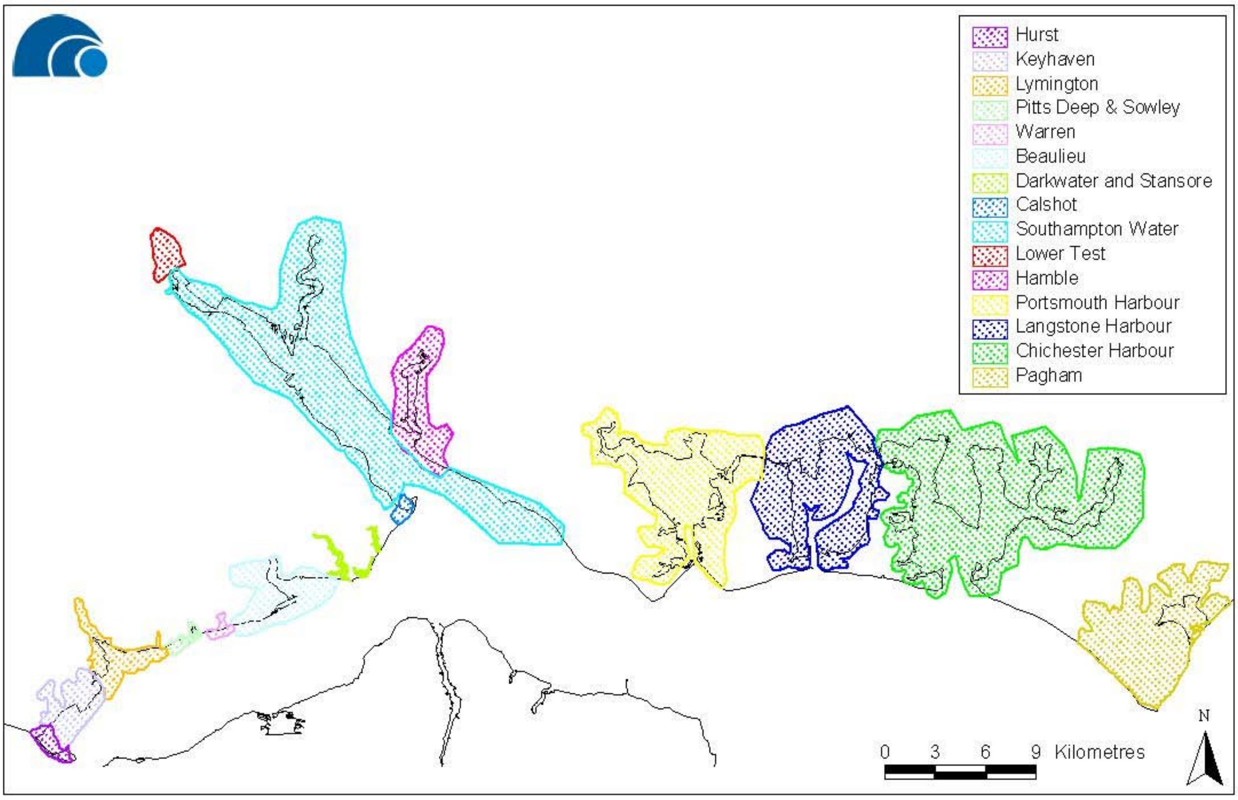


Figure 1.7: Geographical units in the north Solent

1.5 Outline of report

Both this report and the summary report are divided into five further sections:

Section 2 summarizes environmental policies and legal drivers.

Section 3 outlines the methodology undertaken.

Section 4 presents findings for inter-tidal habitat loss and coastal squeeze.

Section 5 presents findings for inter-tidal habitat gain.

Section 6 shows the balance of coastal squeeze and inter-tidal habitat gain.

Section 7 concludes the project, providing recommendations for the North Solent SMP.

2 Summary of environmental policies and legal drivers

The north Solent encompasses a suite of international, national and local designations which are protected through the following legislation and guidance; Natura 2000 sites (Special Areas of Conservation (SACs) under the EU Habitats Directive 92/43/EEC and Special Protection Areas (SPAs) under the EU Birds Directive 79/409/EEC), Ramsar sites (Ramsar Convention, 1971) and Sites of Special Scientific Interest (Wildlife & Countryside Act, 1981) (SSSI's) (Figure 2.1).

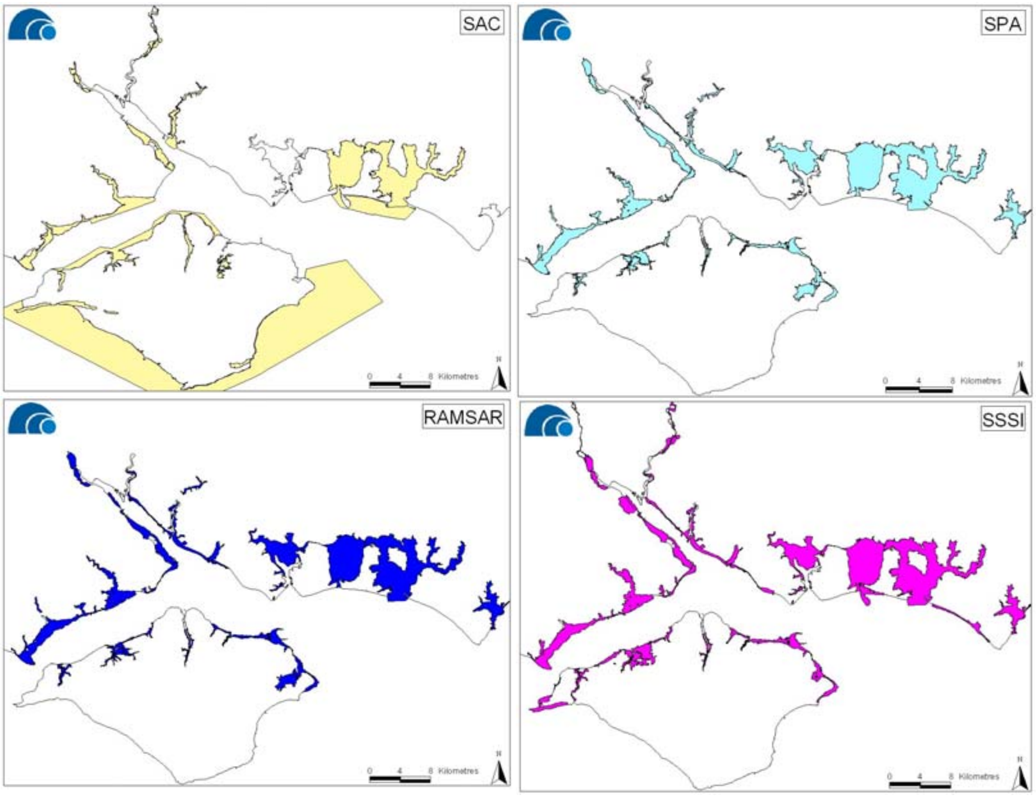


Figure 2.1: Natura 2000, Ramsar and SSSI designations across the Solent

2.1 International and European designations

The Solent has two SACs (Solent and IOW lagoons and Solent Maritime SACs – Figure 1.5) identified through the Habitats Directive and four SPA sites (The Solent and Southampton Water, Chichester and Langstone Harbours, Portsmouth Harbour and Pagham Harbour – Figure 1.6) identified through the Birds Directive. The overarching term is Natura 2000 sites.

Where possible, Natura 2000 coastal habitat should be protected in situ, where it is sustainable to do so. An Appropriate Assessment (AA) is required where a plan or project is likely to have a significant effect on a Natura 2000 site or Ramsar site. A plan or project can include the maintenance of existing sea walls and new capital schemes. Where an AA cannot conclude that there will not be an adverse affect on the site, the scheme may only proceed if there are no alternative solutions (i.e. mitigation* within SPA), if there are imperative reasons of overriding public interest and compensation habitat is secured before the damaging works start (DEFRA, 2005, DEFRA Circular, 2005). "Adverse effects" include coastal squeeze seaward of a seawall and habitat changes caused by flooding landward of a seawall.

Replacement habitat sought within an adversely affected SPA is classed as mitigation. Replacement habitat sought outside an adversely affected SPA is classed as compensation. Replacement habitat sites are hard to implement. Securing replacement habitat is compounded by the time it takes to create new habitat. Inter-tidal habitat can take more than 10 years to create, whilst freshwater habitat can take more then 50 years. DEFRA guidance advises that the best way to secure compensation for coastal squeeze is through a strategic approach over a suitable geographical unit taking account of 'sustainable' coastal management. Ideally, compensation habitat should be sought close to the European site that is adversely affected (EU Commission guidance, 2007). Where this is not possible a regional approach may be taken (DEFRA, 2005). However this location requirement does not over-ride other 'sustainability' issues of cost, technical and physical capability and the need to defend landward designated sites as long as it is cost-effective to do so.

2.2 National nature conservation designations

There are fifteen Sites of Special Scientific Interest (SSSIs) in the Solent (including Pagham Harbour) (Figure 2.1). They were initially protected under the Wildlife and Countryside Act 1981 and later, protection was further strengthened by the Countryside and Rights of Way Act 2000 (CRoW Act). Within the Solent, large areas of SSSI's are in unfavourable condition due to coastal squeeze. DEFRA High Level Target 4 states that all OAs have a responsibility to find new coastal habitat to offset the effects of coastal squeeze and return 95% of the SSSI series to favourable condition to achieve the Public Service Agreement (PSA) target. NE must be consulted before carrying out an operation likely to damage any feature for which a SSSI has been designated (DEFRA 2001).

In the north Solent nearly all SSSI's are also EU Natura 2000 sites and so the Habitat Regulation procedures will serve to offset unfavourable condition at the same time as compensating for losses to European sites.

Following the UK Action Plan (1994), NE, the EA and other OAs were advised to achieve targets set out for BAPS. DEFRA High Level Target 4 requires all OAs to;

- avoid damage to environmental interest
- ensure no net loss to habitats covered by BAPs
- seek opportunities for environmental enhancement.

* Mitigation = to offset coastal squeeze losses within a European site. Compensation = to offset coastal losses outside of European site.

OAs are to report annually to the EA who then report to DEFRA on all losses and gains of habitats covered by BAPs as a result of flood and coastal defence operations (http 1).

Inter-tidal mudflat and saltmarsh are priority BAP habitats. National and local targets have been set to create new habitat to offset losses due to coastal squeeze (UK BAP target review).

3 Method

The work undertaken in this study comprised a mixture of technical analysis and statutory body 'expert opinion'. Table 3.1 demonstrates the different stages the study underwent to produce a spatial and temporal picture of inter-tidal coastal squeeze balanced against potential habitat gain.

Stage 1	**Inter-tidal loss and coastal squeeze** A technical analysis to confirm inter-tidal habitat loss and establish coastal squeeze for current 'hold the line' policies, using: • Historical aerial photography interpretation • LiDAR interpretation
Stage 2	**Potential inter-tidal habitat creation sites** Investigate the potential inter-tidal habitat creation sites derived from tidal elevation and topography. • Remove buildings and landfill • Apply "least cost assumption" through questionnaire • Apply criteria matrix to rank sites within epoch
Stage 3	**Balancing inter-tidal loss with potential habitat creation sites** Assess the inter-tidal losses and gains across the north Solent spatially and temporally.
Stage 4	**Replacement freshwater habitat** Identify the amount of potential replacement freshwater habitat required.

Table 3.1: SDCP approach

The method for stages 1 and 2 are presented below.

Historical aerial photography interpretation (HPI) was analysed to assess historical saltmarsh losses, whilst topographic data from Light Detection and Ranging (LiDAR) and tidal elevation interpretation (LTEI) were used to predict and visually demonstrate future mudflat and saltmarsh change and to identify suitable land levels for potential habitat creation sites.

3.1 Historical aerial photography interpretation

HPI was used to quantify historical saltmarsh changes for each geographical unit (Figure 1.7) for bi-decadal periods from the 1940s to 2002 (Figure 3.1). This work extended the framework developed for the CHaMP (2003), by adding analysis of more recent epochs and extending the HPI back to the 1940s to better understand past and future trends.

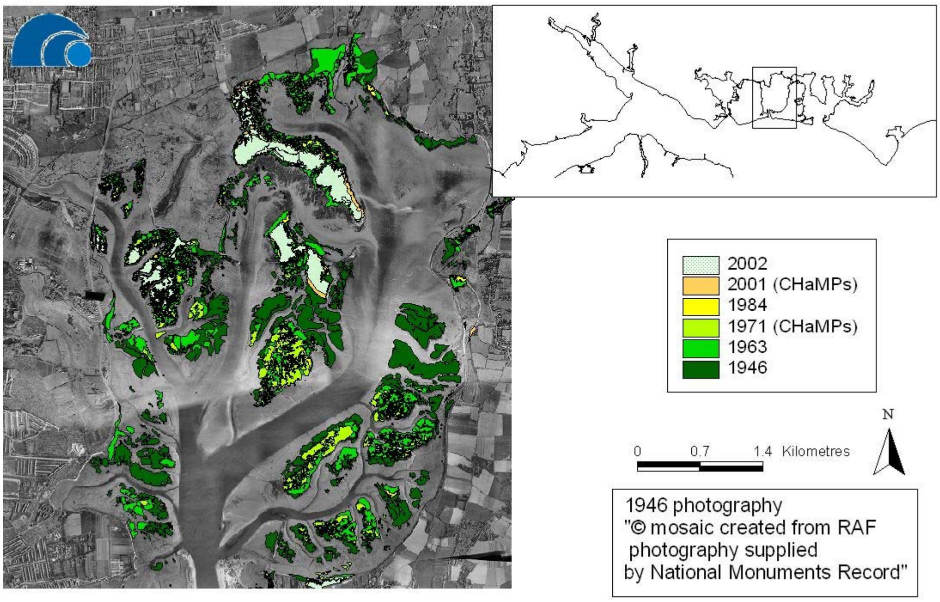


Figure 3.1: Changing saltmarsh extent in Langstone Harbour (from HPI)

Rates of saltmarsh change were extrapolated for 2025, 2055 and 2105, based on the best, worst and most recent bi-decadal periods (Section 4). This provided measured historical and projected future rates, accounting for all local factors operating at each site, such as *Spartina* dieback, wave attack, sea level rise, dredging, reclamation, development and pollution. Mudflat was not digitized from the historical photography because it rarely extended to Mean Low Water Springs (MLWS).

3.1.1 Data collection

Aerial photography between the 1940's to 1970's was obtained from the National Monuments Record Centre (NMR) and local authorities. Aerial photography flown later than the 1970's was sought from Hampshire County Council, West Sussex County Council, the EA and the South-east Strategic Coastal Process Monitoring Programme. The aim was to obtain a good quality, bi-decadal sample at each site, i.e. – 1940's, 1960's, 1980's and 2000 at approximately 1:10,000 scale, with low tide between the months of April and September. This was not always possible due to data limitations. The following presents the years used (Table 3.2).

Geographical Unit	Years used											
	1940	1946	1947	1954	1963	1965	1971	1984	1991	2001	2002	2003
Hurst Spit							x	x		x		
Keyhaven							x	x		x		
Lymington		x		x			x	x		x		
Pitts Deep and Sowley		x		x			x	x		x		
Beaulieu				x			x	x				
Calshot	x						x	x		x		
Southampton Water		x		x	x		x	x	x	x		x
Hamble		x					x	x		x		
Portsmouth Harbour							x	x			x	
Langstone Harbour		x			x		x	x		x	x	
Chichester Harbour		x				x	x				x	
Pagham Harbour			x			x			x			

Table 3.2: Years used for HPI

Aerial photography that was not already geo-rectified or ortho-rectified was scanned at 600 DPI, geo-rectified using ER MAPPER and mosaiced using IMAGE XUITE. The data was digitized in a Geographical Information System (GIS) at approximately a 1:1,000 scale. The average error for the historical photography geo-rectification and digitizing was approximately +/- 6 to 12 metres (1940's – 1991) and +/-2.2 metres for photography flown after the year 2000. CHaMP (2003) data was amended in some cases and was recorded accordingly (Table 4.1).

3.2 LiDAR and tidal elevation interpretation

One of the most crucial factors promoting mudflat and saltmarsh development is duration and frequency of tidal inundation in relation to land elevation and gradient. Mudflat exists between MLWS and Mean High Water Neaps (MHWN), whilst saltmarsh colonizes between MHWN to highest astronomical tide (HAT) (Williams, 1994). Control by tidal range accounts for 86-89% of lateral variation in *Spartina anglica* colonization for 19 estuaries in south and west Britain, when compared with local factors that potentially influence salt marsh colonization (Gray, 1992).

Based on this, a theoretical approach was applied in a GIS whereby the north Solent-wide 2005 LiDAR data was "flooded" to the corresponding tidal elevations to determine the expected areas of coverage of inter-tidal habitat. Recent aerial photography was used to verify the "existing" extent of mudflat and saltmarsh suggested by the LiDAR and tidal elevation interpretation (LTEI) findings. A good correlation was found at most sites. Exceptions were noted where the LTEI over-predicted the extent of saltmarsh, but these small areas were attributed to the influence of local factors mentioned above. The high level of confidence in the LTEI enabled prediction of "potential" mudflat or saltmarsh sites based on the same criteria, in the event of removal of sea defence structures; this provided a good indicator of possible managed re-alignment sites (Cope *et al.,* 2007a). Figure 3.2 illustrates the "existing" situation (2005) in Langstone Harbour for mudflat and saltmarsh and also identifies the "potential" coverage if sea defences were removed and natural evolution occurred.

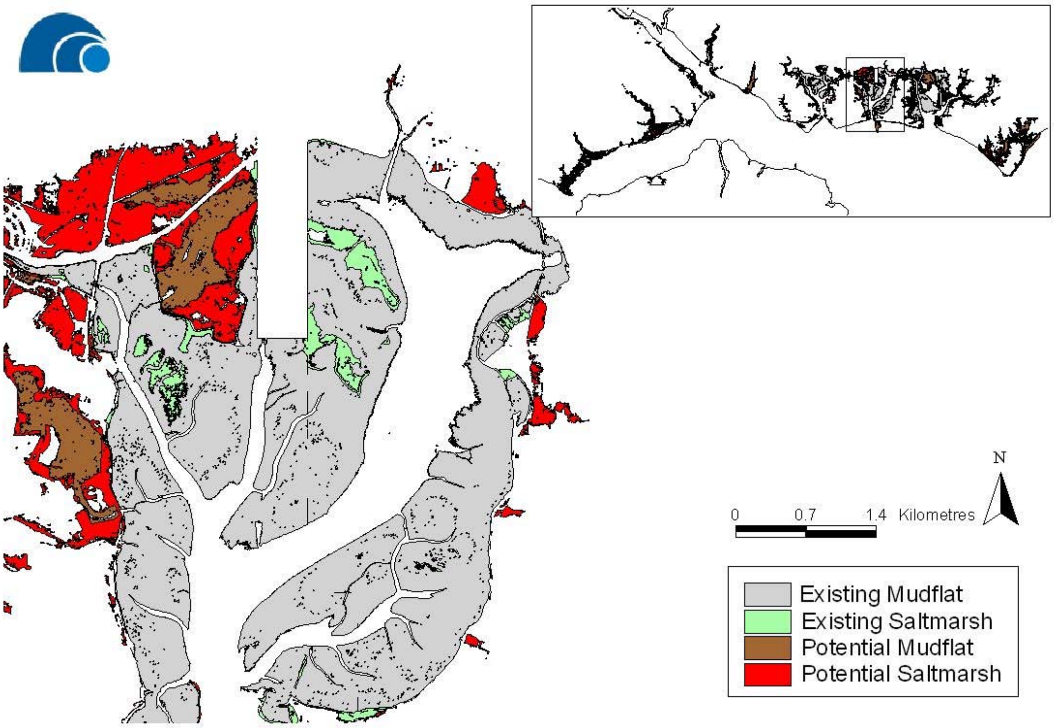


Figure 3.2: "Existing" and "potential" inter-tidal habitat at Langstone Harbour, 2005 (LTEI)

LTEI was used to predict and visually demonstrate probable future mudflat and saltmarsh evolution for 2025, 2055 and 2105 across the north Solent. Sensitivity to varying scenarios of sea level rise and vertical sediment accretion were estimated. The 2025, 2055 and 2105 epochs were flooded using 6mm per annum sea level rise (DEFRA guidance prior to 2006) assuming no vertical sediment accretion, then 3mm and 6mm sediment accretion per annum. Further details about the validation of LiDAR and tidal elevation interpretation (LTEI) are given in Section 4.2.

3.2.1 Data collection

The most recent LiDAR and photogrammetry data were used (Figure 3.3). However, in some areas, the lowest topographic contour was not low enough to depict mudflat. In these instances, bathymetric data, where available, was merged with the LiDAR. Where bathymetric data was not available or did not cover all of the mudflat area, the mudflat extent was not as reliable. This was the case for the Sowley area and north-east side of Portsmouth and Langstone Harbours (Figure 1.7). Photogrammetry was used for Medmerry.

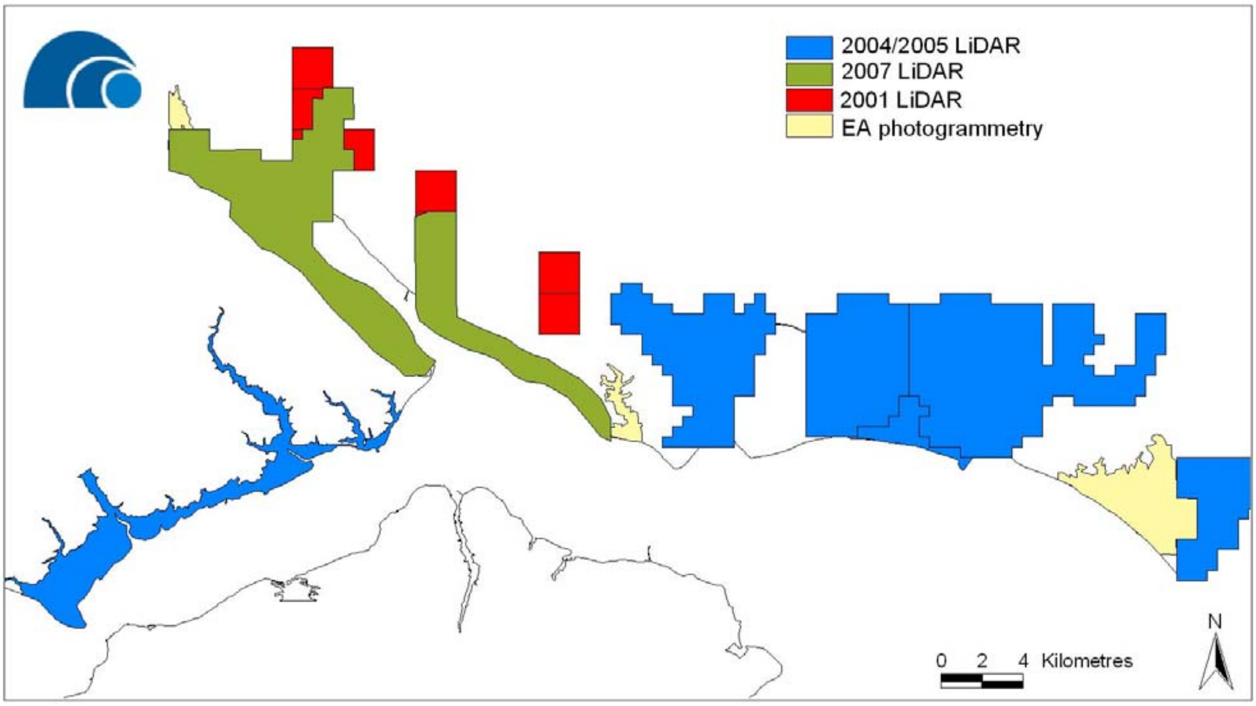


Figure 3.3: Solent LiDAR and photogrammetry data used

4 Inter-tidal loss and coastal squeeze results

The historical and predicted future inter-tidal loss for each geographical unit, using HPI and LTEI are presented.

4.1 Demonstration of inter-tidal analysis

The graphs and tables presented in Section 4 are explained using Langstone Harbour as an example. The Langstone Harbour graphs and tables are located in Section 4.2.10.

4.1.1 Explanation of "historical saltmarsh change"

The graphs in this section show changes in saltmarsh extent from HPI (see Graph 4.10a and Figures 4.11b-g for the Langstone Harbour example). CCO and CHaMP (2003) data was distinguished using the symbology presented in Table 4.1.

		Definition
◆	**CCO**	CCO digitization
▲	**CCO/CHaMP**	CCO digitization with CHaMP data included
▲	**CHaMP/CCO**	CHaMP data amended by CCO
■	**CHaMP**	CHaMP digitization

Table 4.1: Different sources used for aerial photography interpretation

Rates of loss from the last epoch, worst epoch and best epoch were extrapolated to determine the amount of loss in 2005, 2010, 2025, 2055 and 2100 (Table 4.2 and Graph 4.10a). It should be noted that past reclamation was subtracted when extrapolating the HPI predictions because reclamation of mudflat and saltmarsh requires replacement habitat under international environmental law. Otherwise, a more severe saltmarsh loss prediction, in cases such as Southampton Water (42% reclaimed since 1946), would result. These rates of loss were applied to the final year area.

		Definition
*	**Last epoch**	Extrapolation based on rate of loss from last erosive epoch
*	**Worst case**	Extrapolation based on rate of loss from worst erosive epoch
*	**Best case**	Extrapolation based on rate of loss from best erosive epoch

Table 4.2: Extrapolation of the HPI results

The accompanying tables to the graphs (Table 4.12 for the Langstone Harbour example), present the rate of saltmarsh loss (ha per annum), total % loss and % loss per annum between each epoch. Results were expressed as a % of the area in the first year of each epoch. Where past reclamation was identified from the aerial photography, the "% loss (of saltmarsh) excluding past reclamation" was also presented in the table.

A visual comparison of saltmarsh extent change, taken from the HPI was undertaken for each geographical unit (see Figures 4.11h-m). This was to show change between epochs. The following definitions were used;

Stable: refers to areas of saltmarsh which existed in both epochs analysed. For example when looking at the change between 1947 (T1) and 2001 (T2), stable saltmarsh would refer to areas of saltmarsh present in both T1 and T2.

Losses: refers to areas of saltmarsh lost between the epochs analysed, for example saltmarsh which existed in T1 but not in T2.

Gains: refers to areas of saltmarsh gained between the epochs analysed, for example saltmarsh which existed in T2 but not in T1.

4.1.2 Explanation of “predicted future inter-tidal change”

The change in mudflat and saltmarsh extent was also assessed using LTEI for each geographical unit. “Existing” and “potential” mudflat and saltmarsh extent were predicted for 2005, 2010, 2025, 2055 and 2100 (Graph 4.10b and 4.10c respectively).

The HPI and LTEI predictions (2005, 2010, 2025, 2055 and 2100) were compared for each geographical unit (Graph 4.10d) for “existing” saltmarsh. In order to make a direct comparison, the LTEI scenarios were clipped to the same saltmarsh coverage as the HPI (Figure 4.11n). The same comparison could not be undertaken for mudflat because the aerial photography was not analysed.

4.1.3 Explanation of calculating “coastal squeeze requiring replacement habitat”

The mudflat and saltmarsh loss predictions do not account for coastal squeeze specifically. “Coastal squeeze requiring replacement habitat” refers to the existence of a man made structure that inhibits rollback of European designated, inter-tidal habitat. Those areas in Langstone Harbour undergoing “coastal squeeze requiring replacement habitat” are shown in Figure 4.1.

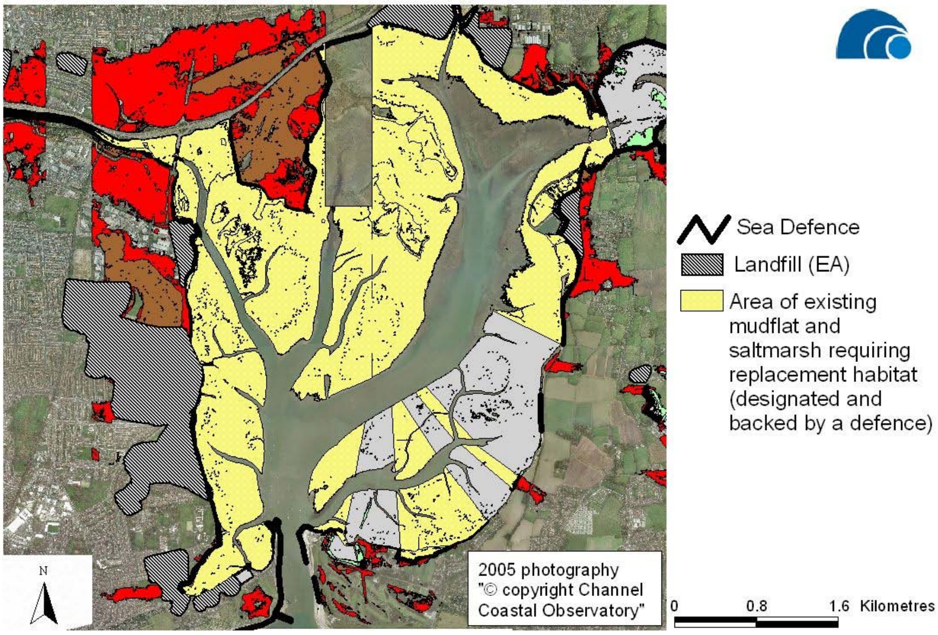


Figure 4.1: Example of area undergoing coastal squeeze requiring replacement habitat in Langstone Harbour

Coastal squeeze requiring replacement habitat was calculated at a Solent wide (Section 4.6) and European site scale (Section 6.1) using the GIS. Accurate predictions of coastal squeeze could only be carried out where sea defence data was available and the LTEI mudflat predictions were reliable. Sea defence data was readily available for the west Solent but was not so consistent for Southampton Water or the east Solent. Therefore, data from the East Solent Shoreline Management Plan (1997) was used to indicate the location of defences.

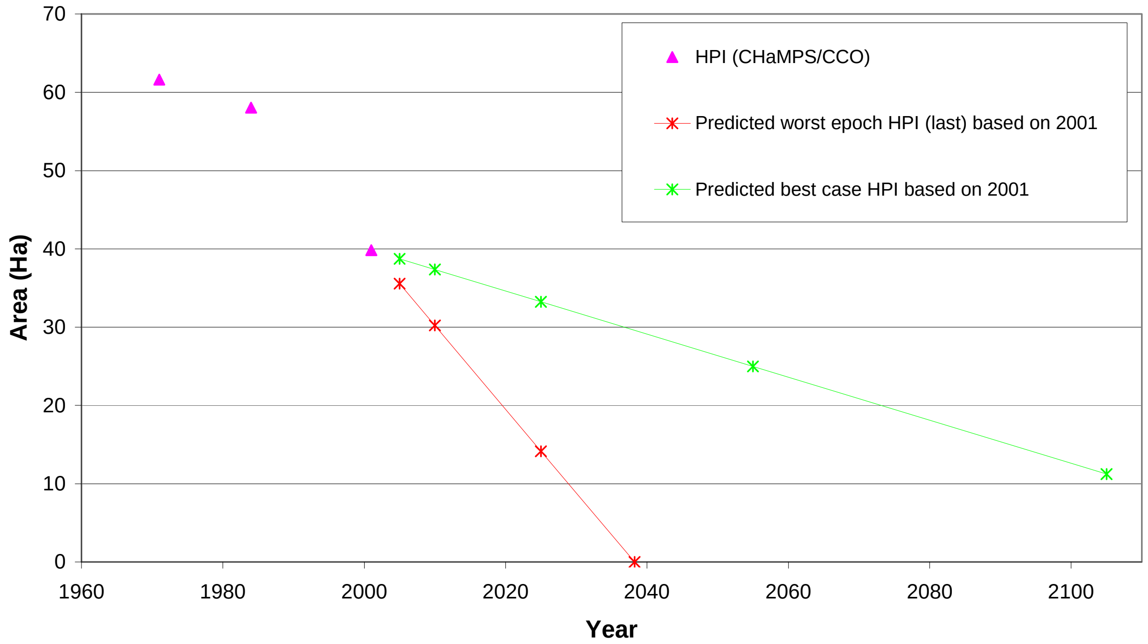
4.2 Results for geographical units

Mudflat and saltmarsh loss is highly variable depending on the physical and anthropogenic factors operating at a site. Therefore, the north Solent was broken down into geographical units reflecting these factors. Sections 4.2.1 – 4.2.12 detail historical and predicted future mudflat and saltmarsh loss, on a site by site basis, using HPI and LTEI. The method behind the graphs and tables is explained in Section 4.1.

4.2.1 Hurst Spit

4.2.1.1 Historical saltmarsh change

The total saltmarsh extent for 1971, 1984 and 2001 is shown at Hurst Spit (Graph 4.1a, Table 4.3 and Figures 4.2). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015.



Graph 4.1a: Historical and predicted saltmarsh extent at Hurst (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss excluding reclamation	
				% loss	% loss per year	% loss	% loss per year
1971	61.6	CHaMP/CCO					
1984	58.0	CHaMP/CCO	**1971-1984**	5.8	0.4	N/A	N/A
2001	39.8	CHaMP/CCO	**1984-2001**	31.4	1.8	N/A	N/A
			1971-2001	35.3	1.2	N/A	N/A

Table 4.3: Historical and predicted saltmarsh extent at Hurst (based on HPI)

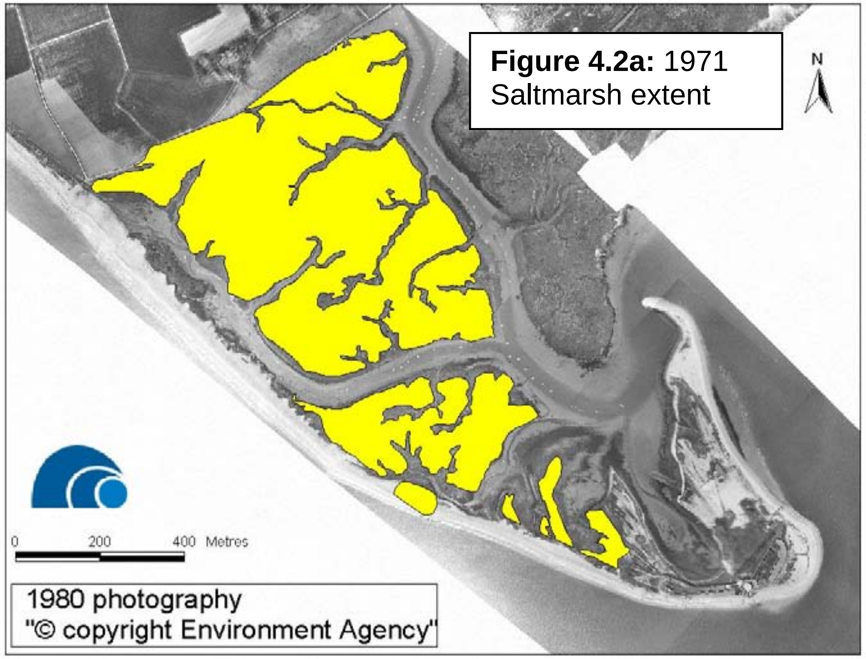


Figure 4.2a: 1971 Saltmarsh extent

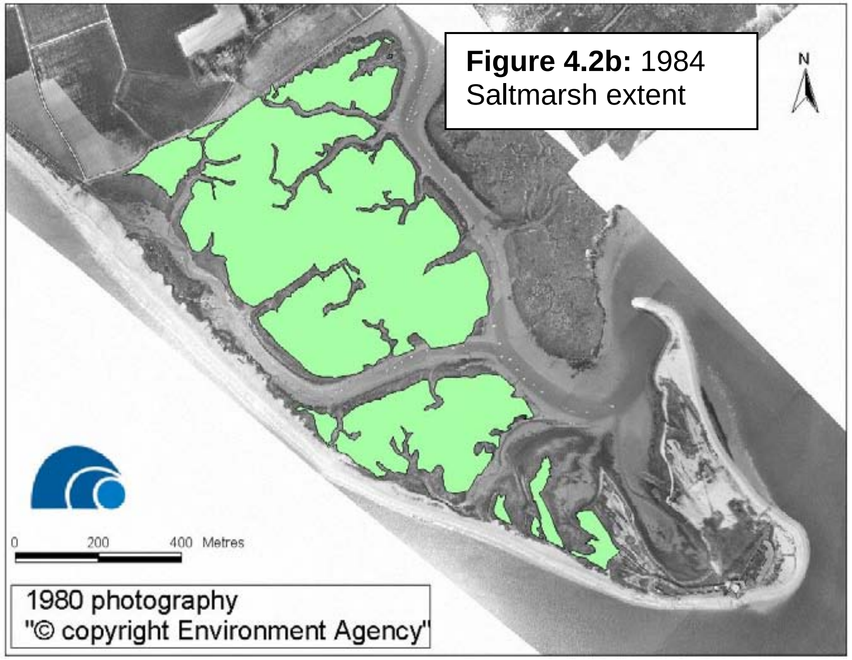


Figure 4.2b: 1984 Saltmarsh extent

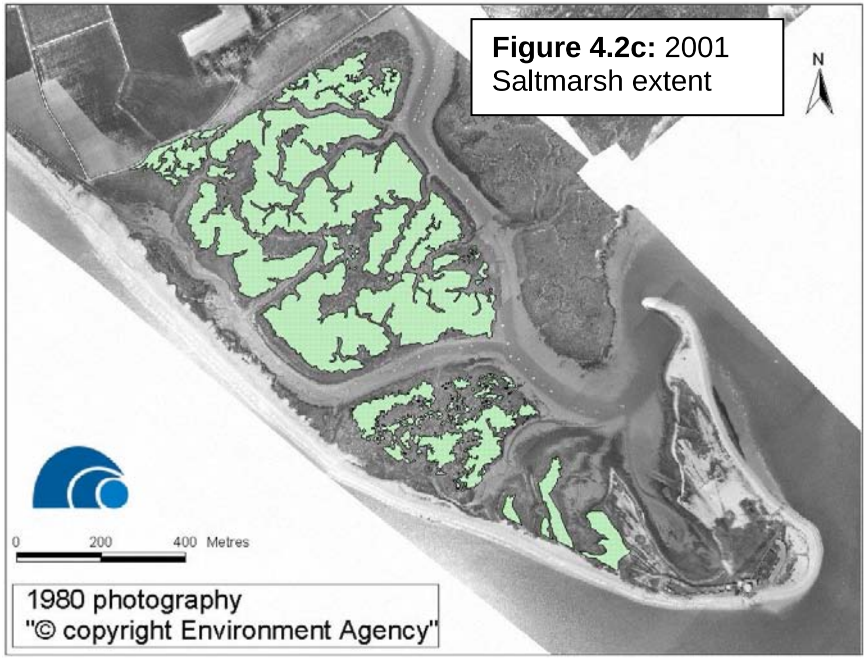


Figure 4.2c: 2001 Saltmarsh extent

1971-2001 (Figure 4.2d and Table 4.3)

Changes between 1971 and 2001, indicates 35% saltmarsh loss, which equates to 1.2% per annum (Table 4.3). The dominant erosive processes are internal dissection and loss from spit rollback (Figure 4.2g). There is also a small amount of edge erosion. As would be expected, the marshes directly behind Hurst Spit have the lowest rate of loss in the west Solent since 1971. This is because of the protection afforded by the spit itself from prevailing south-westerly storms, the recurved tip (North Point) and the adjacent marshes.

1971-1984 (Figure 4.2e and Table 4.3)

The data for this epoch indicates the lowest rate of saltmarsh loss, being 0.4% per annum (Table 4.3). Most loss is through edge erosion (Figure 4.3b). Internal dissection processes maybe in operation but these are not identifiable from the coarser CHaMP digitizing.

1984-2001 (Figure 4.2f and Table 4.3)

This epoch has the greatest amount of saltmarsh loss at 1.8% per annum (Table 4.3). The area decreased from 58 ha to 40 ha in 17 years. Internal dissection is apparent, although some of this may be attributed to the CHaMP 2001 infra-red aerial photography being digitized to a slightly higher specification than the 1971 black and white aerial photography. The area of saltmarsh lost directly behind the spit probably occurred during the 1989 storm when Hurst Spit underwent major sluicing over washing. The amount of saltmarsh lost to spit rollback since 1968 is shown in Figure 4.2g. The 1968 aerial photography was not used for detailed analysis because the water level when flown was too high.

The following Figures (4.2d – 4.2f) show change in saltmarsh extent for the various epochs at Hurst Spit.

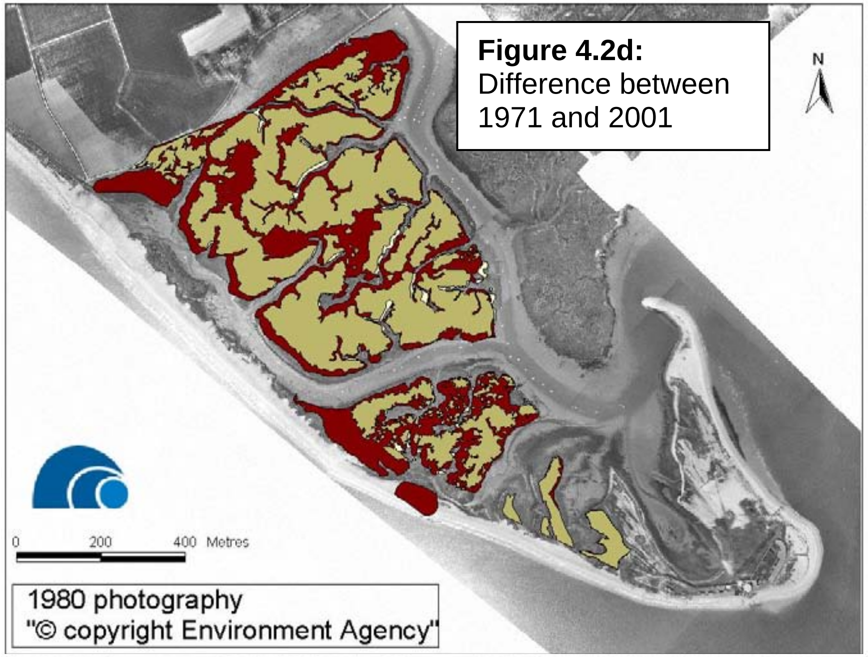


Figure 4.2d: Difference between 1971 and 2001

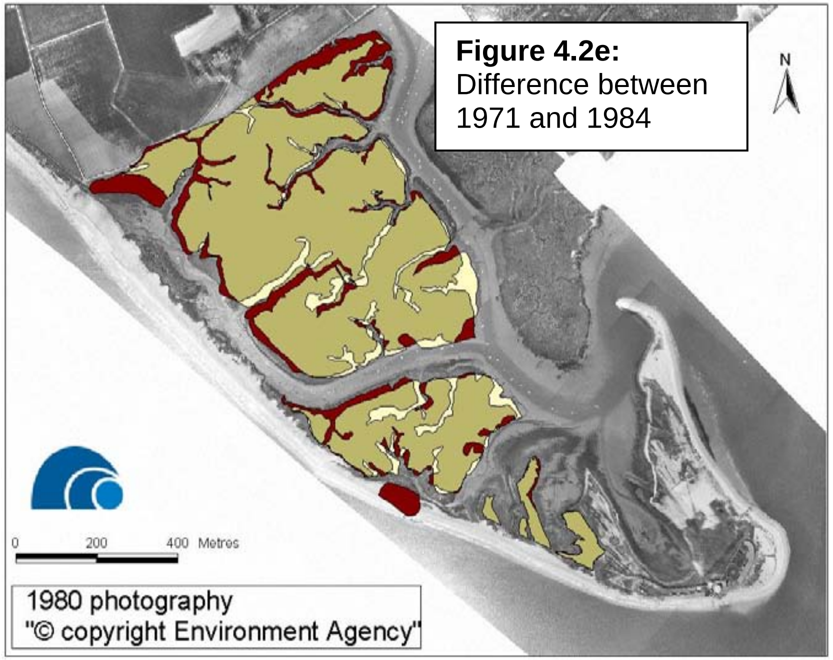


Figure 4.2e: Difference between 1971 and 1984

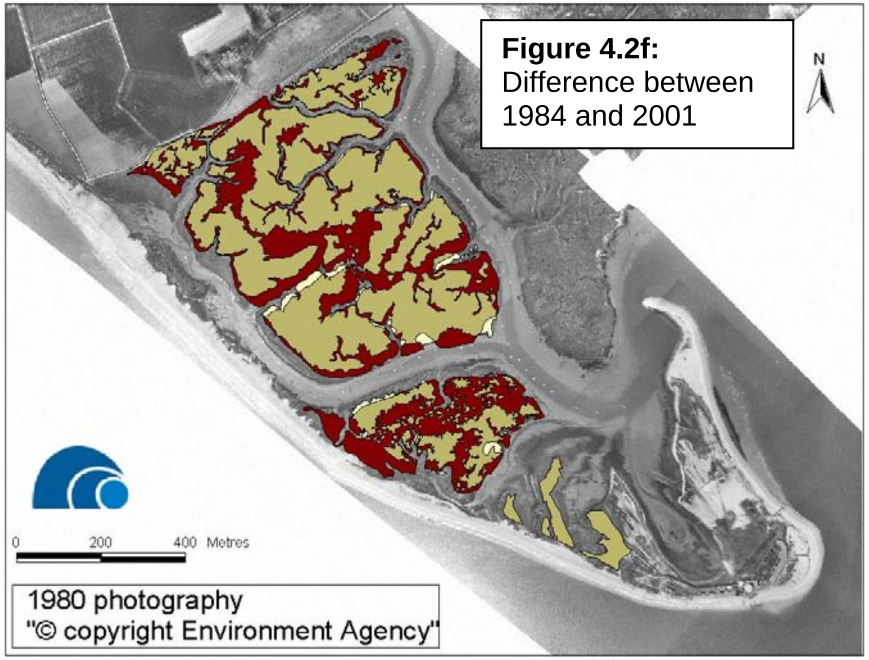


Figure 4.2f: Difference between 1984 and 2001

Stable
Loss
Gain

1980 photography – "© copyright Environment Agency"

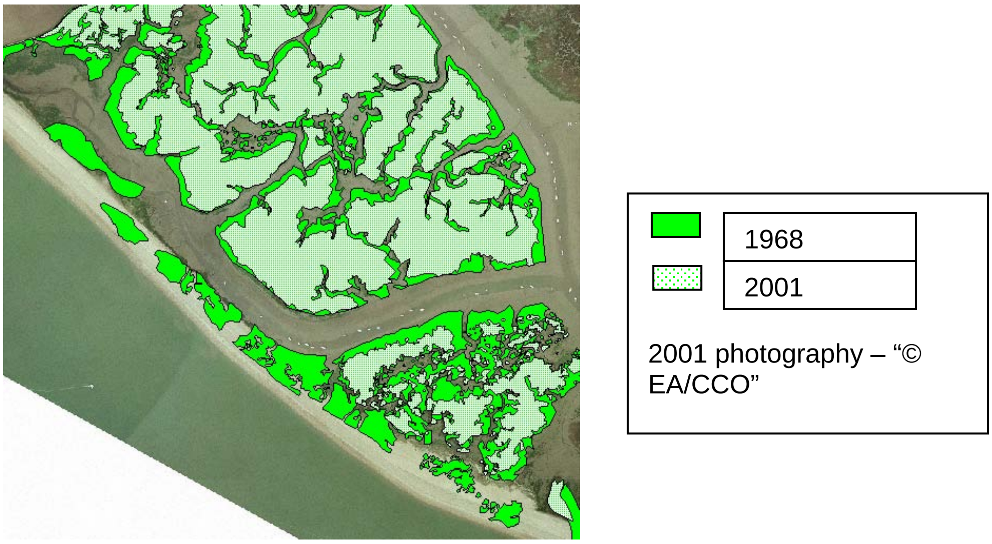


Figure 4.2g: Saltmarsh lost between 1968 and 2001 from spit rollback.

4.2.1.2 Predicted inter-tidal change

The area selected for LTEI calculations at Hurst Spit, for comparison with the HPI is shown on Figure 4.2h.

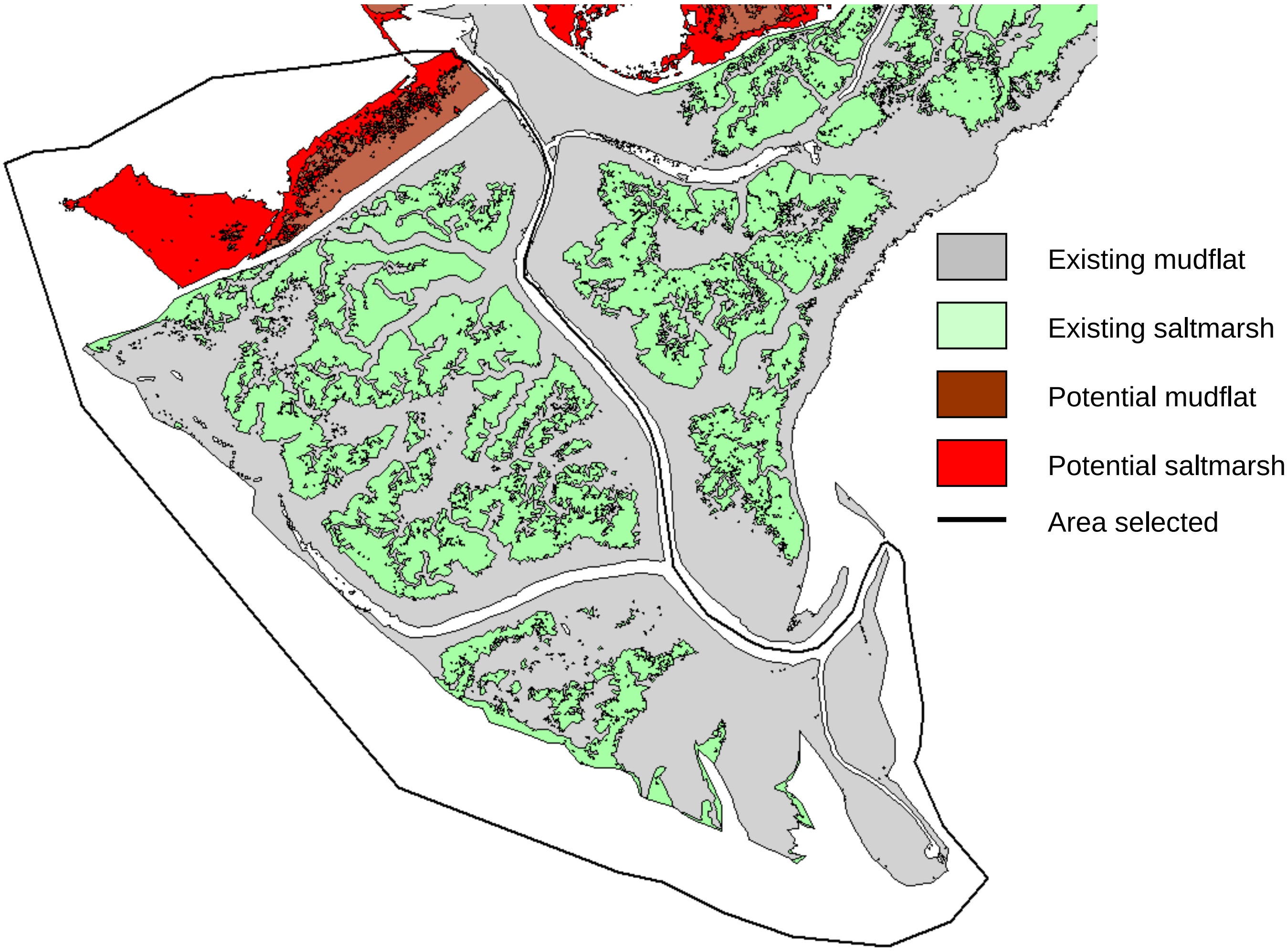
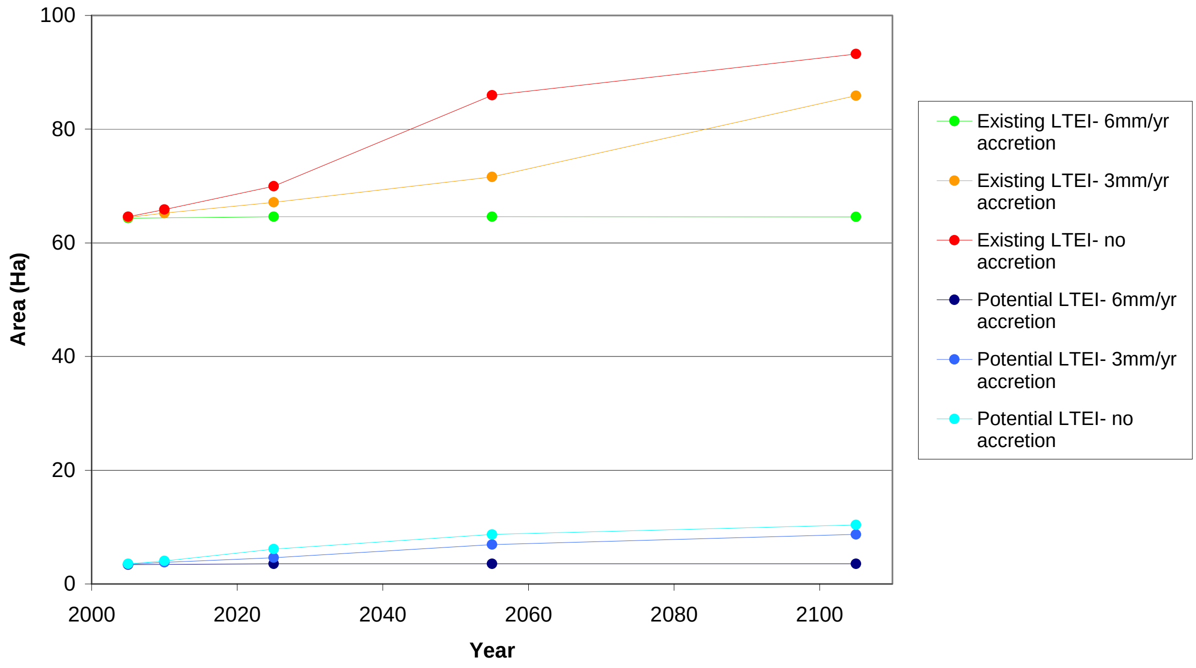
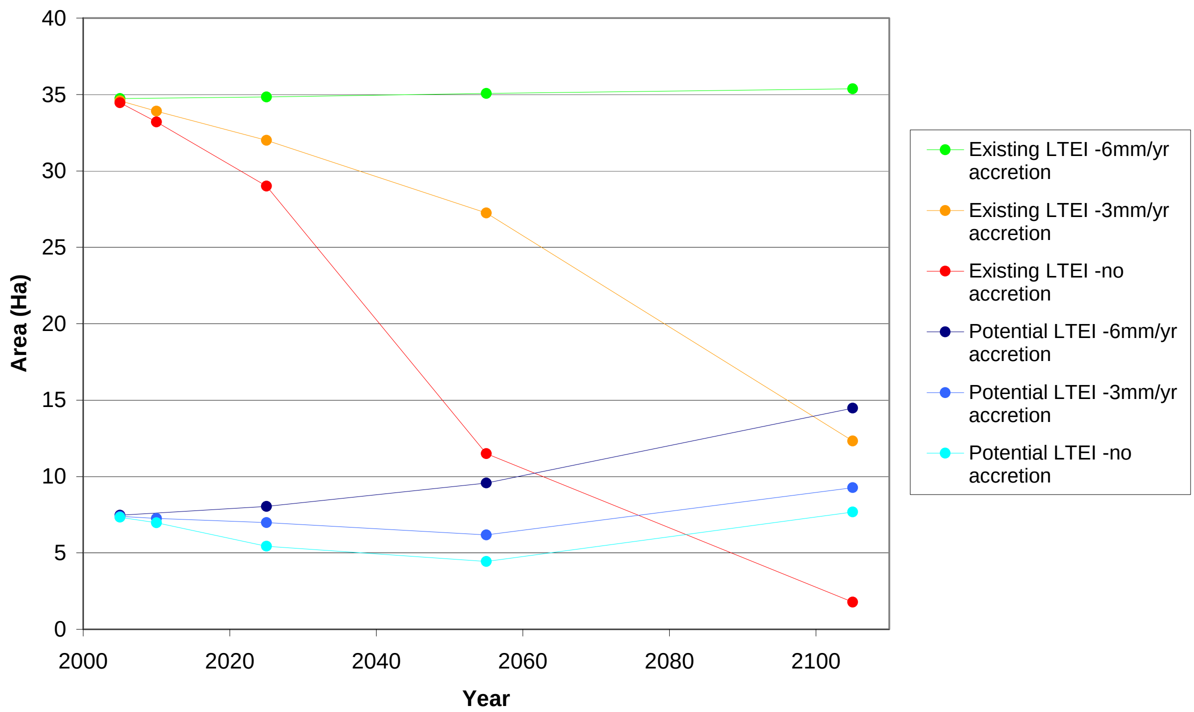


Figure 4.2h: Area selected for LTEI calculations at Hurst Spit

Projected changes are presented for the “existing” management scenario (seawards of the seawall) and for “potential” increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for mudflat (Graph 4.1b) and saltmarsh (Graph 4.1c), for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios.



Graph 4.1b: “Existing” and “potential” predicted mudflat extent at Hurst (based on LTEI)



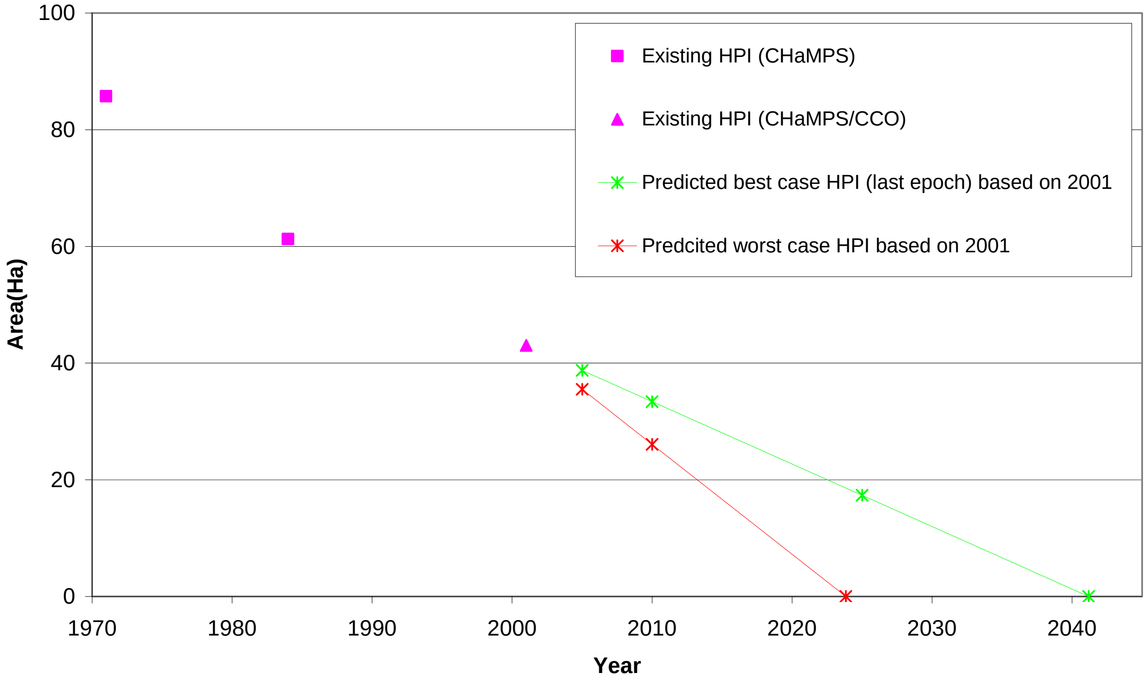
Graph 4.1c: “Existing” and “potential” predicted saltmarsh extent at Hurst (based on LTEI)

Results show mudflat evolution under the existing management regime slightly increase through time (Graph 4.1b) as saltmarsh slightly decreases (Graph 4.1c). The area of "potential" mudflat and saltmarsh landwards of the seawall is much smaller compared to the "existing" area. In the event of re-alignment, mudflat and saltmarsh increase through time as the system migrates onto higher land.

4.2.2 Keyhaven

4.2.2.1 Historical saltmarsh change

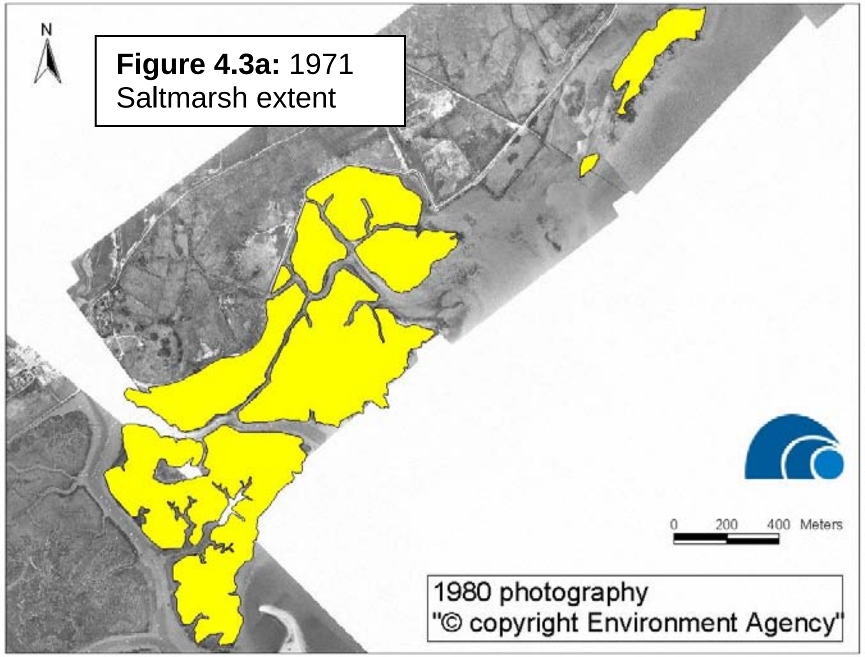
The total saltmarsh extent for 1971, 1984 and 2001 is shown for Keyhaven (Graph 4.2a, Table 4.4 and Figures 4.3). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015.

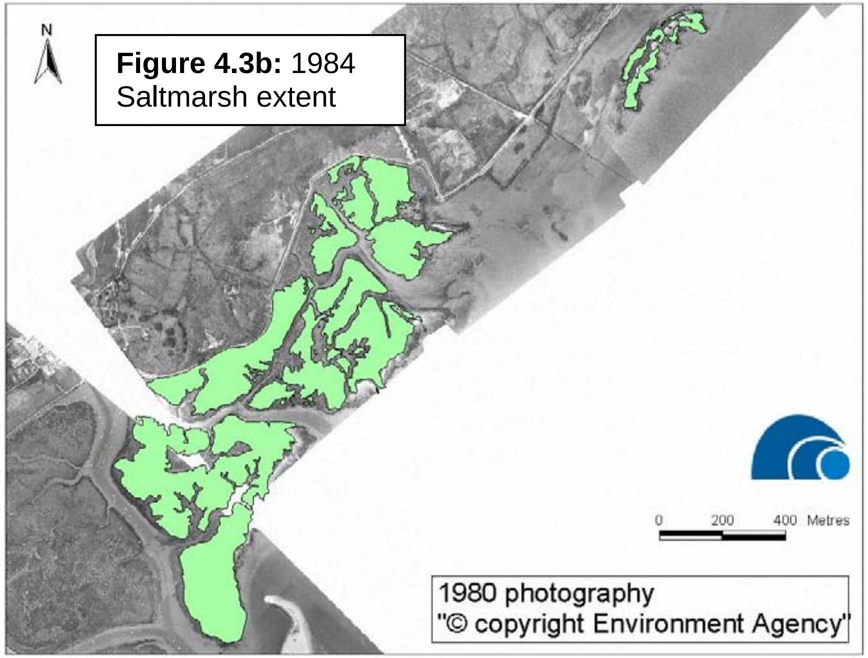


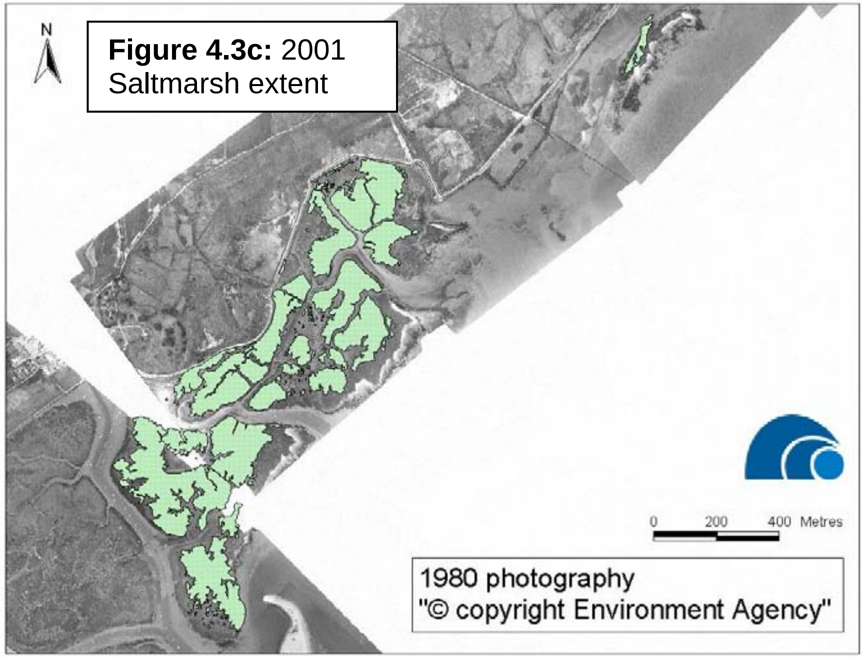
Graph 4.2a: Historical and predicted saltmarsh extent at Keyhaven (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss excluding reclamation	
				% loss	% loss per year	% loss	% loss per year
1971	85.8	CHaMP					
1984	61.3	CHaMP	**1971-1984**	28.6	2.2	N/A	N/A
2001	43.0	CHaMP/CCO	**1984-2001**	29.7	1.7	N/A	N/A
			1971-2001	49.8	1.7	N/A	N/A

Table 4.4: Saltmarsh extent at Keyhaven (based on HPI)


N
Figure 4.3a: 1971
Saltmarsh extent
0 200 400 Meters
1980 photography
"© copyright Environment Agency"


N
Figure 4.3b: 1984
Saltmarsh extent
0 200 400 Metres
1980 photography
"© copyright Environment Agency"


N
Figure 4.3c: 2001
Saltmarsh extent
0 200 400 Metres
1980 photography
"© copyright Environment Agency"

1971-2001 (Figure 4.3d and Table 4.4)

Changes between 1971 and 2001, indicates 50% saltmarsh loss, which equates to 1.7% per annum (Table 4.4). This rate is 0.5% per annum higher than the marshes directly behind Hurst Spit because those at Keyhaven are more exposed to easterly wave attack. As a result the dominant erosive process is edge erosion. There is also some internal dissection. The small amount of marsh to the east of the main marshes has virtually disappeared by 2001.

1971-1984 (Figure 4.3e and Table 4.4)

This epoch underwent the most extreme rate of saltmarsh loss at Keyhaven (2.2% per annum – see Table 4.4). This is mainly due to edge erosion from south-easterly wave attack. Internal dissection is also apparent, as is erosion of the marshes immediately adjacent to the seawall.

1984-2001 (Figure 4.3f and Table 4.4)

This epoch underwent the same amount of loss per annum as 1971-2001 (1.7 % based on the 1971 area). Again, edge erosion is the dominant process.

The following Figures (4.3d – 4.3f) show the spatial change in saltmarsh extent for the various epochs at Keyhaven.

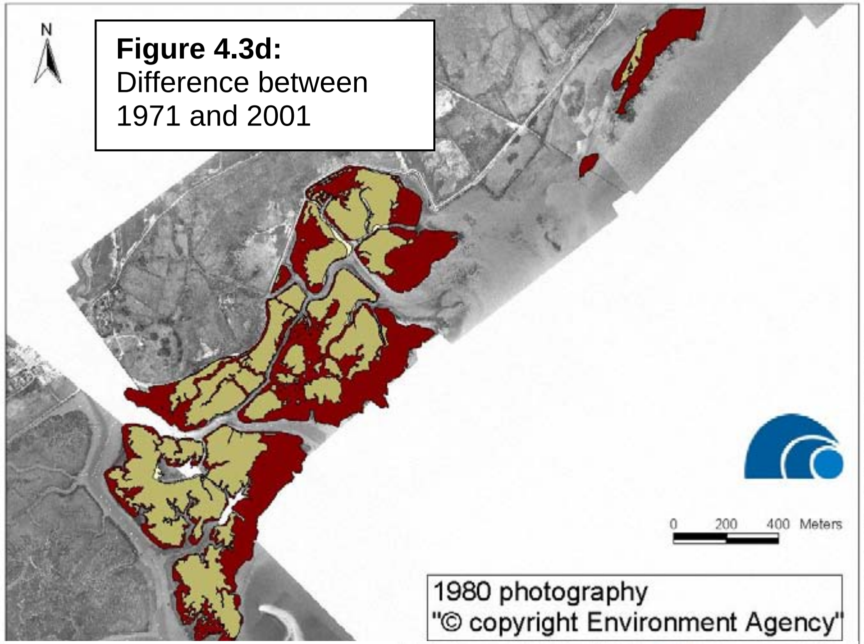


Figure 4.3d: Difference between 1971 and 2001

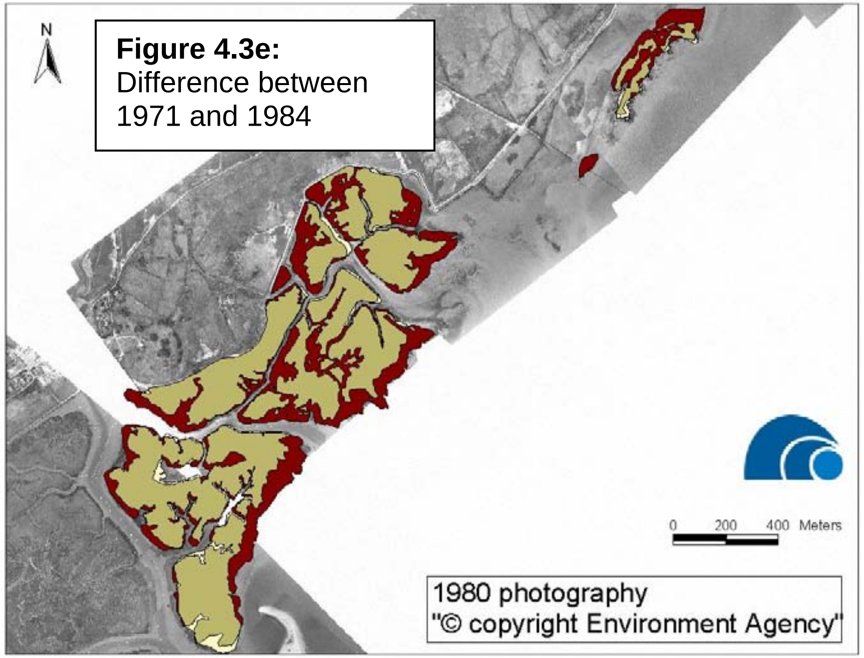


Figure 4.3e: Difference between 1971 and 1984

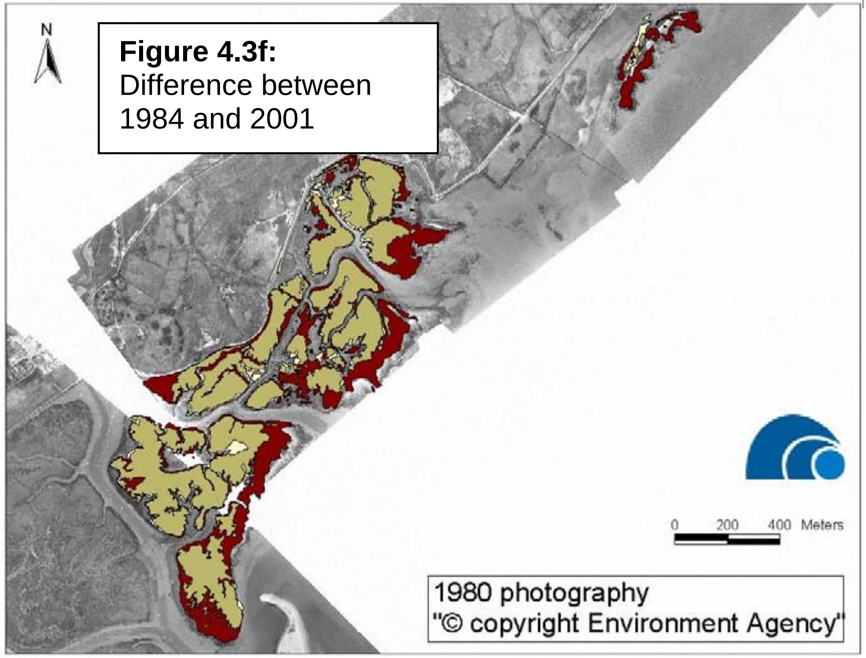


Figure 4.3f: Difference between 1984 and 2001

(yellow)	Stable
(brown)	Loss
(pale yellow)	Gain

1980 photography – "© copyright Environment Agency"

4.2.2.2 Predicted inter-tidal change

The area selected for LTEI calculations at Keyhaven, for comparison with the HPI is shown on Figure 4.3g.

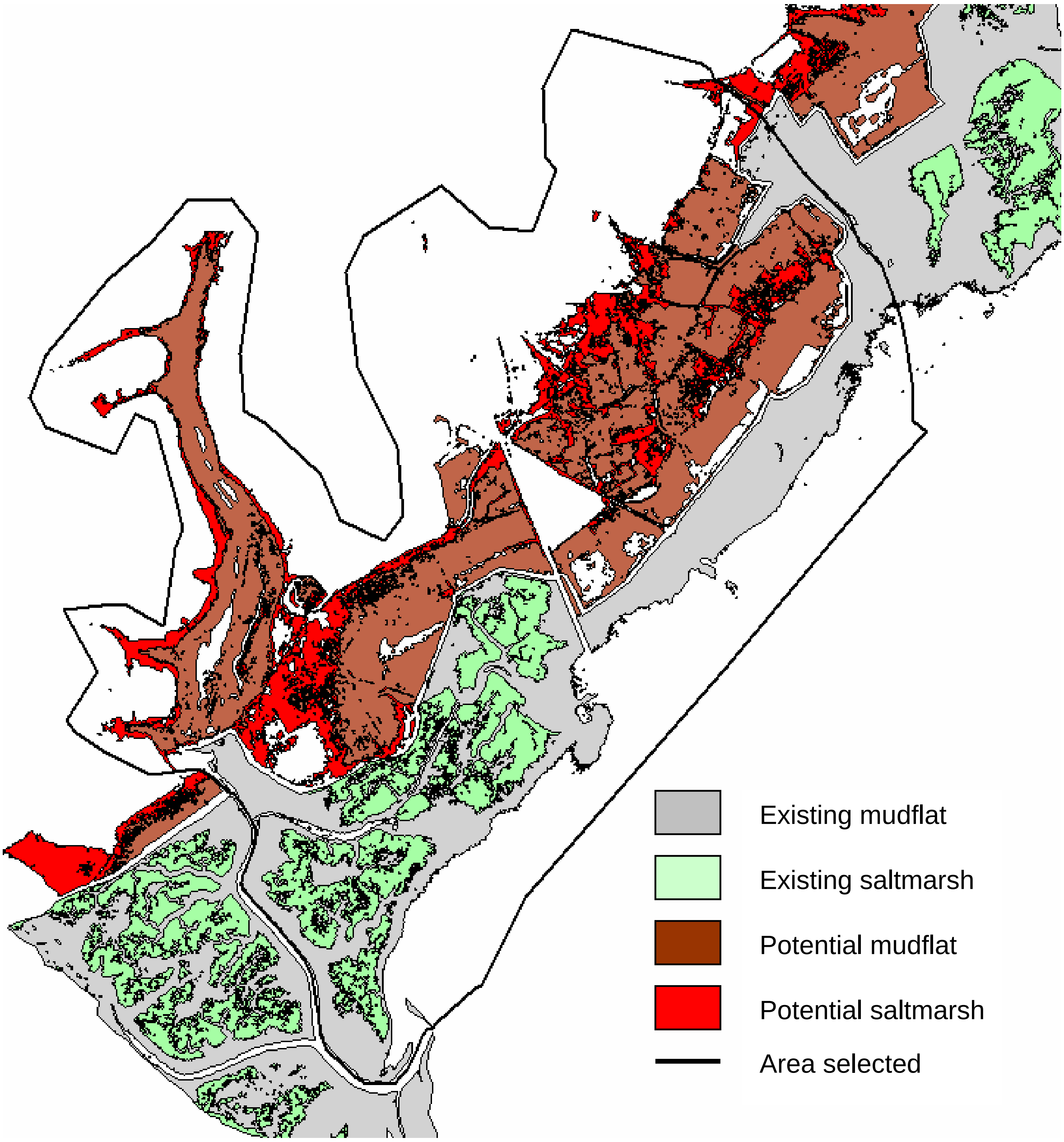
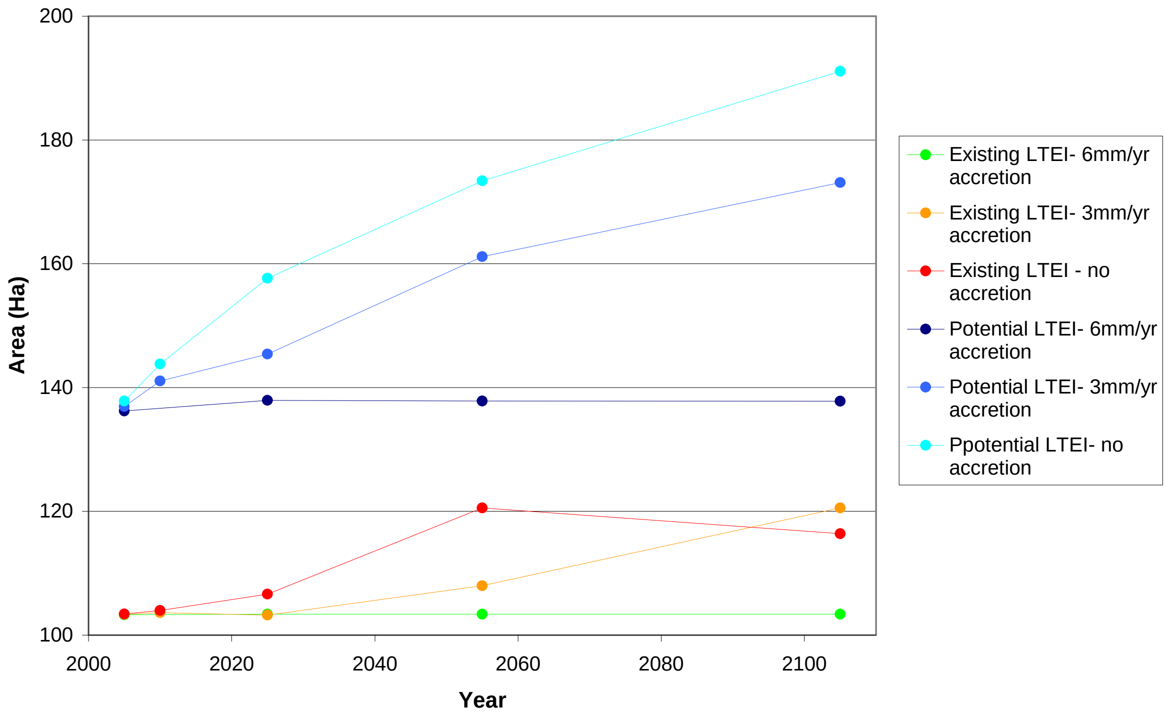
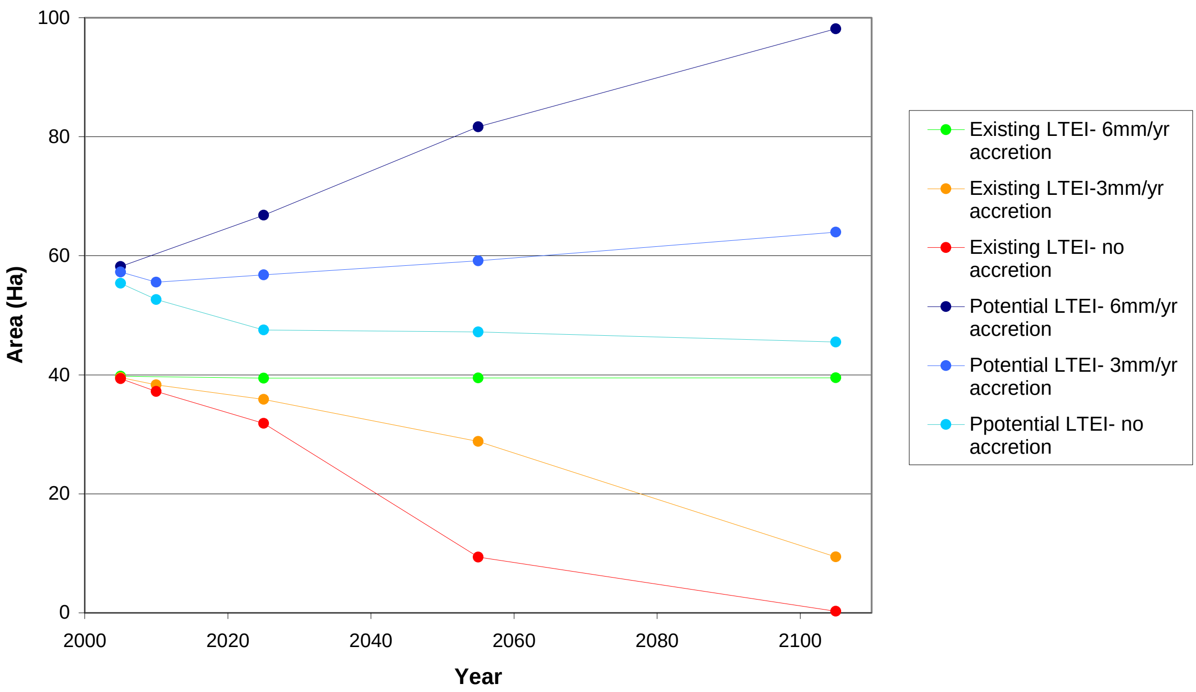


Figure 4.3g: Area selected for LTEI calculations at Keyhaven

Projected changes are presented for the "existing" management scenario (seawards of the seawall) and for "potential" increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for mudflat (Graph 4.2b) and saltmarsh (Graph 4.2c), for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios.



Graph 4.2b: "Existing" and "potential" predicted mudflat extent at Keyhaven (based on LTEI)



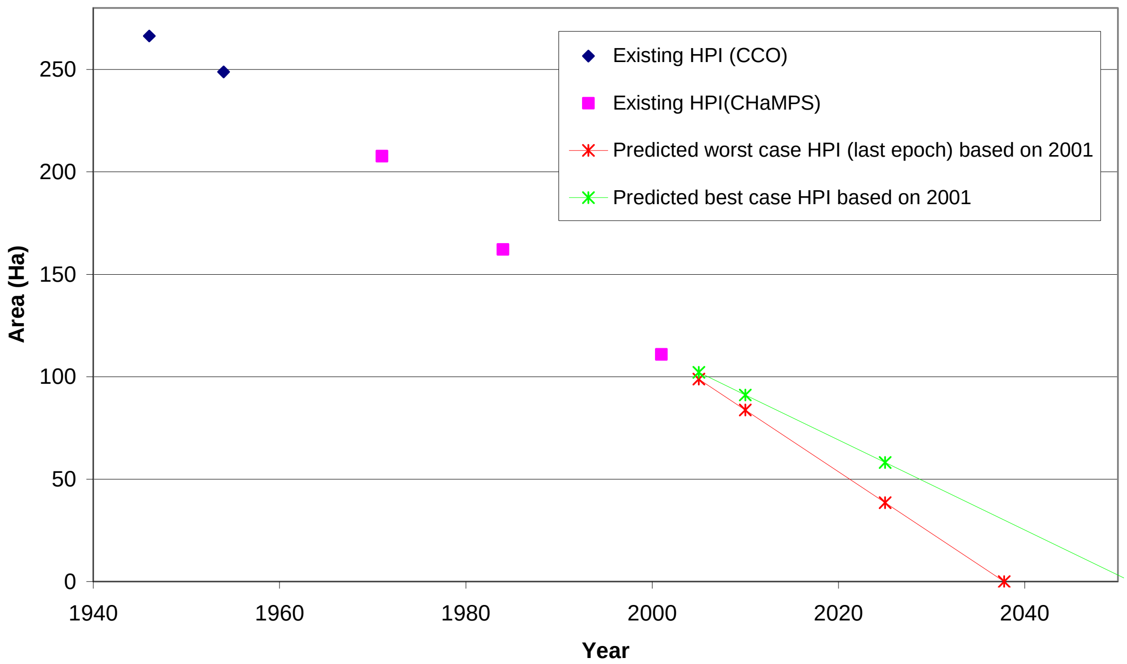
Graph 4.2c: "Existing" and "potential" predicted saltmarsh extent at Keyhaven (based on LTEI)

Results show mudflat evolution under the existing management regime slightly increase through time (Graph 4.2b) as saltmarsh slightly decreases (Graph 4.2c). In the event of re-alignment, there is a larger area of potential inter-tidal habitat landwards of the seawall compared to that seaward of the seawall.

4.2.3 Lymington

4.2.3.1 Historical saltmarsh change

The total saltmarsh extent is shown for 1946, 1954, 1971, 1984 and 2001 at Lymington (Graph 4.3a, Table 4.5 and Figures 4.4). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015.



Graph 4.3a: Historical and predicted saltmarsh extent at Lymington (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss excluding reclamation	
				% loss	% loss per year	% loss	% loss per year
1946	266.3	CCO					
1954	248.7	CCO	**1946-1954**	6.6	0.8	N/A	N/A
1971	207.7	CHaMP	**1954-1971**	16.5	1.0	N/A	N/A
1984	162.2	CHaMP	**1971-1984**	21.9	1.7	N/A	N/A
2001	110.9	CCO	**1984-2001**	31.6	1.9	N/A	N/A
			1946-2001	58.4	1.1	N/A	N/A

Table 4.5: Saltmarsh extent at Lymington (based on HPI)

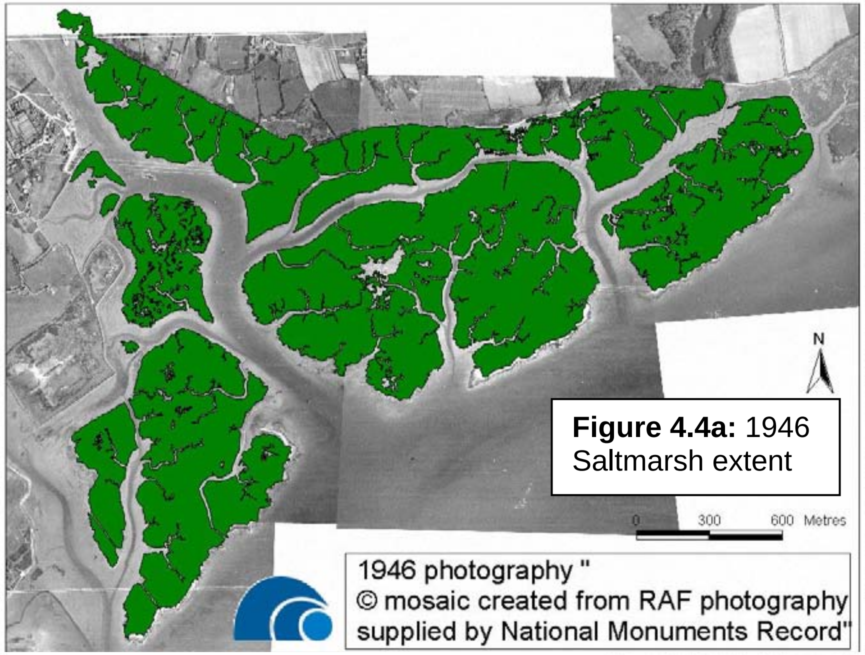


Figure 4.4a: 1946 Saltmarsh extent

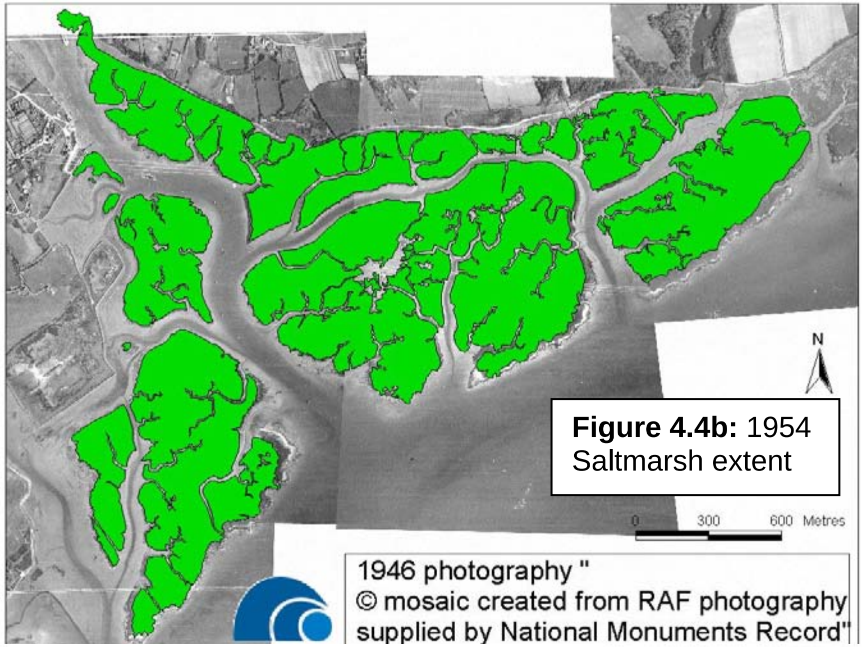


Figure 4.4b: 1954 Saltmarsh extent

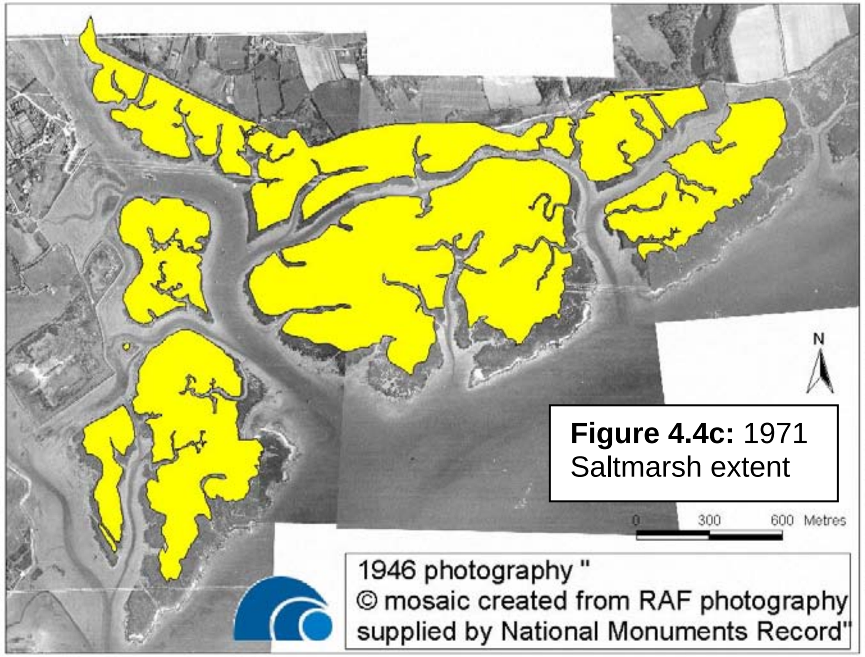


Figure 4.4c: 1971 Saltmarsh extent

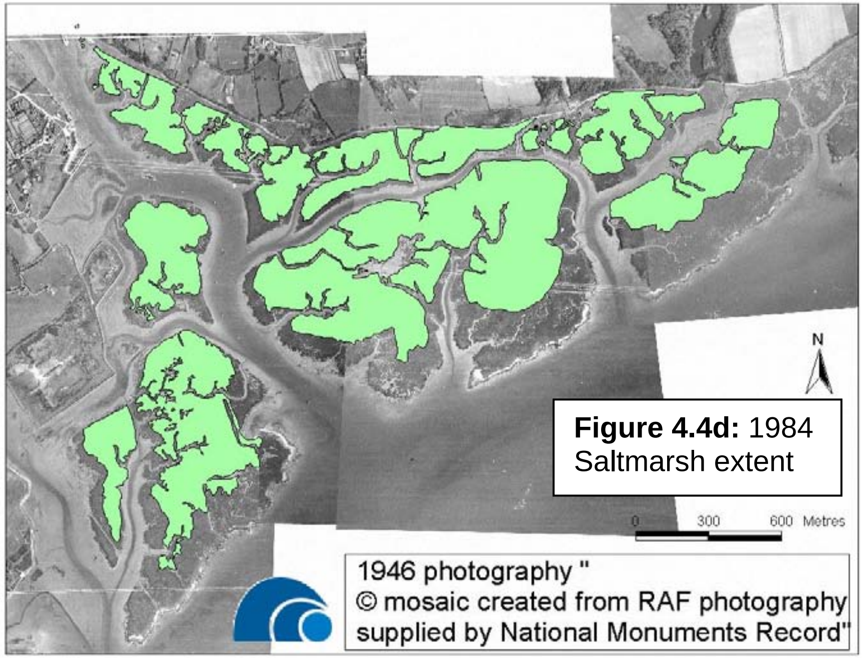
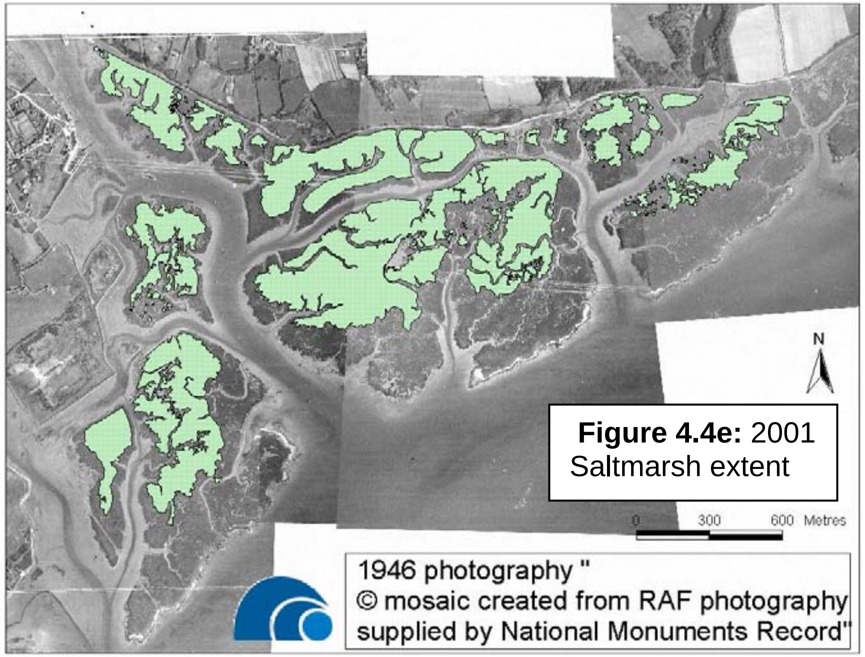


Figure 4.4d: 1984 Saltmarsh extent


N
Figure 4.4e: 2001 Saltmarsh extent
0 300 600 Metres
1946 photography "
© mosaic created from RAF photography supplied by National Monuments Record"

1946-2001 (Figure 4.4f and Table 4.5)

Changes between 1946 and 2001, indicates 63% saltmarsh loss, which equates to 1.1% per annum (Table 4.5). Edge erosion is substantial, indicating that wave attack is a dominant erosive process. As would be expected, areas of loss are greatest along the seaward edge of the outer marshes, rather than the more sheltered areas further up the estuary mouth (Colenutt, 2002). There is a relatively small amount of internal dissection on the expanses of marsh immediately to the east of the main Lymington channel, although this appears to have been exacerbated by wave attack through time. There are also very small, localised gains (7.2 ha gain).

1946-1954 (Figure 4.4g and Table 4.5)

The data for this epoch indicates the lowest rate of saltmarsh loss, being 0.8% per annum (Table 4.2). Loss is focused on the seaward edge of the outer marshes. What initially appears to be erosion along the landward edge of the marshes (Figure 4.8) can be attributed to the tide being slightly higher in the 1954 photography than the 1946 photography. The rest of the area is relatively stable, however, a closer examination of the 1954 photography indicates the start of internal dissection.

1954-1971 (Figure 4.4h and Table 4.5)

The rate of saltmarsh loss increased to 1% per annum between 1954 and 1971 (Table 4.5). Edge erosion continues to dominate. In addition, 1.4 hectares of marsh was lost to dredging of the Lymington marina. Initial examination of results suggests some areas of gain; these can be attributed to the 1954 dataset being digitized to a more detailed specification compared with the 1971 CHaMP dataset.

1971-1984 (Figure 4.4i and Table 4.5)

The rate of saltmarsh loss between 1971 and 1984 increased drastically to 1.7% per annum (Table 4.5). Again, edge erosion dominates with some internal dissection in the marsh immediately to the east of the channel. The increased fragmentation of this marsh, as well as those areas to the east, is not identified by the coarser scale of the CHaMP digitizing.

1984 -2001 (Figure 4.4j and Table 4.5)

The annual rate of loss is highest between 1984 – 2001, at 2.3% (Table 4.5). Not only is there substantial edge erosion along the seaward margins of the outer marshes but increased internal dissection on the marshes also occurs to the east of the main channel.

The following Figures (4.4f – 4.4j) show the spatial change in saltmarsh extent for the various epochs at Lymington.

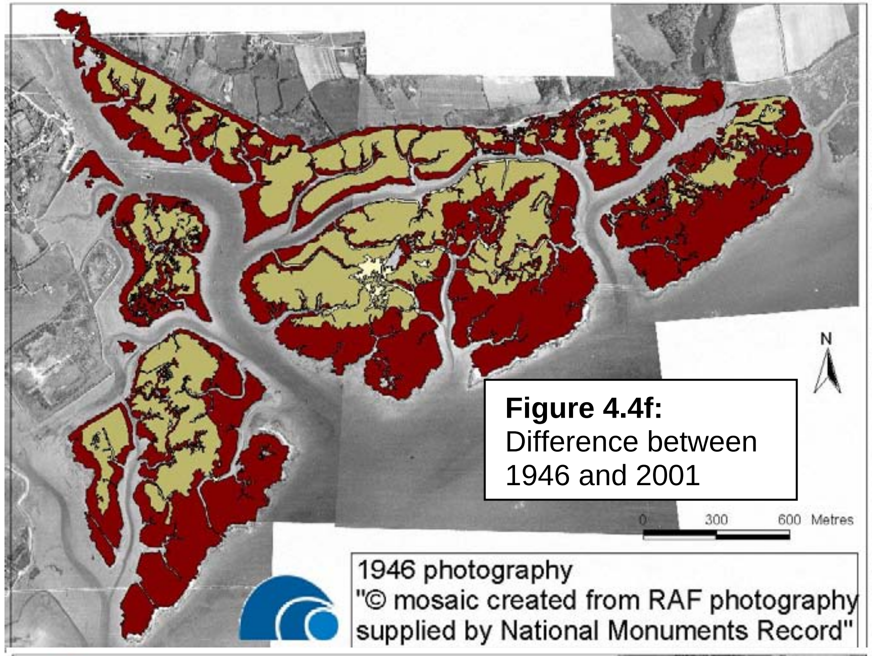


Figure 4.4f: Difference between 1946 and 2001

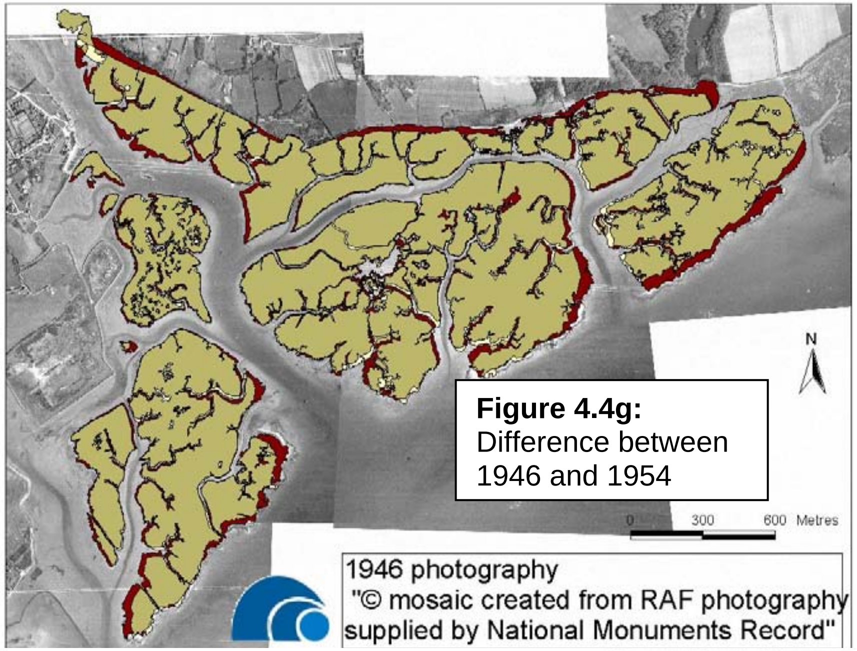


Figure 4.4g: Difference between 1946 and 1954

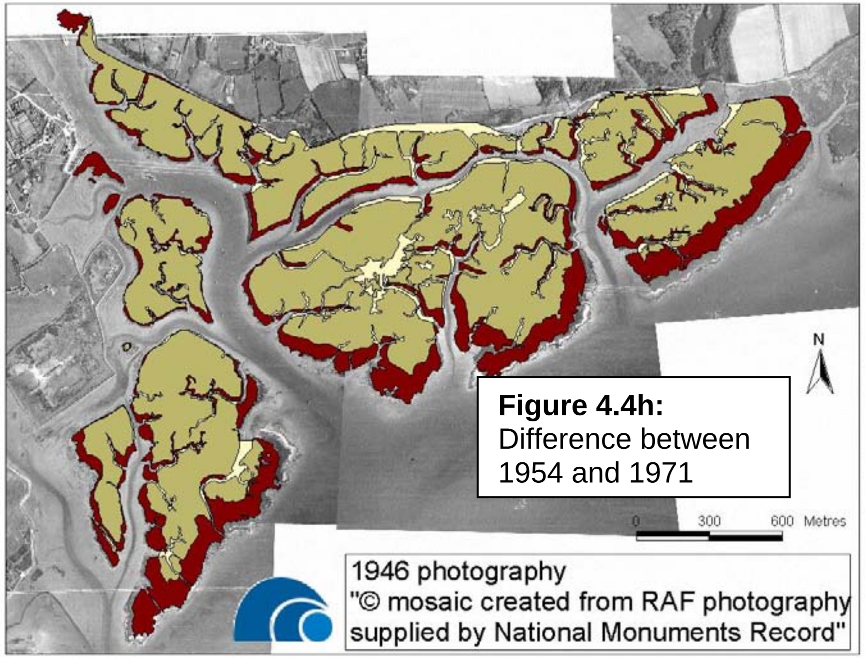


Figure 4.4h: Difference between 1954 and 1971

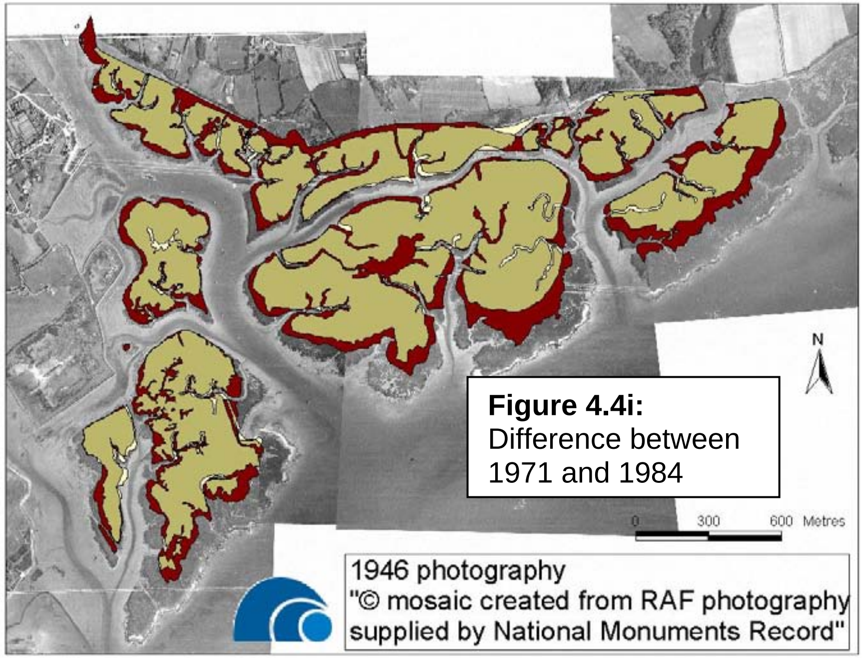


Figure 4.4i: Difference between 1971 and 1984

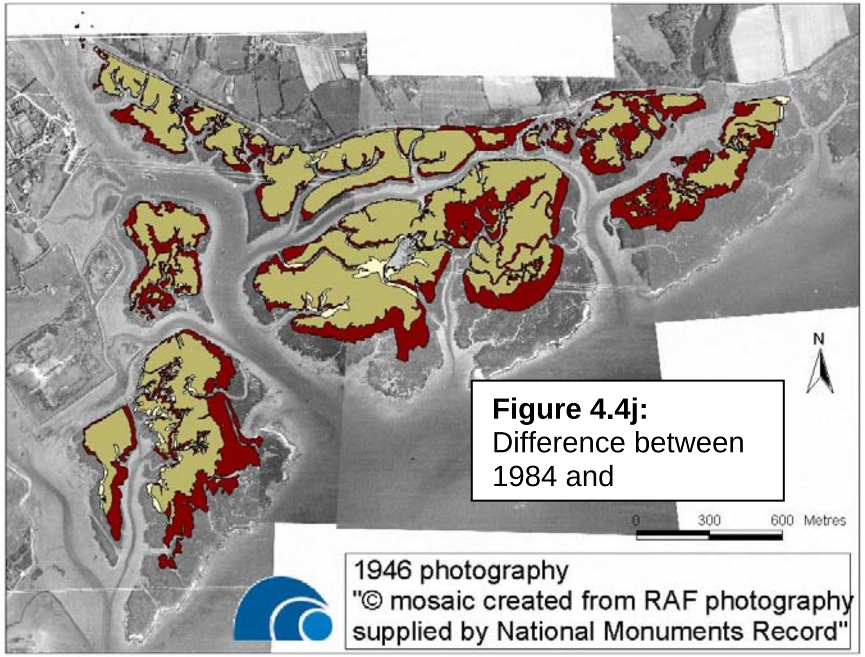


Figure 4.4j: Difference between 1984 and

4.2.3.2 Predicted inter-tidal change

The area selected for LTEI calculations at Lymington, for comparison with the HPI is shown on Figure 4.4k.

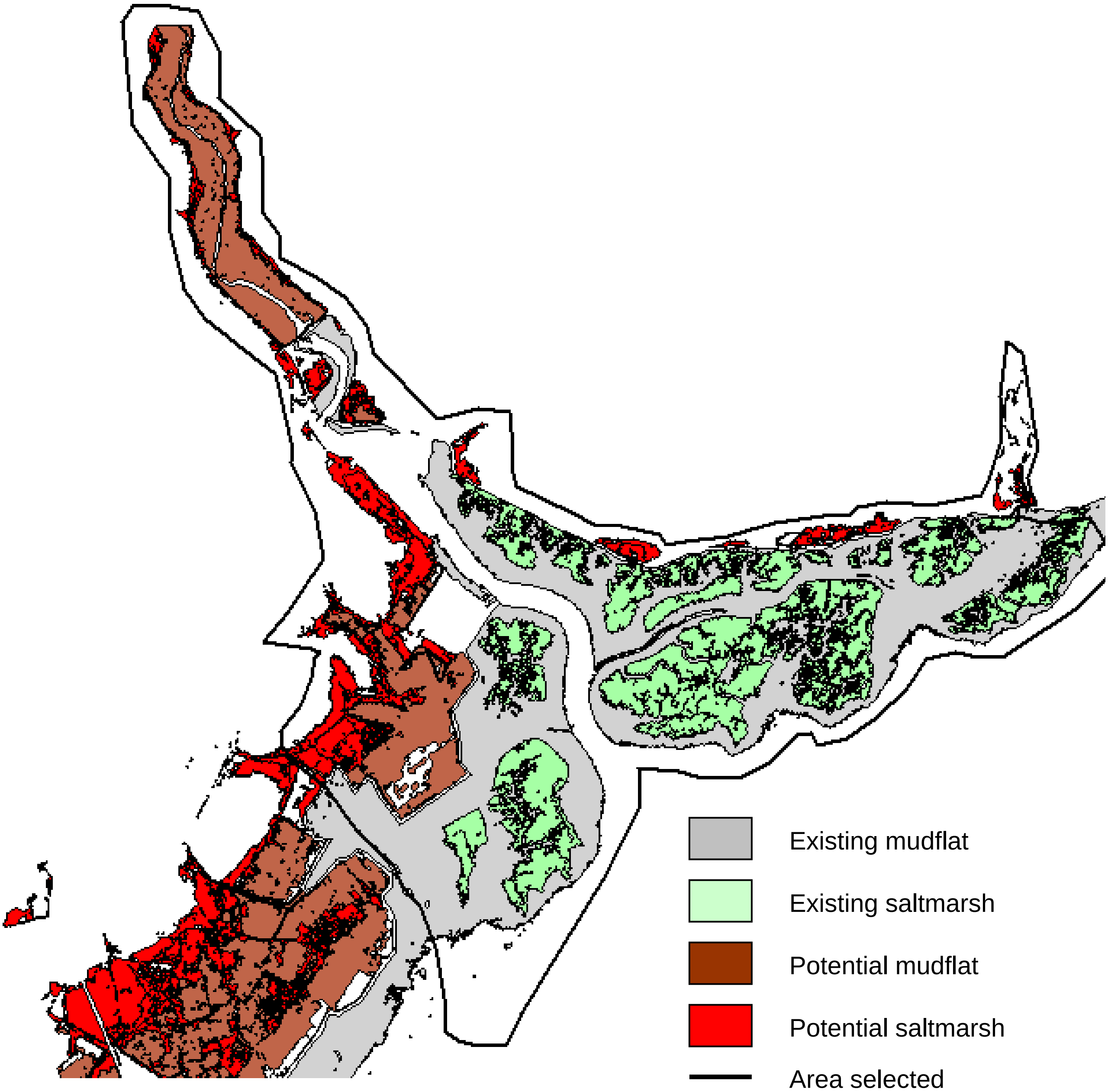
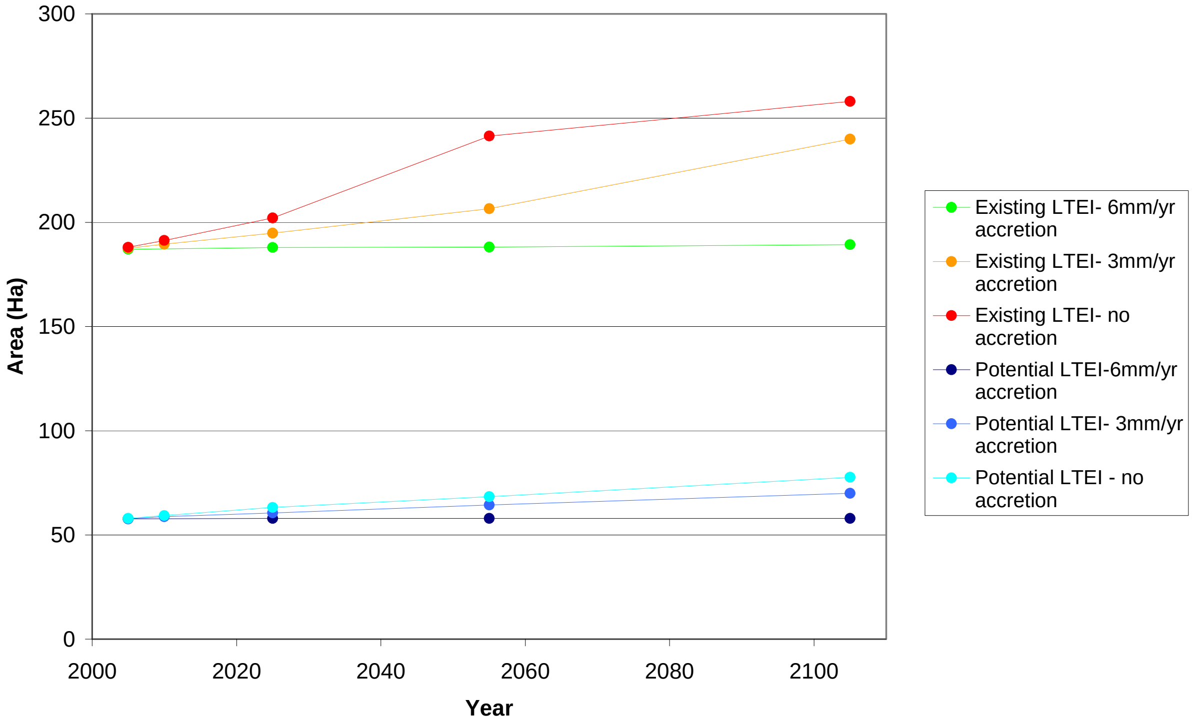
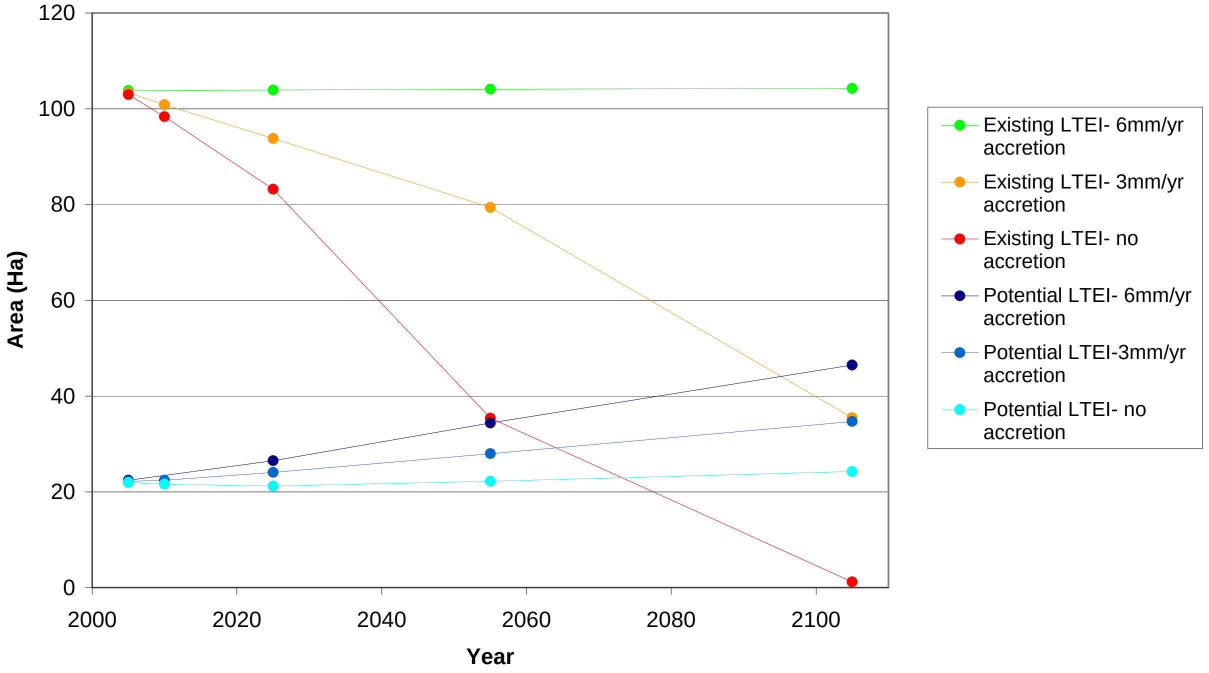


Figure 4.4k: Area selected for LTEI calculations at Lymington

Projected changes are presented for the "existing" management scenario (seawards of the seawall) and for "potential" increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for mudflat (Graph 4.3b) and saltmarsh (Graph 4.3c), for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios.



Graph 4.3b: "Existing" and "potential" predicted mudflat extent at Lymington (based on LTEI)



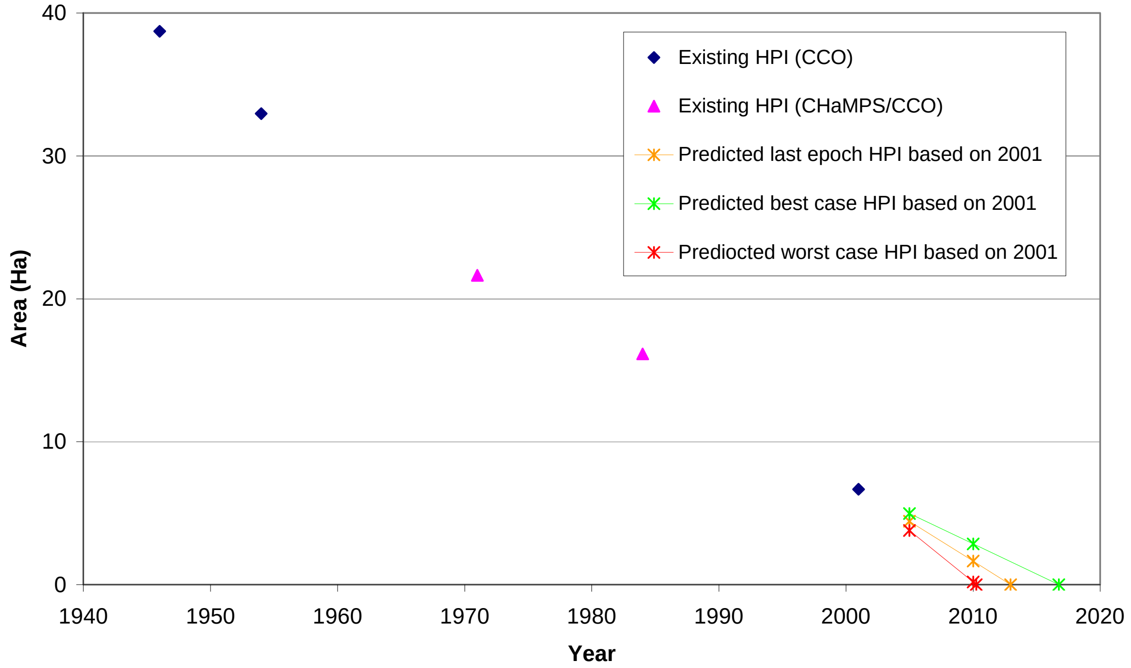
Graph 4.3c: "Existing" and "potential" predicted saltmarsh extent at Lymington (based on LTEI)

Results show mudflat evolution under the existing management regime slightly increase through time (4.3b) as saltmarsh slightly decreases (Graph 4.3c). In the event of re-alignment, mudflat and saltmarsh has the potential to increase over the next 100 years as the system would migrate onto higher land.

4.2.4 Pitts Deep and Sowley

4.2.4.1 Historical saltmarsh change

The total saltmarsh extent is shown for 1946, 1954, 1971, 1984 and 2001 at Sowley and Pitts Deep (Graph 4.4a, Table 4.6 and Figures 4.5). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015.



Graph 4.4a: Historical and predicted saltmarsh extent at Pitts and Sowley (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss excluding reclamation	
				% loss	% loss per year	% loss	% loss per year
1946	38.7	CCO					
1954	33.0	CCO	**1946-1954**	14.9	1.9	N/A	N/A
1971	21.6	CHaMP/CCO	**1954-1971**	34.3	2.0	N/A	N/A
1984	16.1	CHaMP/CCO	**1971-1984**	25.4	2.0	N/A	N/A
2001	6.7	CCO	**1984-2001**	58.7	3.5	N/A	N/A
			1946-2001	82.8	1.5	N/A	N/A

Table 4.6: Saltmarsh extent at Pitts and Sowley (based on HPI)

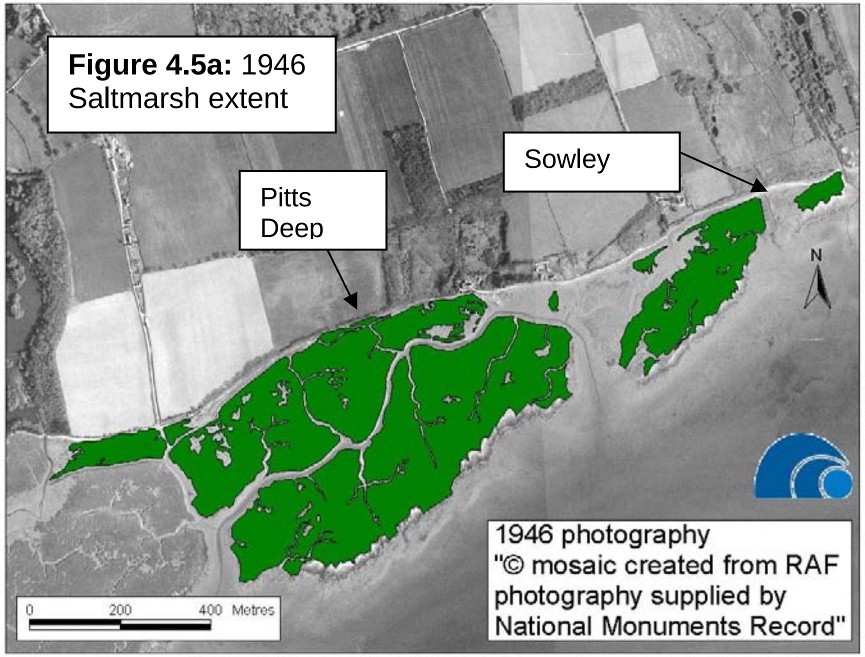


Figure 4.5a: 1946 Saltmarsh extent

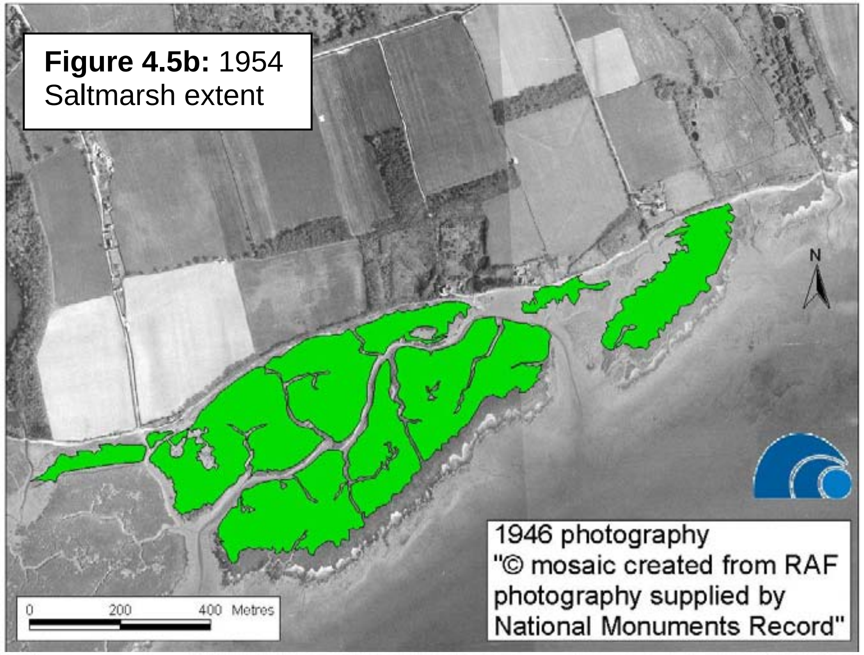


Figure 4.5b: 1954 Saltmarsh extent

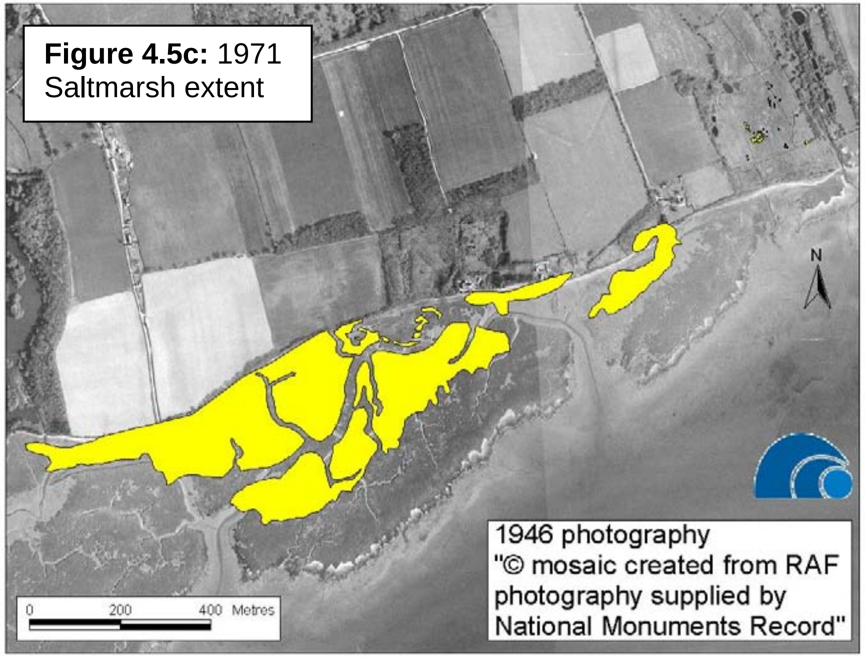


Figure 4.5c: 1971 Saltmarsh extent

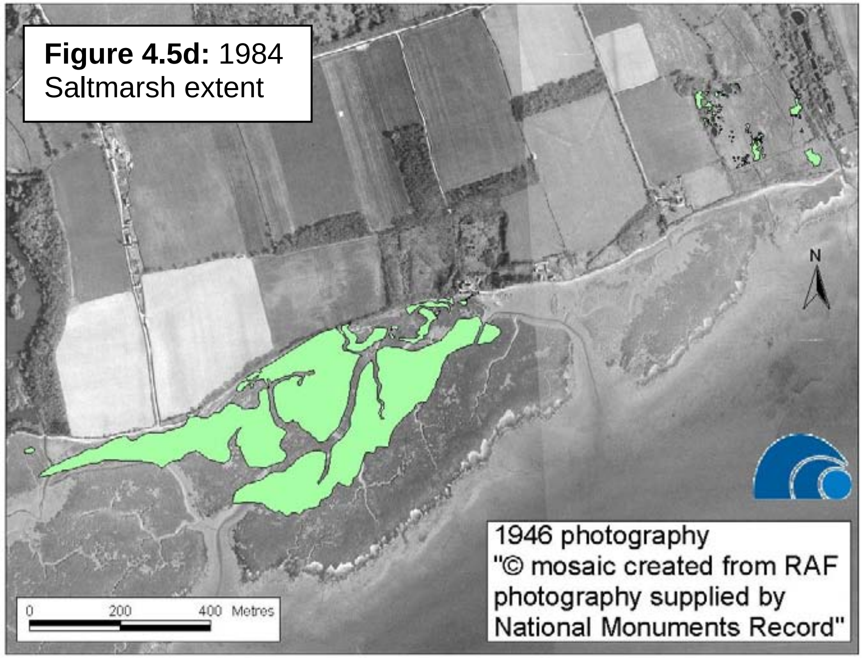


Figure 4.5d: 1984 Saltmarsh extent

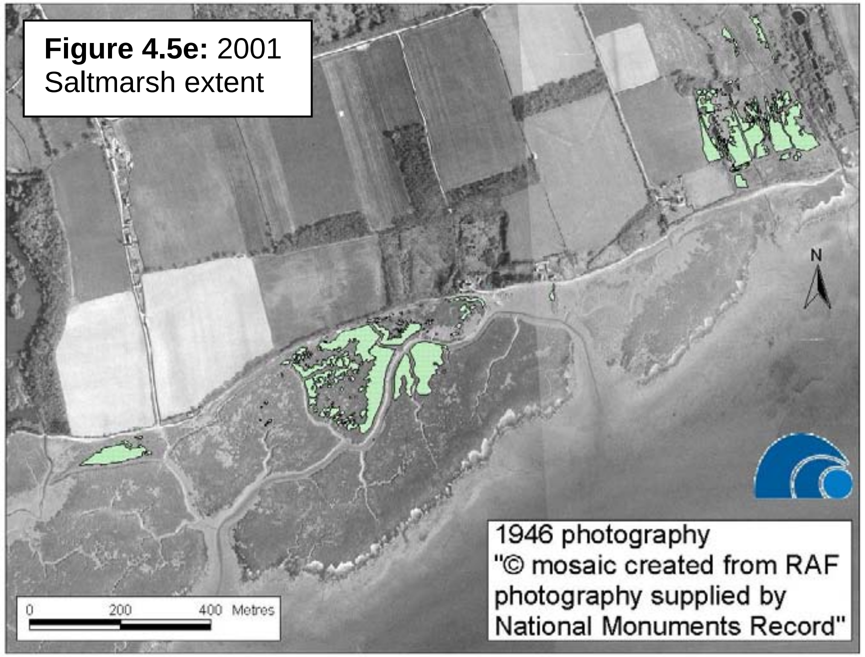


Figure 4.5e: 2001 Saltmarsh extent

1946-2001 (Figure 4.5f and Table 4.6)

Changes between 1946 and 2001, indicates 83% saltmarsh loss, which equates to 1.5% per annum (Table 4.6). This is a high annual loss, which is comparable with Langstone, particularly given the fact that the Sowley marsh has increased in area since 1955 (2.6 ha). As would be expected, areas of loss are greatest along the seaward edge of the outer marshes. There is a relatively small amount of internal dissection.

1946-1954 (Figure 4.5g and Table 4.6)

The rate of loss is 1.9% per annum between 1946 and 1954 (Table 4.6). Loss is focused on the seaward edge of the outer marshes. There appears to be a small area of gain between the two sets of main marsh. However, it is difficult to tell from the historical photography if this is just algae, rather than saltmarsh. What appears to be erosion along the landward edge of the marshes (Figure 4.5g) can be attributed to the tide being slightly higher in the 1954 photography than the 1946 photography.

1954-1971 (Figure 4.5h and Table 4.6)

The rate of saltmarsh loss between 1954 and 1971 was 2% per annum (Table 4.6). Edge erosion continues to dominate. The Sowley marsh starts to colonize (0.07 ha). Any areas of gain can be attributed to the 1954 CCO dataset, which was digitized to a more detailed specification compared with the 1971 CHaMP dataset. In addition, different geo-rectification methodologies were used for the CHaMP data compared with the SDCP data, which has resulted in apparent displacement of the saltmarsh just to the west of the Sowley spits.

1971-1984 (Figure 4.5i and Table 4.6)

The rate of saltmarsh loss between 1971 and 1984 was again, 2% per annum (Table 4.6). Edge erosion dominates, with complete disappearance of the marsh just to the west of the Sowley spits. By 1984, the Sowley saltmarsh extent was 0.43 ha.

1984 -2001 (Figure 4.5j and Table 4.6)

Large scale saltmarsh loss occurred in the epoch 1984 and 2001, at 3.5% per annum. The saltmarsh eventually suffered fragmentation and internal dissection processes. This high rate of loss is the worst in the north Solent for this epoch, even though the Sowley saltmarsh continued to grow and had reached an extent of 2.6 ha by 2001. In terms of saltmarsh loss across the north Solent for this epoch, Lymington suffered the next largest % loss at 2.3%, followed by, Beaulieu (2%), Hurst (1.8%) and Keyhaven (1.7%). Calshot underwent a comparable loss of 3.5% between 1971 and 1984. The east Solent losses were much lower.

The following Figures (4.5f – 4.5j) show the spatial change in saltmarsh extent for the various epochs at Sowley and Pitts Deep.

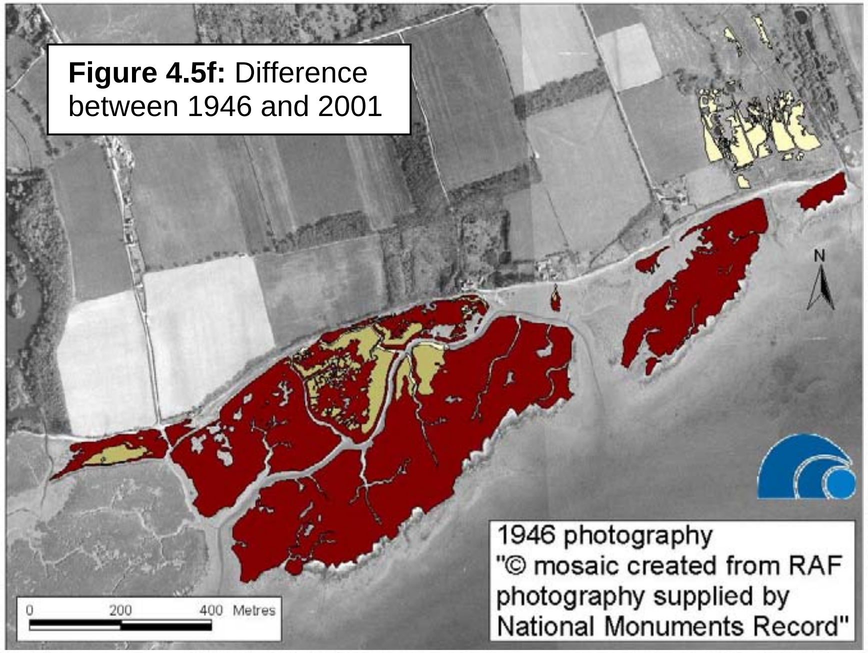


Figure 4.5f: Difference between 1946 and 2001
N
0 200 400 Metres
1946 photography
"© mosaic created from RAF photography supplied by National Monuments Record"

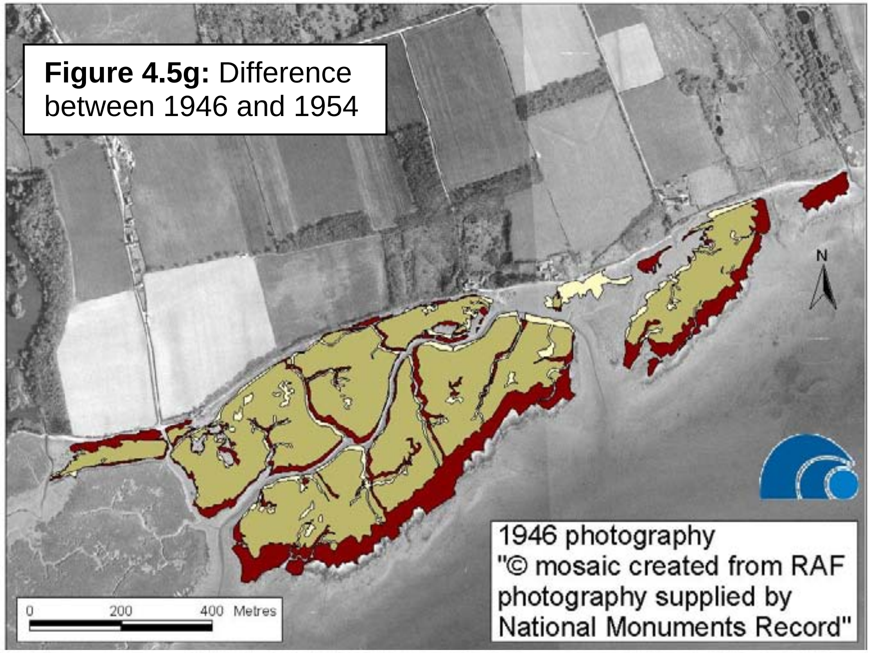


Figure 4.5g: Difference between 1946 and 1954
N
0 200 400 Metres
1946 photography
"© mosaic created from RAF photography supplied by National Monuments Record"

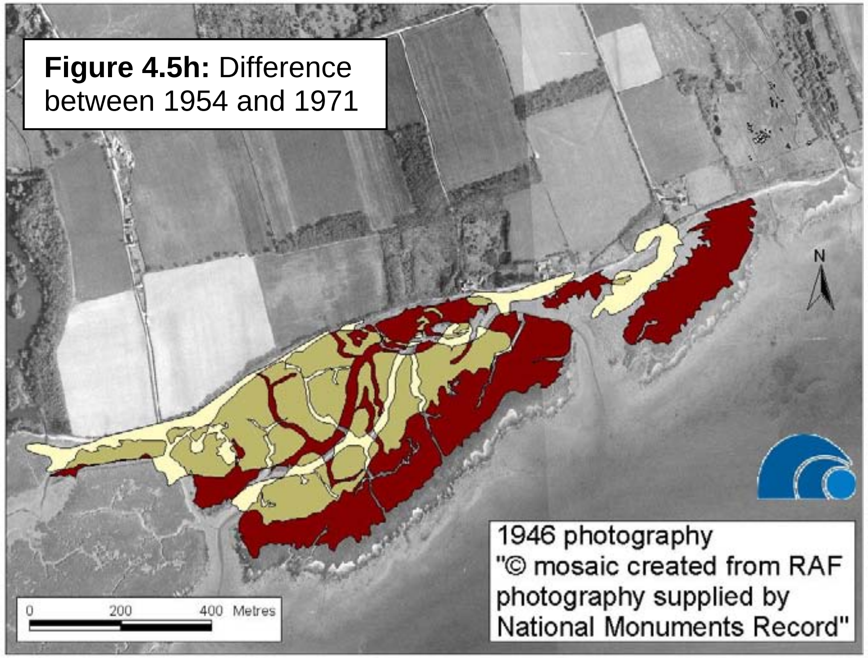


Figure 4.5h: Difference between 1954 and 1971
N
0 200 400 Metres
1946 photography
"© mosaic created from RAF photography supplied by National Monuments Record"

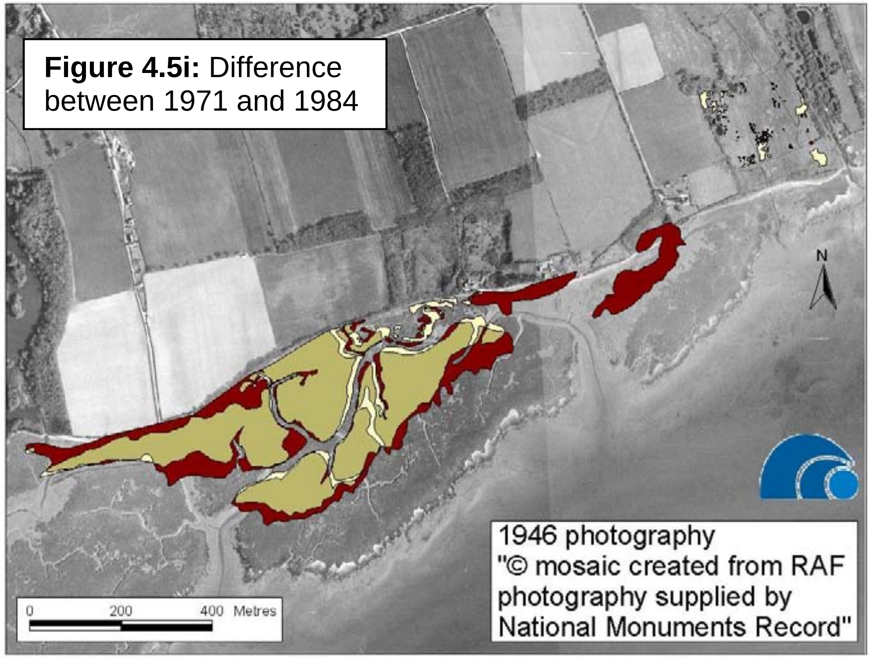


Figure 4.5i: Difference between 1971 and 1984
N
0 200 400 Metres
1946 photography
"© mosaic created from RAF photography supplied by National Monuments Record"

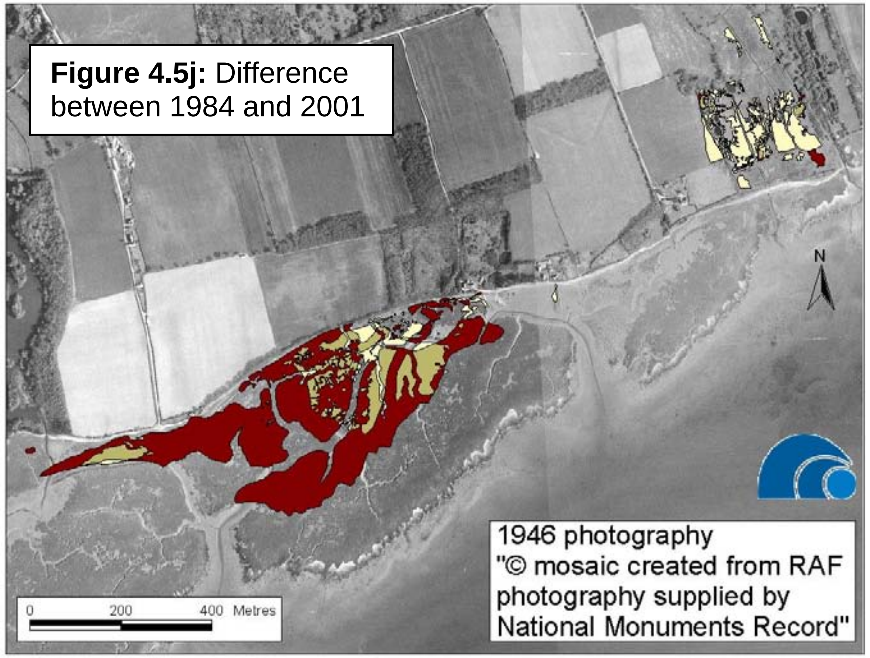
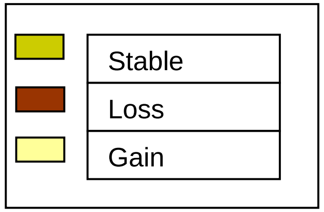


Figure 4.5j: Difference between 1984 and 2001
N
0
200
400 Metres
1946 photography
"© mosaic created from RAF photography supplied by National Monuments Record"


Stable
Loss
Gain

4.2.4.2 Predicted inter-tidal change

The area selected for LTEI calculations at Pitts and Sowley, for comparison with the HPI is shown on Figure 4.5k.

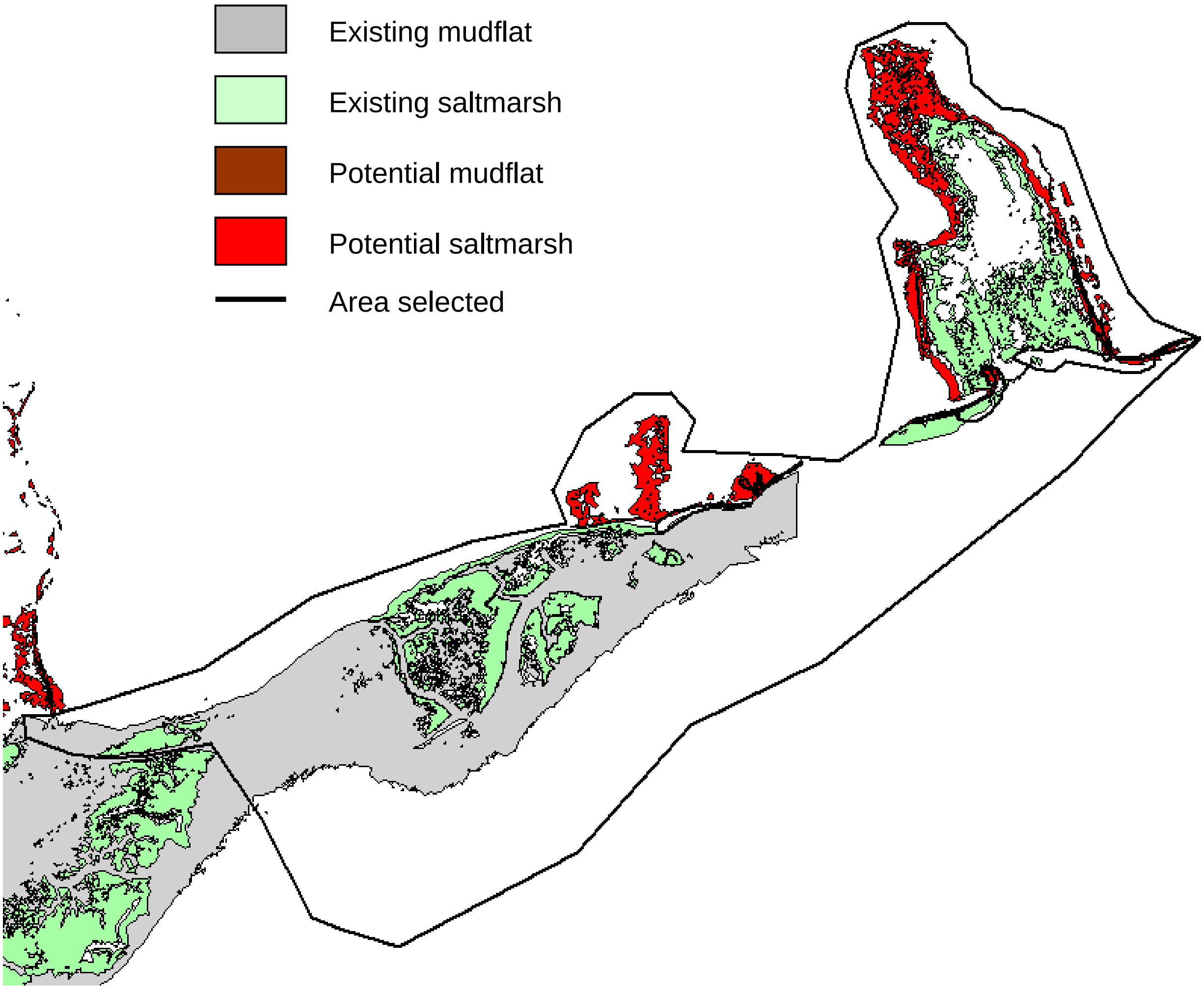
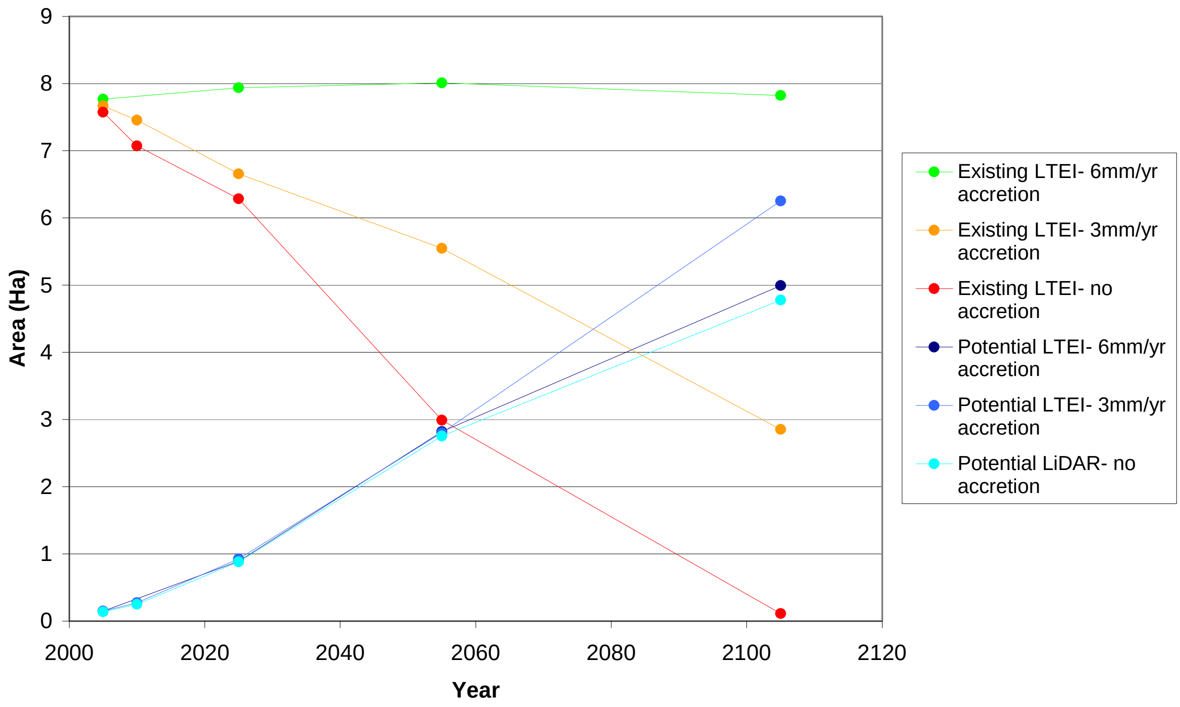


Figure 4.5k: Area selected for LTEI calculations at Pitts and Sowley

Projected changes are presented for the "existing" management scenario (seawards of the seawall) and for "potential" increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for saltmarsh (Graph 4.4b), for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios. Mudflat is not presented because the topographic data did not reach MLWS for the Sowley area.



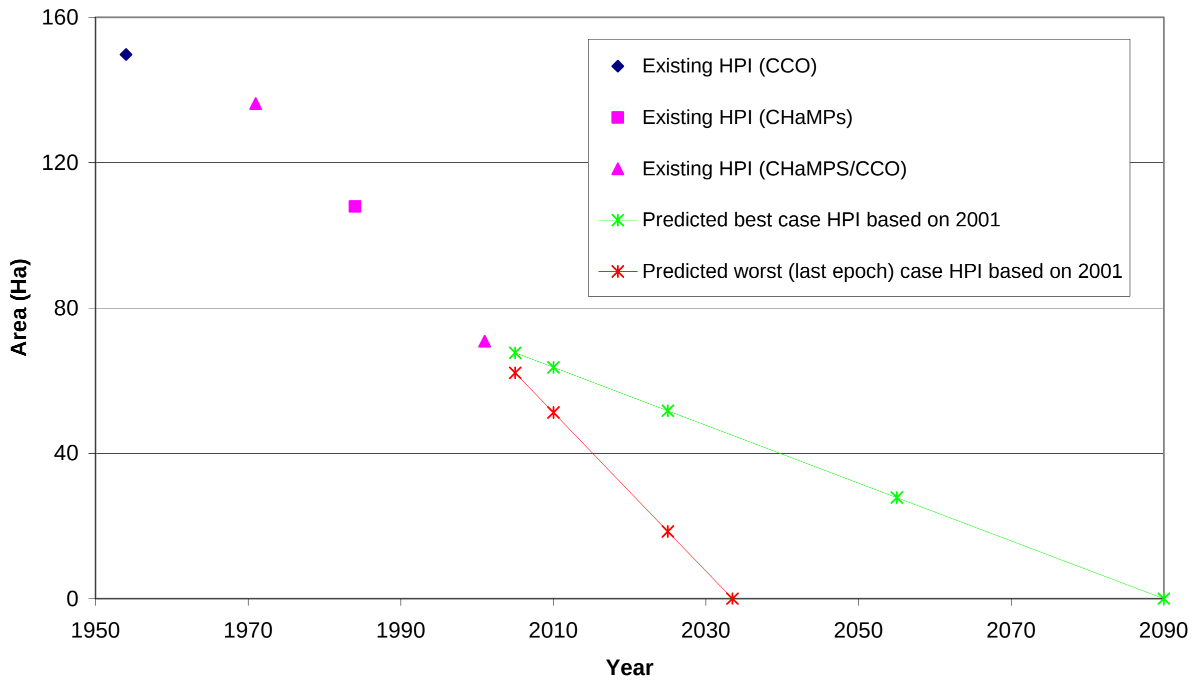
Graph 4.4b: "Existing" and "potential" predicted saltmarsh extent at Pitts and Sowley (based on LTEI)

Results show saltmarsh evolution under the existing management regime decrease through time for scenarios with no sediment accretion and 3mm sediment accretion per annum (Graph 4.4b). In the event of re-alignment, saltmarsh has the potential to almost replace the same amount lost (Graph 4.4b).

4.2.5 Beaulieu

4.2.5.1 Historical saltmarsh change

The total saltmarsh extent is shown for 1954, 1971, 1984, and 2001 at Beaulieu (Graph 4.5a, Table 4.7 and Figures 4.6). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015.



Graph 4.5a: Historical and predicted saltmarsh extent at Beaulieu (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss excluding reclamation	
				% loss	% loss per year	% loss	% loss per year
1954	149.8	CCO					
1971	136.2	CHaMP/CCO	**1954-1971**	9.0	0.5	N/A	N/A
1984	107.9	CHaMP	**1971-1984**	20.8	1.6	N/A	N/A
2001	70.9	CHaMP/CCO	**1984-2001**	34.4	2.0	N/A	N/A
			1954-2001	52.7	1.1	N/A	N/A

Table 4.7: Saltmarsh extent at Beaulieu (based on HPI)

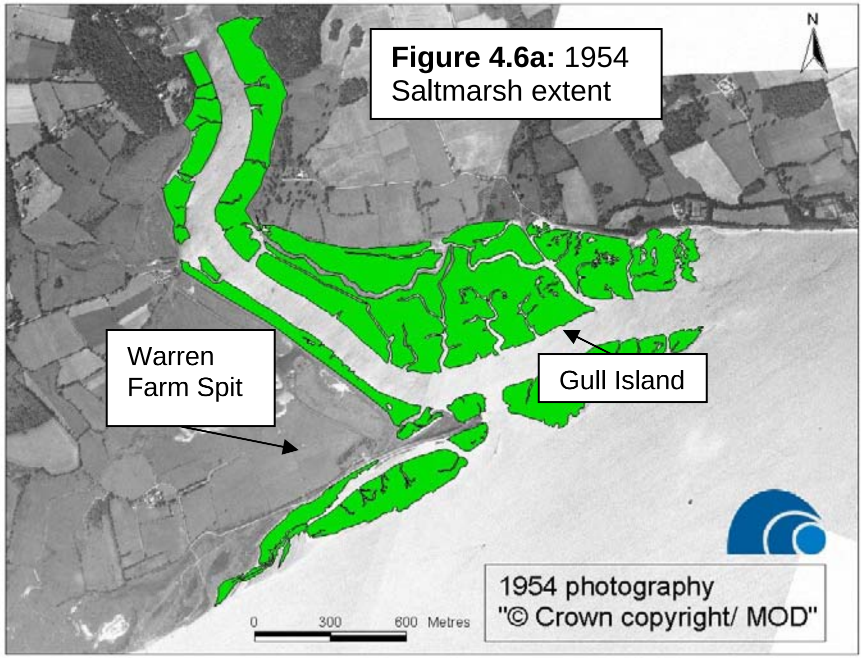


Figure 4.6a: 1954
Saltmarsh extent

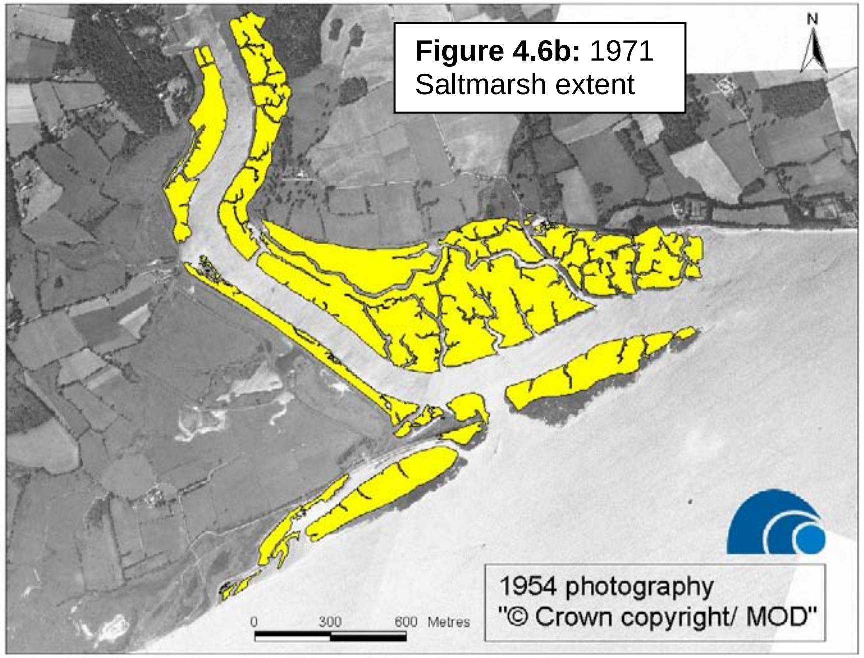


Figure 4.6b: 1971
Saltmarsh extent

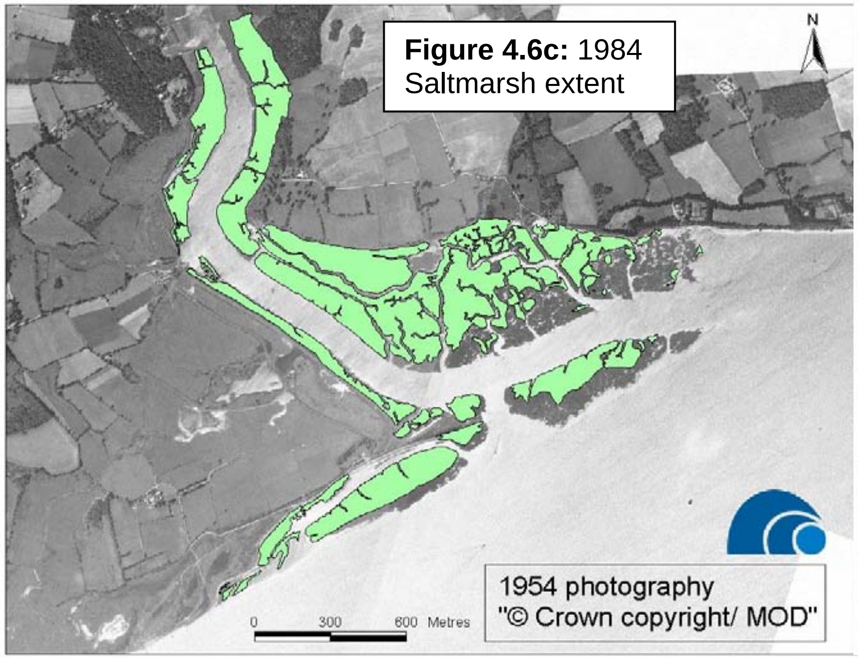


Figure 4.6c: 1984
Saltmarsh extent

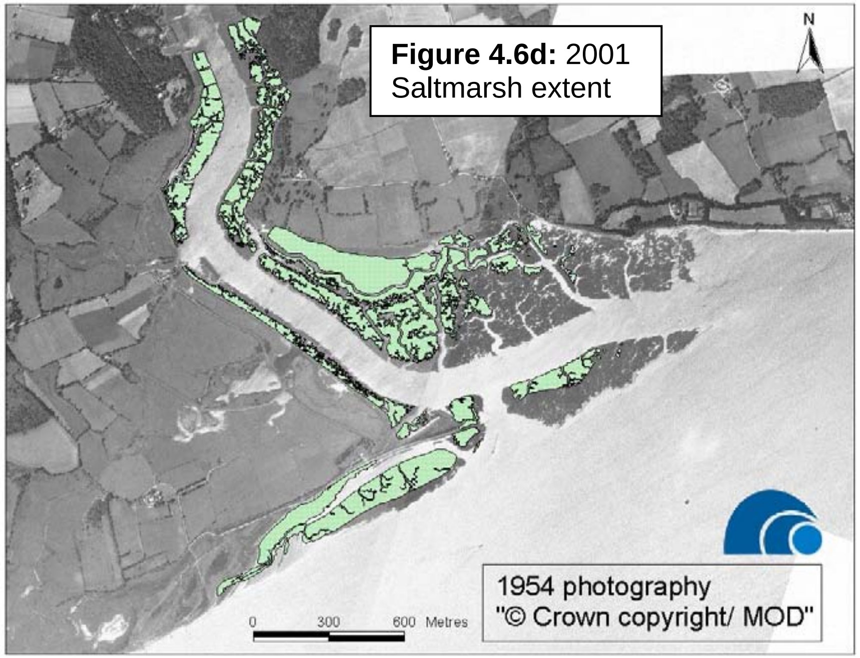


Figure 4.6d: 2001
Saltmarsh extent

1954-2001 (Figure 4.6e and Table 4.7)

Changes between 1954 and 2001, indicates 53% saltmarsh loss, which equates to 1.1% per annum (Table 4.7). This overall rate of loss is equal to that operating at Lymington. Edge erosion is dominant, which is surprising, given the protection afforded by Warren Farm Spit/Gull Island. This indicates that easterly wave attack, sea level rise and *Spartina* dieback are the main forces at work. As would be expected, areas of loss are greatest along the seaward edge of the outer marshes, rather than the more sheltered areas further up the estuary mouth.

1954-1971 (Figure 4.6f and Table 4.7)

This epoch shows the lowest rate of loss at Beaulieu, being 0.5% per annum. This may be because the 1954 CCO dataset was digitized to a more detailed specification compared with the 1971 CHaMP dataset. In addition, the 1954 photography was not ideal in terms of tidal height, brightness and contrast and therefore concealed a lot of the existing saltmarsh.

Warren Farm Spit is starting to accrete downdrift (east) during this epoch. Loss of the outer marshes at Warren Farm Spit and Gull Island maybe due to rollback of the spit during the 1953 storm or edge erosion.

1971-1984 (Figure 4.6g and Table 4.7)

The rate of saltmarsh loss between 1971 and 1984 increased to 1.6% per annum (Table 4.7). The majority of loss can be attributed to edge erosion of the main Beaulieu marshes.

1984 -2001 (Figure 4.7h and Table 4.7)

Between 1985 and 2001, the rate of loss increased to 2% per annum, which is the highest for Beaulieu. This epoch was also the worst for saltmarsh loss at Hurst (1.8%), Lymington (2.3%) and Pitts Deep and Sowley (3.5%). Not only has edge erosion dominated the outer Beaulieu marshes but appears to affect those up the Beaulieu river. However, this difference could be because the 2001 CHaMP/CCO dataset was digitized to a more detailed specification compared with the 1984 CHaMP dataset.

The following Figures (4.6e – 4.6h) show the spatial change in saltmarsh extent for the various epochs at Beaulieu.

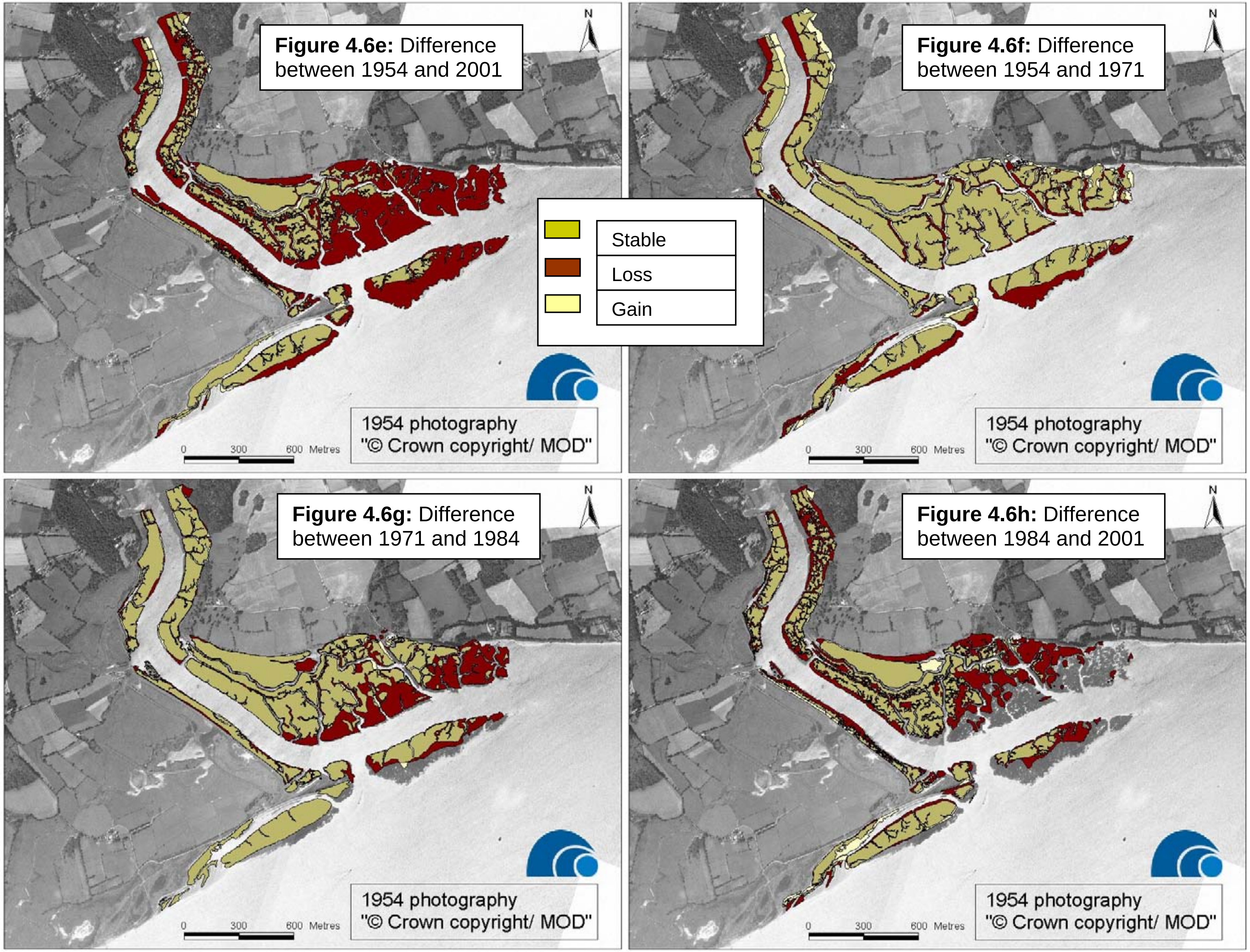


Figure 4.6e: Difference between 1954 and 2001

Figure 4.6f: Difference between 1954 and 1971

Figure 4.6g: Difference between 1971 and 1984

Figure 4.6h: Difference between 1984 and 2001

4.2.5.2 Predicted inter-tidal change

The area selected for LTEI calculations at Beaulieu, for comparison with the HPI is shown on Figure 4.6i.

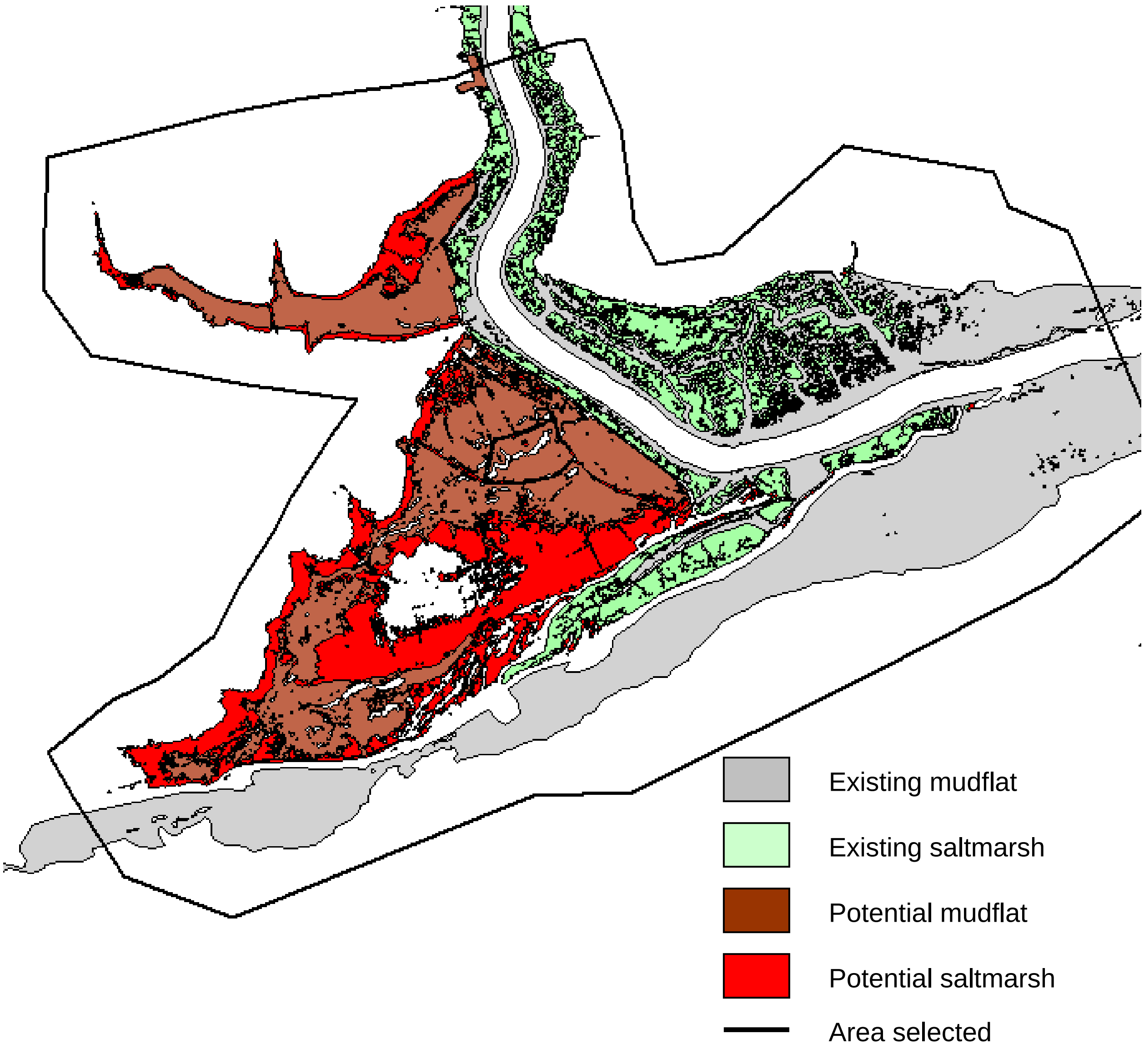
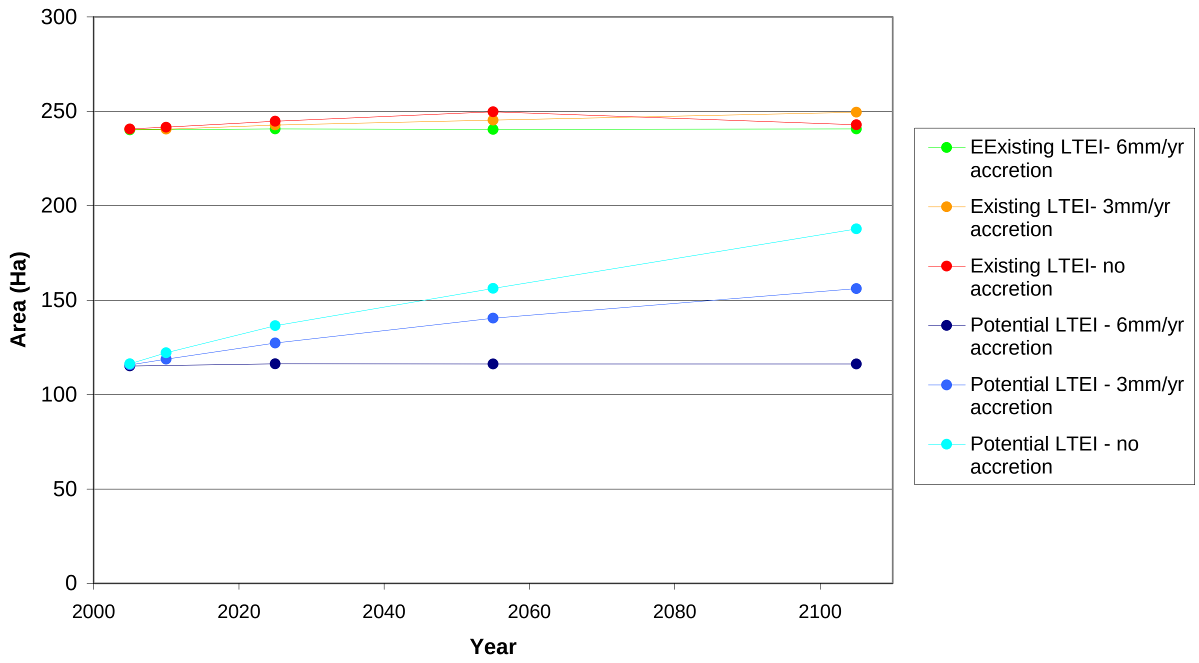
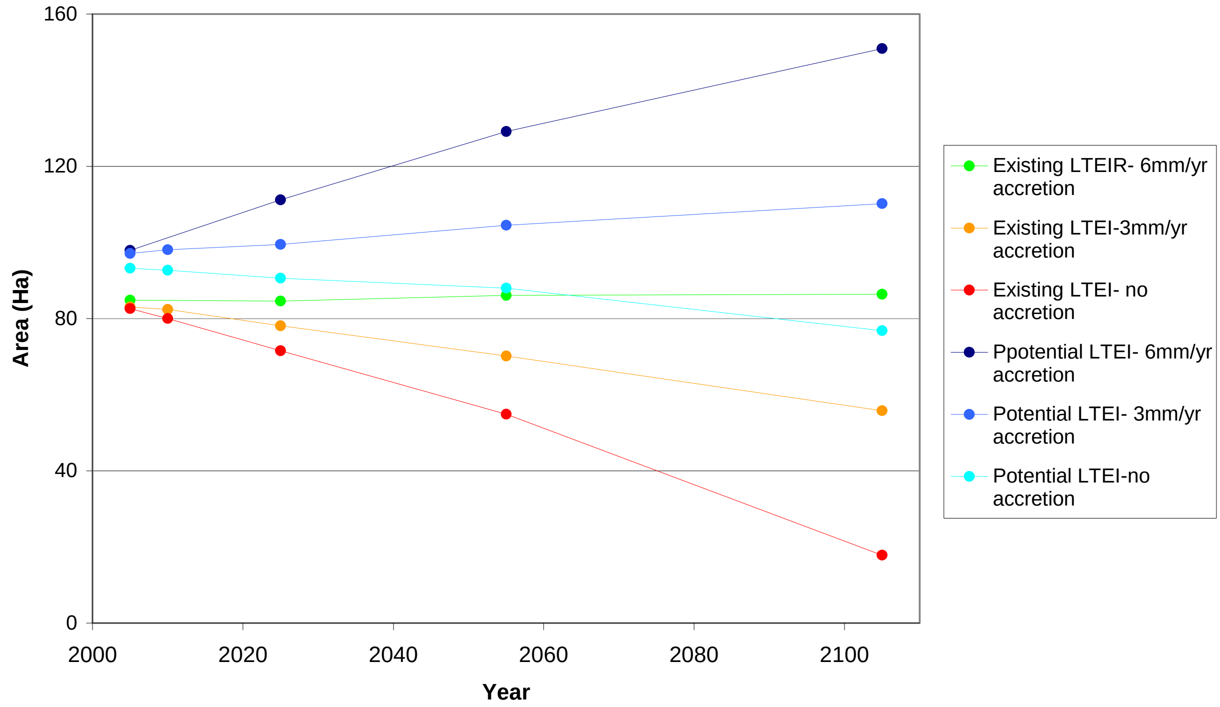


Figure 4.6i: Area selected for LTEI calculations at Beaulieu

Projected changes are presented for the “existing” management scenario (seawards of the seawall) and for “potential” increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for mudflat (Graph 4.5b) and saltmarsh (Graph 4.5c), for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios.



Graph 4.5b: "Existing" and "potential" predicted mudflat extent at Beaulieu (based on LTEI)



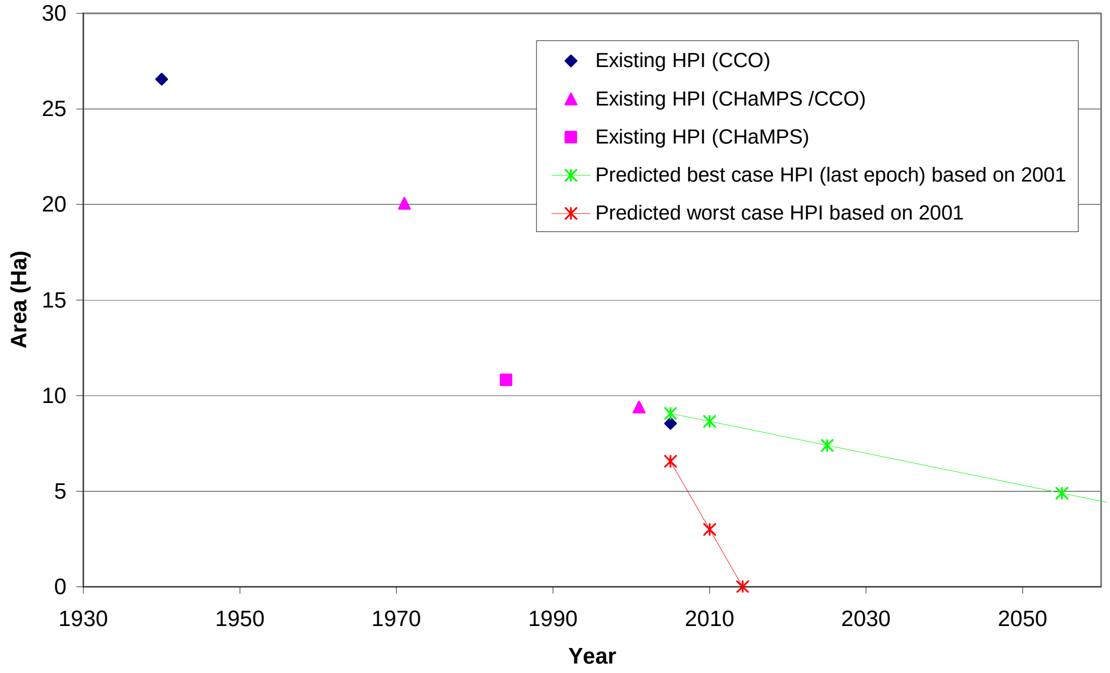
Graph 4.5c: "Existing" and "potential" predicted saltmarsh extent at Beaulieu (based on LTEI)

Results show mudflat evolution under the existing management regime remaining relatively stable (Graph 4.5b) whilst saltmarsh decreases through time (Graph 4.5c). In the event of re-alignment, mudflat and saltmarsh have the potential to increase through time for the 3mm and 6mm sediment accretion per annum per annum.

4.2.6 Calshot

4.2.6.1 Historical saltmarsh change

The total saltmarsh extent is shown for 1940, 1971, 1984 and 2001 at Calshot (Graph 4.6a, Table 4.8 and Figures 4.7). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015. Losses exclude reclamation.



Graph 4.6a: Historical and predicted saltmarsh extent at Calshot (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss excluding reclamation	
				% loss	% loss per year	% loss	% loss per year
1940	34.8	CCO					
1971	20.1	CHaMP/CCO	**1940-1971**	42.4	1.4	18.7	0.6
1984	10.8	CHaMP	**1971-1984**	46.1	3.5	46.1	3.5
2001	9.4	CHaMP/CCO	**1984-2001**	13.1	0.8	13.1	0.8
			1940-2001	73.0	1.2	49.3	0.8

Table 4.8: Historical and predicted saltmarsh extent at Calshot (based on HPI)

The areas of reclamation behind Calshot Spit, from 1940, are shown in Figure 4.7a.

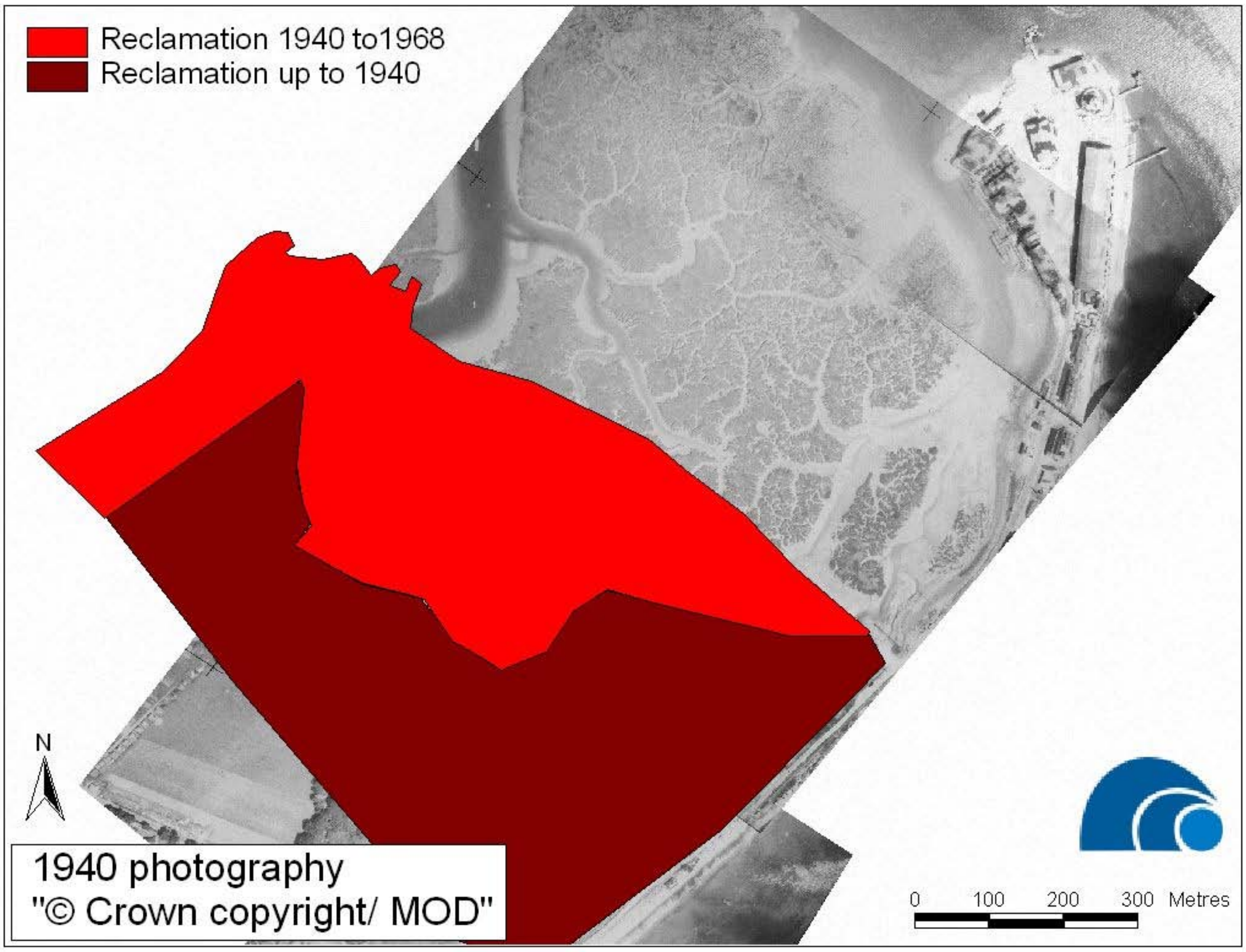


Figure 4.7a: Reclamation at Calshot Spit (based on HPI).

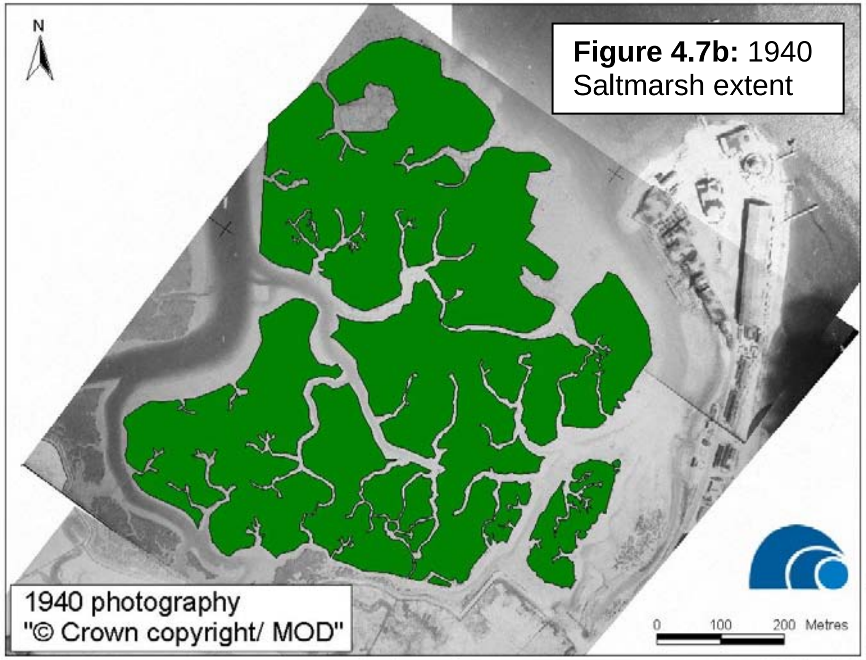


Figure 4.7b: 1940 Saltmarsh extent

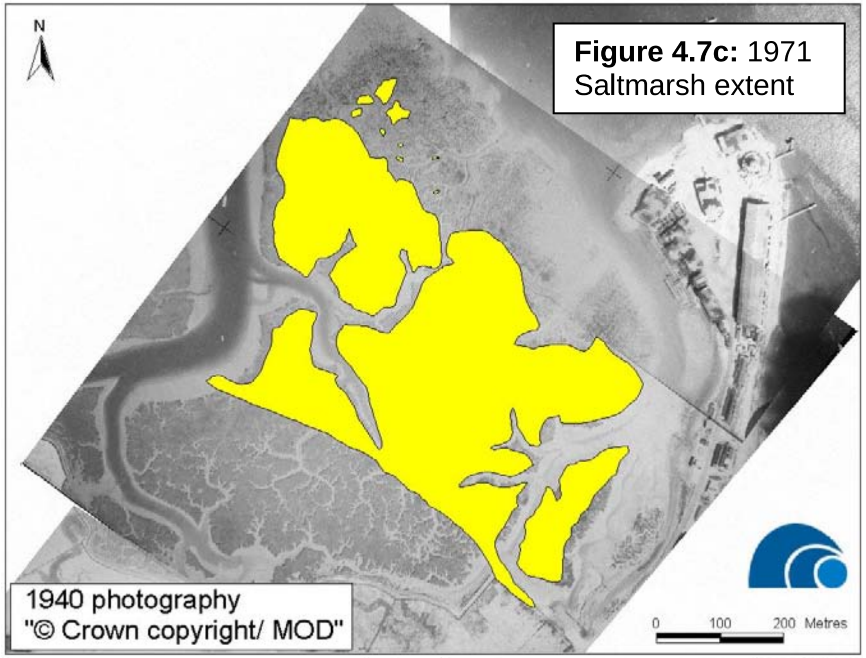


Figure 4.7c: 1971 Saltmarsh extent

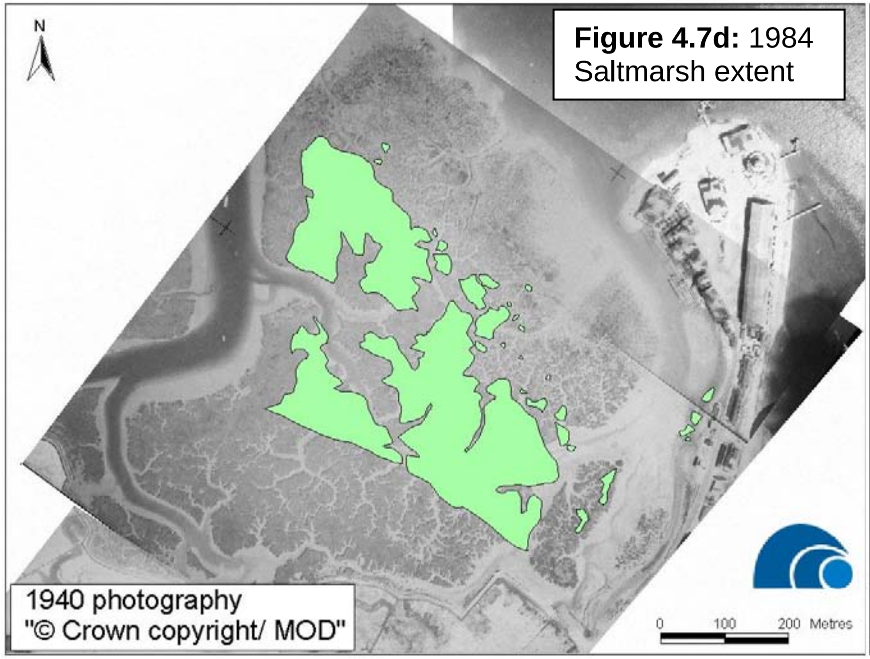


Figure 4.7d: 1984 Saltmarsh extent

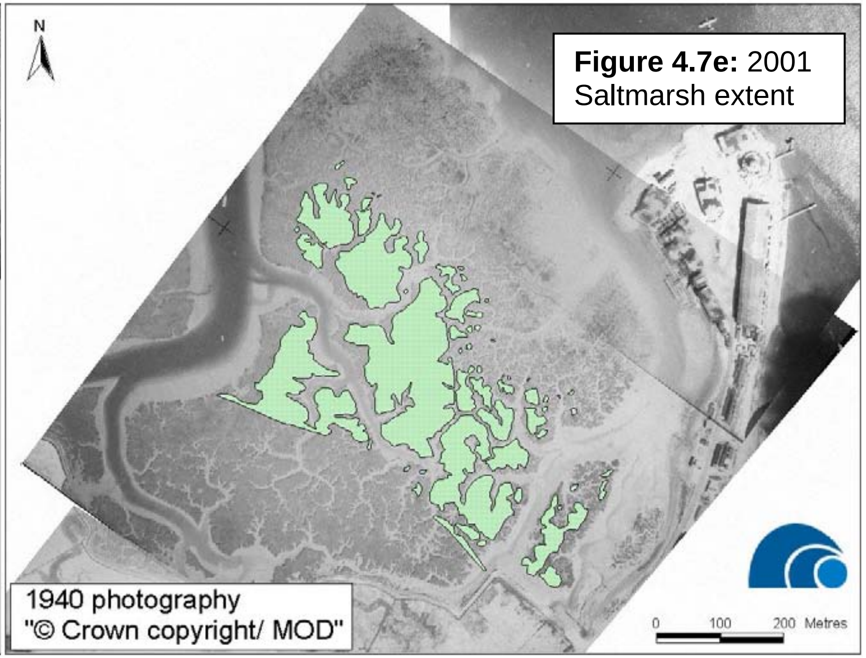


Figure 4.7e: 2001 Saltmarsh extent

1940-2001 (Figure 4.7f and Table 4.8)

Changes between 1940 and 2001, indicates losses of 73% including reclamation of Tom Tiddlers Ground and 49% excluding reclamation. This equates to 1.2% and 0.8% loss per annum, respectively (Table 4.8). Calshot underwent similar processes to the rest of the west Solent, in that edge erosion is dominant, plus small amounts of internal dissection.

1940-1971 (Figure 4.7g and Table 4.8)

This epoch underwent the lowest rate of saltmarsh loss (0.6%) at Calshot, excluding reclamation of Tom Tiddlers Ground. Edge erosion is dominant. Suggested areas of gain are actually error because the 1940 CCO dataset was digitized to a more detailed specification compared with the 1971 CHaMP dataset. If reclamation of Tom Tiddlers Ground is included then the rate of loss per annum increases to 1.4% loss per annum.

1971-1984 (Figure 4.7h and Table 4.8)

This epoch has the highest rate of saltmarsh loss at Calshot, being 3.5% per annum. This is extremely high and is the worst epoch for loss throughout the west Solent, along with Pitts Deep and Sowley which underwent 3.5% per annum loss between 1984 and 2001. Again, edge erosion is the dominant process.

1984 -2001 (Figure 4.7i and Table 4.8)

This epoch underwent a 0.8% loss per annum. Unlike the majority of other sites in the west Solent, this was not the worst epoch for saltmarsh loss. Edge erosion is the dominant process along with fragmentation.

The following Figures (4.7f – 4.7i) show the spatial change in saltmarsh extent for the various epochs at Calshot.

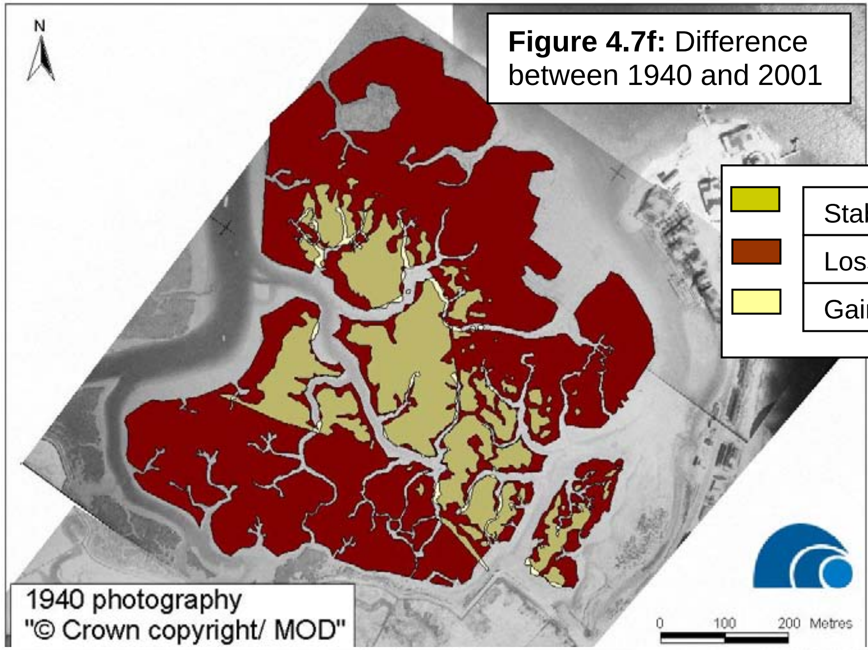


Figure 4.7f: Difference between 1940 and 2001

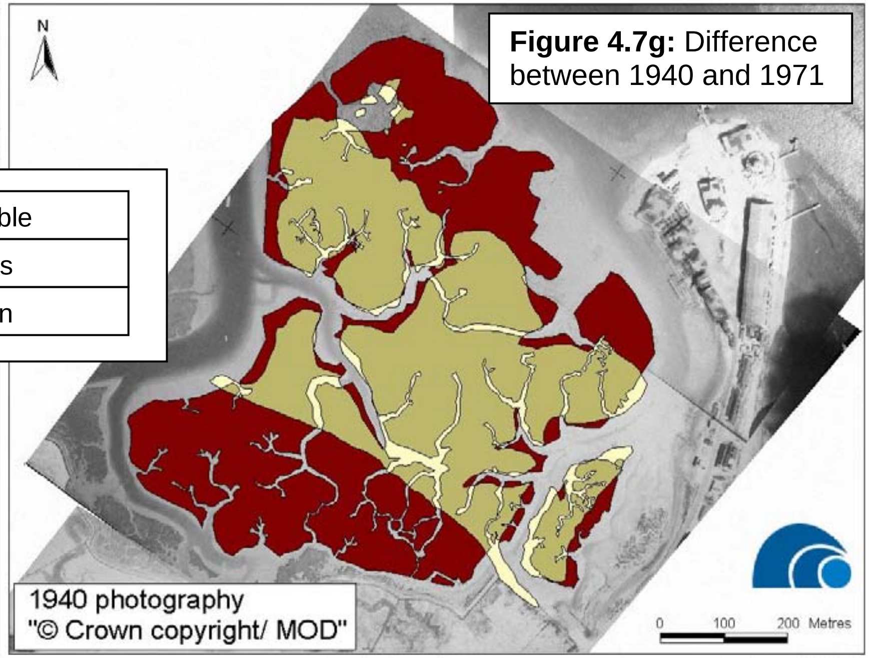


Figure 4.7g: Difference between 1940 and 1971

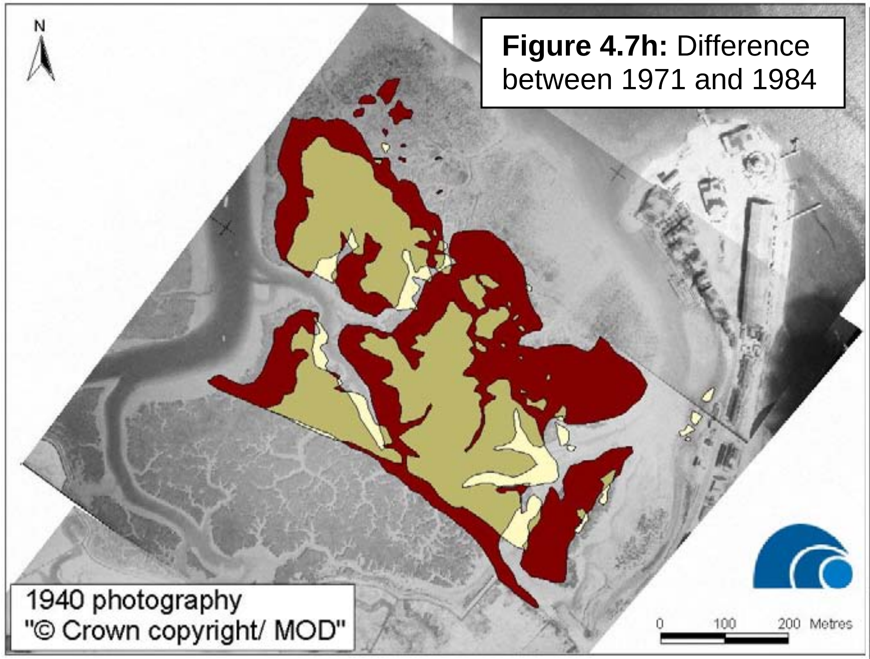


Figure 4.7h: Difference between 1971 and 1984

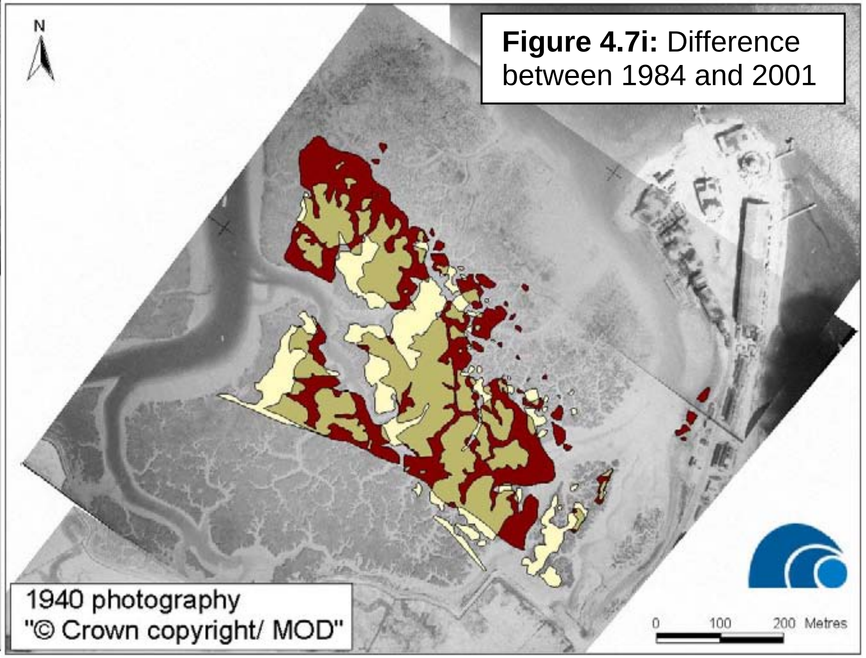


Figure 4.7i: Difference between 1984 and 2001

4.2.6.2 Predicted inter-tidal change

The area selected for LTEI calculations at Calshot, for comparison with the HPI is shown on Figure 4.7j.

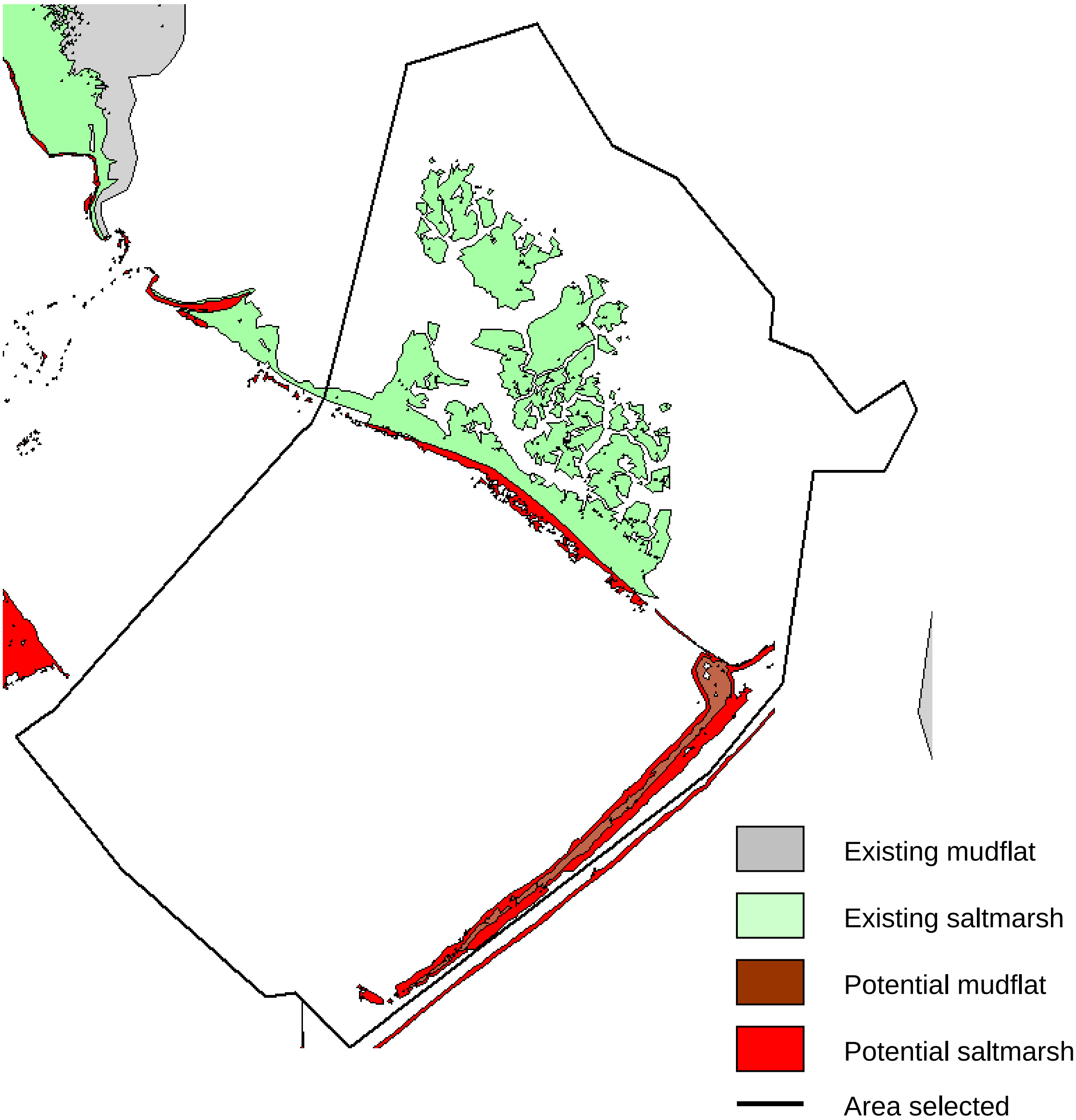
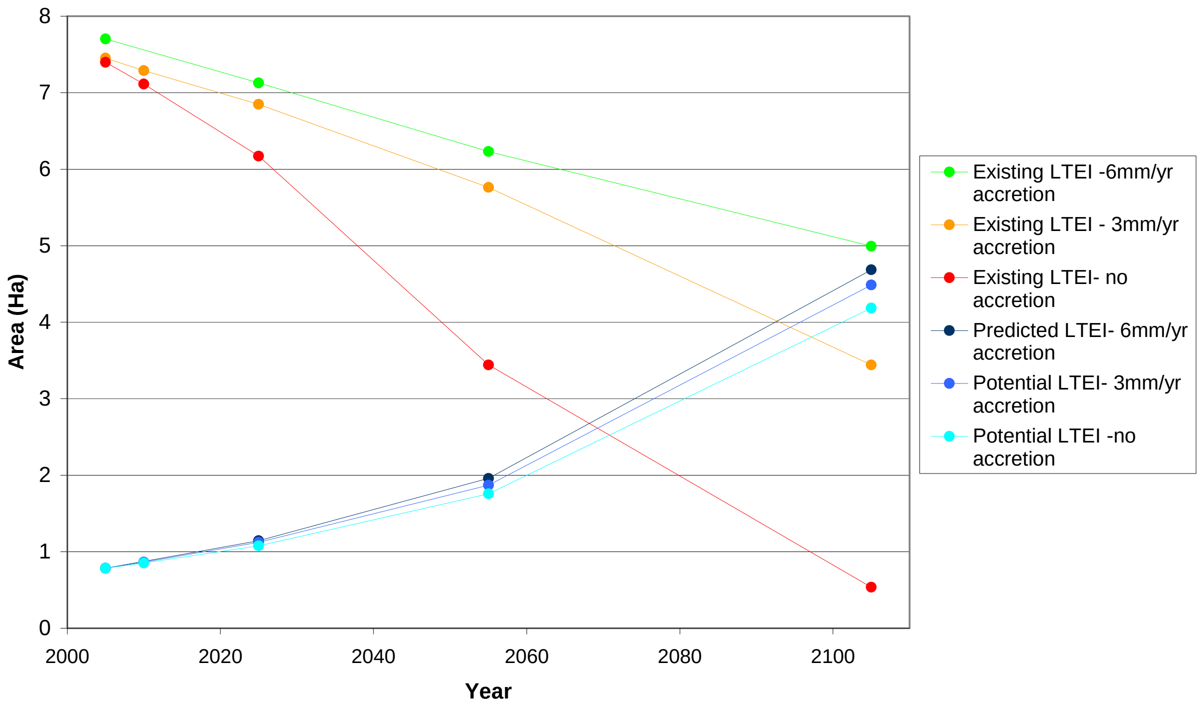


Figure 4.7j: Area selected for LTEI calculations at Calshot

Projected changes are presented for the "existing" management scenario (seawards of the seawall) and for "potential" increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for saltmarsh (Graph 4.6b), for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios. Mudflat is not presented because the topographic data did not reach MLWS for the Calshot area.



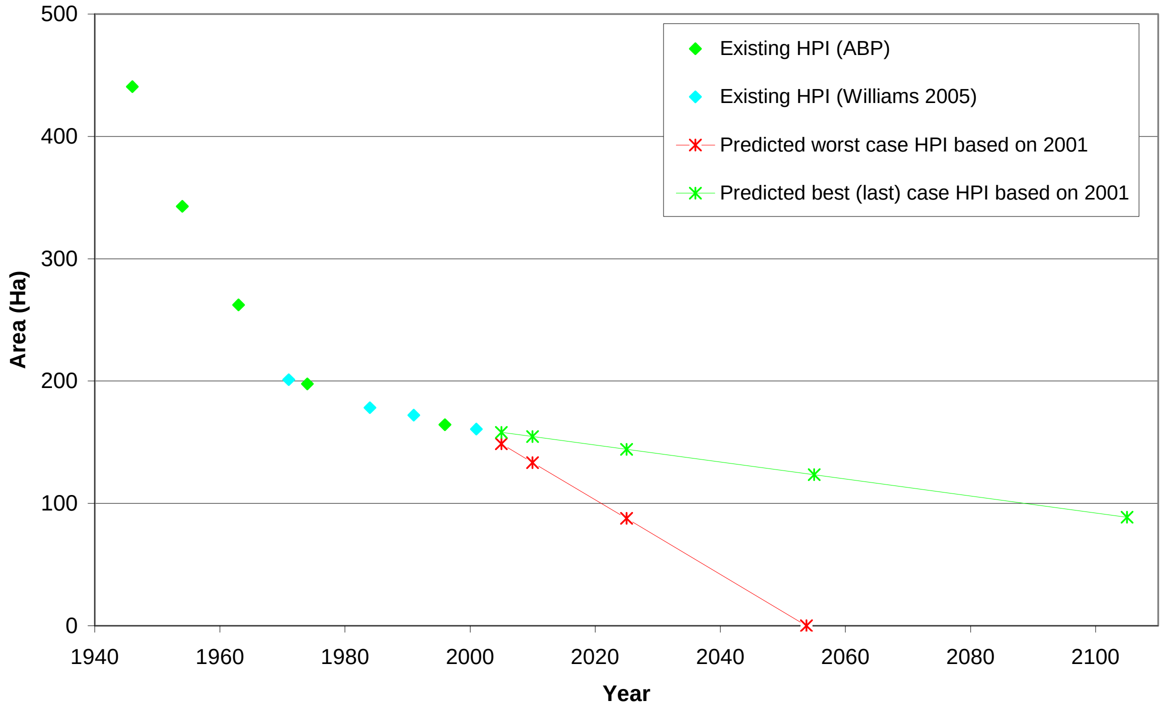
Graph 4.6b: "Existing" and "potential" predicted saltmarsh extent at Calshot (based on LTEI)

Results show saltmarsh evolution under the existing management regime slightly decrease through time (Graph 4.6b). In the event of re-alignment, potential saltmarsh increases through time as sea levels rise and the high land levels at Tom Tiddlers ground become more suitable for saltmarsh formation.

4.2.7 Southampton Water

4.2.7.1 Historical saltmarsh change

The total saltmarsh extent is shown for 1946, 1954, 1963, 1971, 1974, 1984, 1991, 1996, 2001 and 2003 in Southampton Water (Graph 4.7a, Table 4.9 and Figures 4.8). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015. Losses exclude reclamation.



Graph 4.7a: Historical and predicted saltmarsh extent in Southampton Water (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss excluding reclamation	
				% loss	% loss per year	% loss	% loss per year
1946	440.6	ABP					
1954	342.8	ABP	**1946-1954**	22.2	2.8	5.0	0.6
1963	262.3	ABP	**1954-1963**	23.5	2.6	8.0	0.9
1971	201.2	Williams 2005	**1963-1971**	23.3	2.9	2.7	0.3
1984	178.2	Williams 2005	**1971-1984**	11.4	0.9	11.4	0.9
1991	172.1	Williams 2005	**1984-1991**	3.5	0.5	3.5	0.5
2001	160.8	Williams 2005	**1991-2001**	6.5	0.7	6.5	0.7
			1946-2001	63.5	1.2	22.0	0.4

Table 4.9: Saltmarsh extent in Southampton (based on HPI)

The areas of reclamation in Southampton Water, from 1963, are shown in Figure 4.8a.

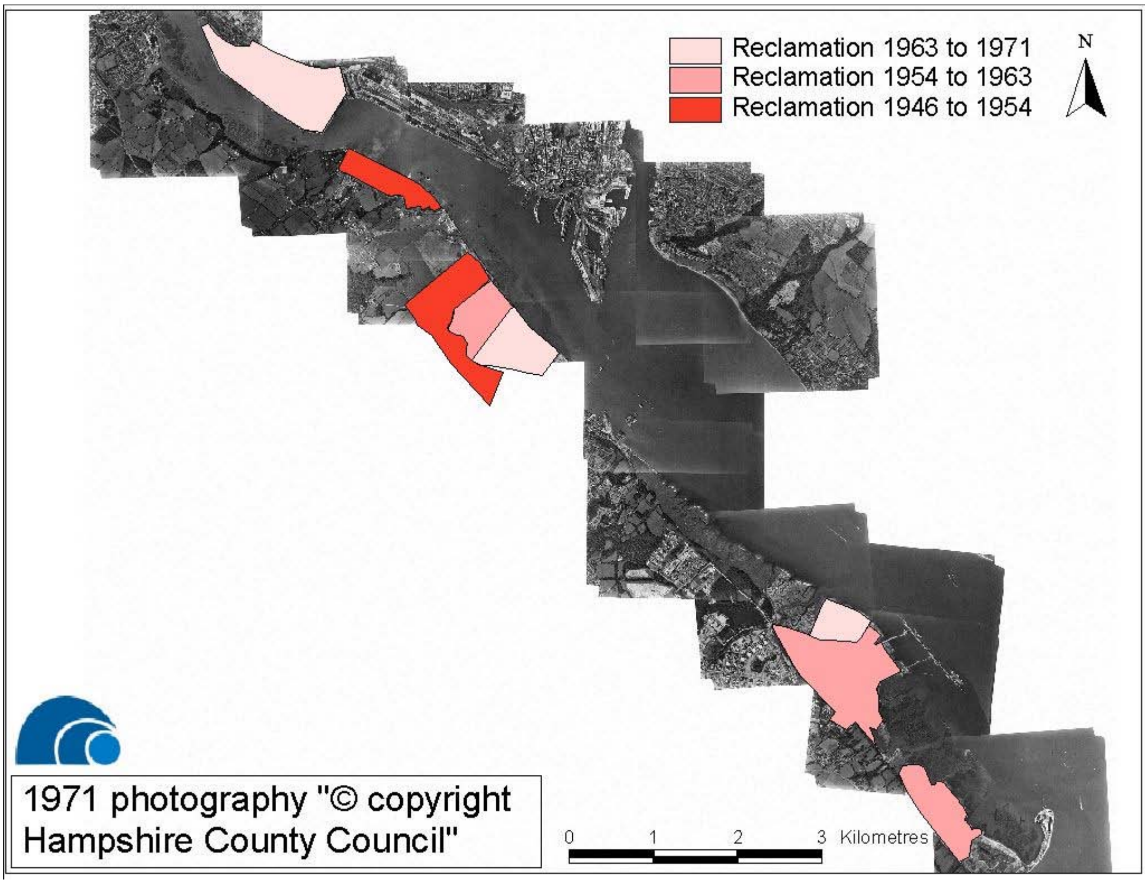


Figure 4.8a: Reclamation within Southampton Water (based on ABP and Williams, 2005 digitizing)

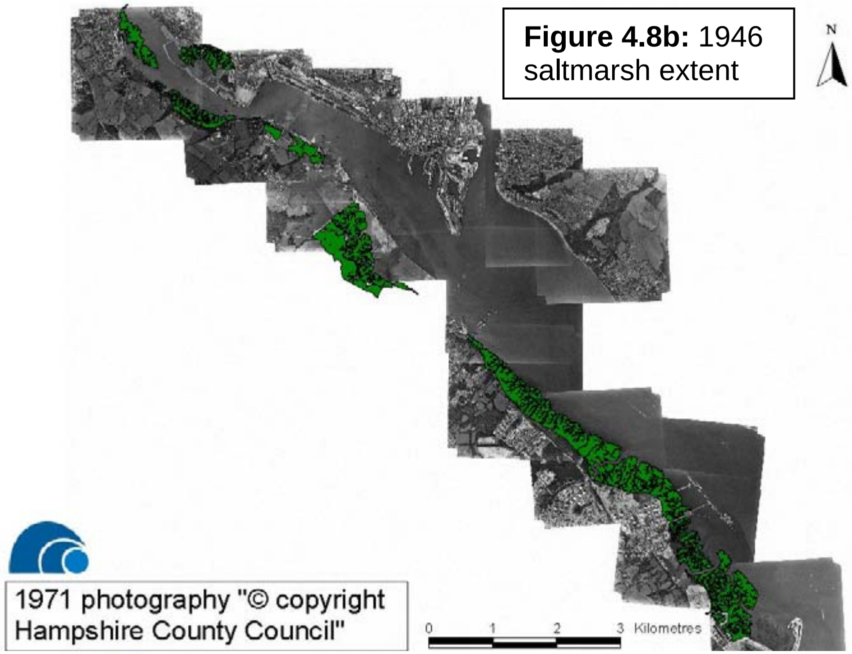


Figure 4.8b: 1946 saltmarsh extent

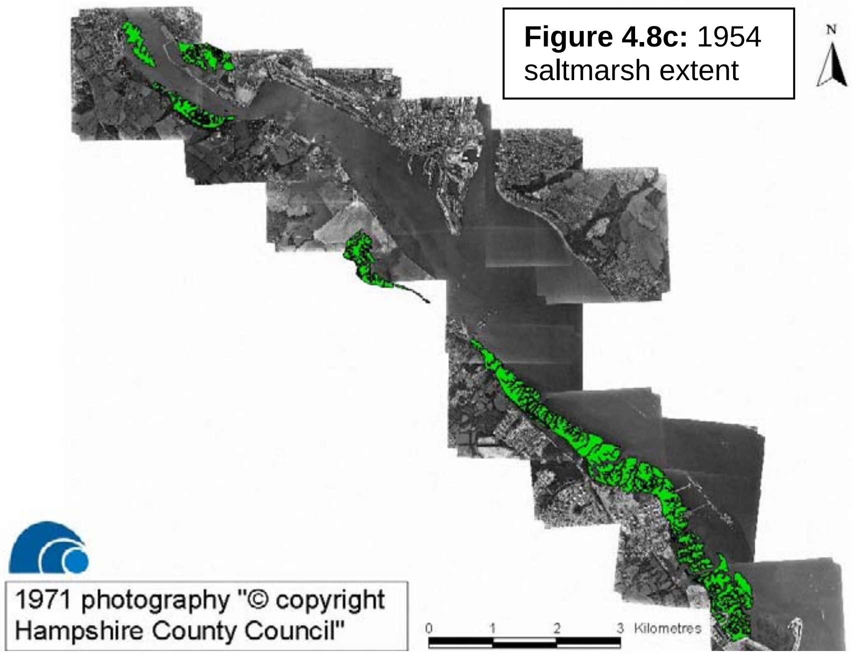


Figure 4.8c: 1954 saltmarsh extent

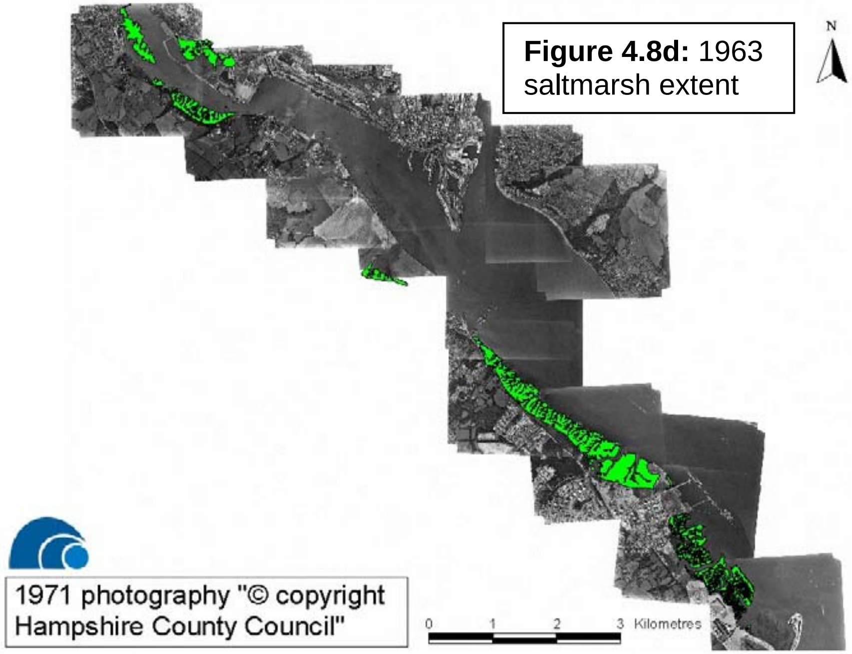


Figure 4.8d: 1963 saltmarsh extent

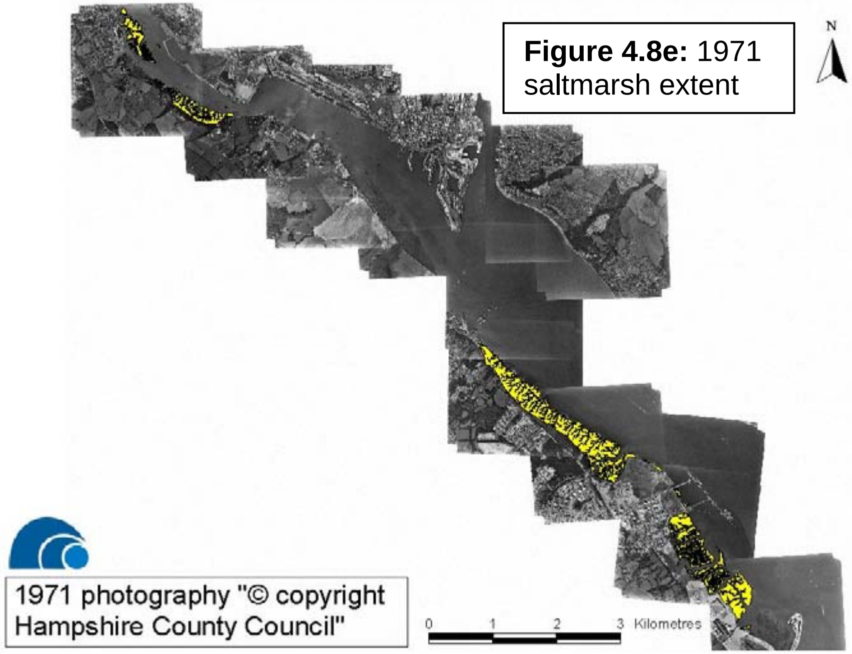


Figure 4.8e: 1971 saltmarsh extent

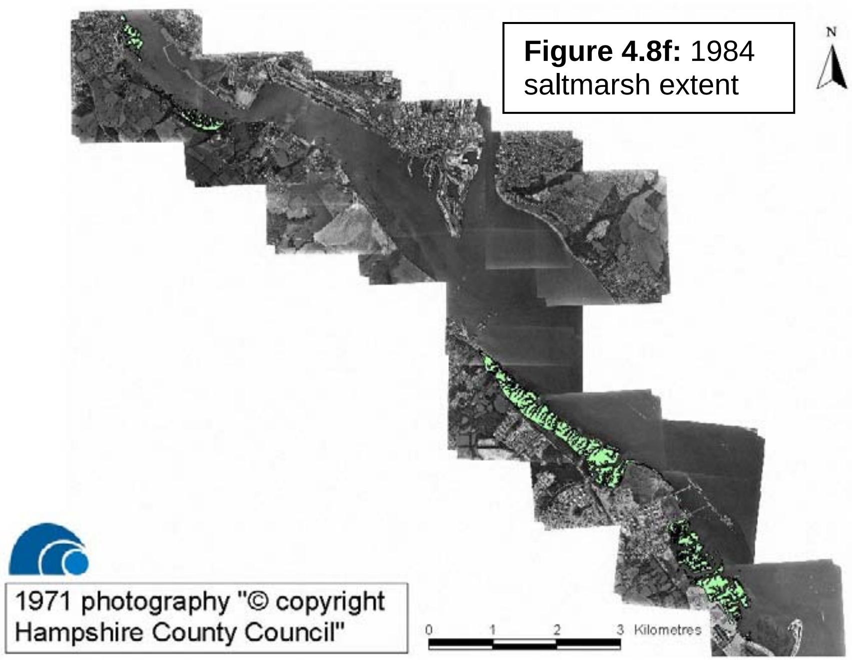


Figure 4.8f: 1984 saltmarsh extent

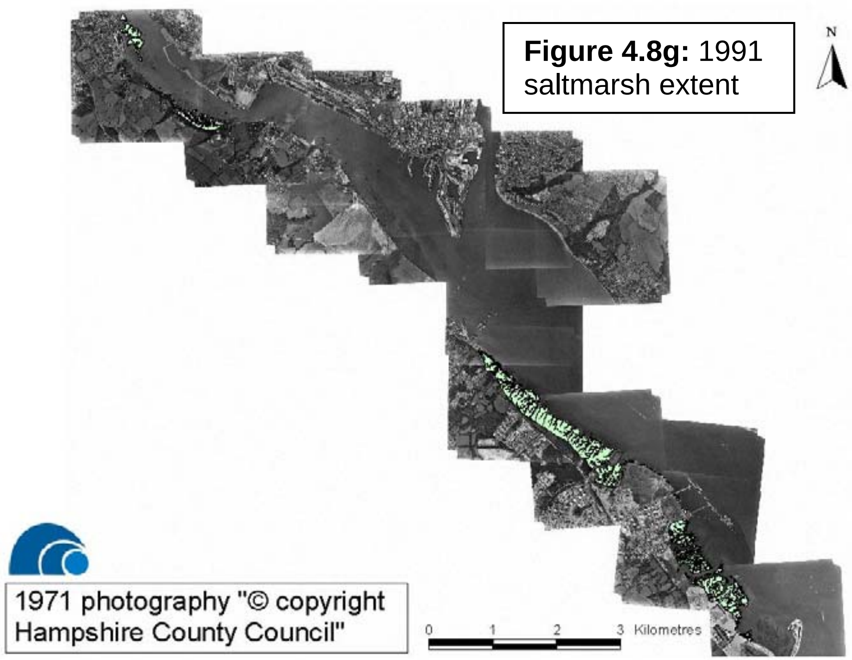


Figure 4.8g: 1991 saltmarsh extent

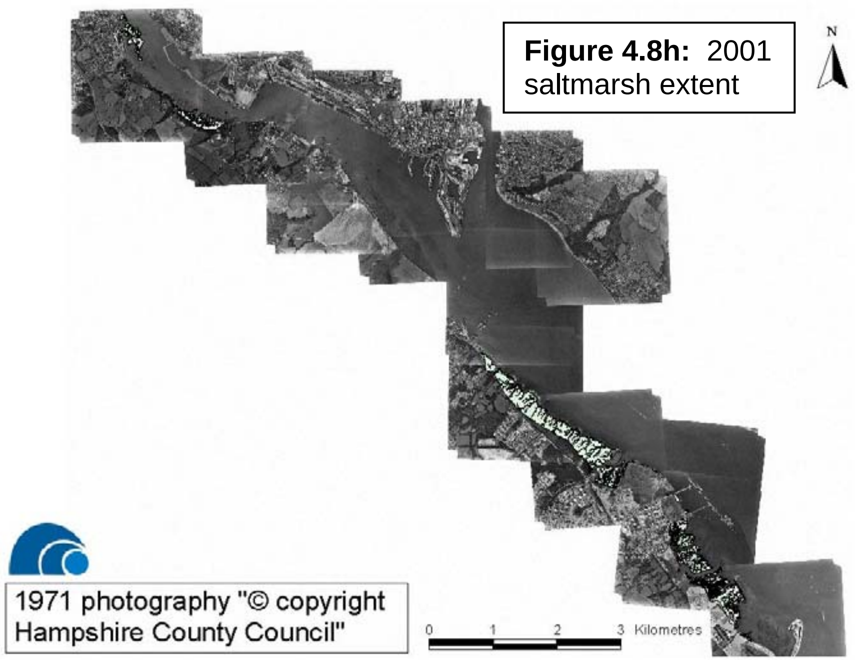


Figure 4.8h: 2001 saltmarsh extent

The Channel Coastal Observatory did not undertake the HPI for Southampton Water. Data were kindly supplied by ABP and Elizabeth Williams. Therefore, areas of reclamation were deduced from the saltmarsh digitizing supplied by ABP and Elizabeth Williams, not from the original aerial photography.

1946-2001 (Figure 4.8i and Table 4.9)

Changes between 1946 and 2001, indicates losses of 64% including reclamation and 22% excluding reclamation. This equates to 1.2% and 0.4% loss per annum, respectively (Table 4.9). Loss, excluding reclamation is remarkably low (0.4% per annum) compared to the rest of the north Solent where the range is 0.2% (Pagham Harbour) to 1.5% (Pitts Deep and Sowley and Langstone Harbour) per annum for the epoch 1946 to 2001.

1946-1954 (Figure 4.8j and Table 4.9)

A relatively high amount of saltmarsh loss (0.6% per annum) occurred during this epoch which was exacerbated by reclamation (2.8% per annum). Edge erosion is the dominant natural process.

1954-1963 (Figure 4.8k and Table 4.9)

One of the highest rates of saltmarsh loss, excluding reclamation (0.9% per annum), occurred during this epoch. Substantial reclamation took place, increasing the loss to 2.6% per annum. Edge erosion is the dominant natural process.

1963-1971 (Figure 4.8l and Table 4.9)

Changes between 1963 and 1971, indicates the highest total loss for any epoch in Southampton Water (2.9% per annum). The majority is attributed to reclamation (2.6%) as the rate of loss per annum excluding reclamation is 0.3% per annum. This is the lowest rate of loss for Southampton Water and the north Solent. Edge erosion is the dominant natural process.

1971-1984 (Figure 4.8m and Table 4.9)

A lower total loss per annum occurred during this decade compared with the previous decade (0.9%). However, no reclamation took place, which means this epoch underwent one of the highest rates of loss in Southampton Water, excluding reclamation (0.9%). Again, edge erosion is the dominant process.

1984-1991 (Figure 4.8n and Table 4.9)

The loss between 1984 and 1991 is 3.5%, which equates to 0.5% per annum. Again there is no visible reclamation during this time and edge erosion is the dominant process.

1991-2001 (Figure 4.8o and Table 4.9)

The rate of loss between 1991 and 2001 increases to 0.7% per annum. Again there is no visible reclamation during this time and edge erosion is the dominant process.
The following Figures (4.8i - 4.8o) show the spatial change in saltmarsh extent for the various epochs in Southampton Water.

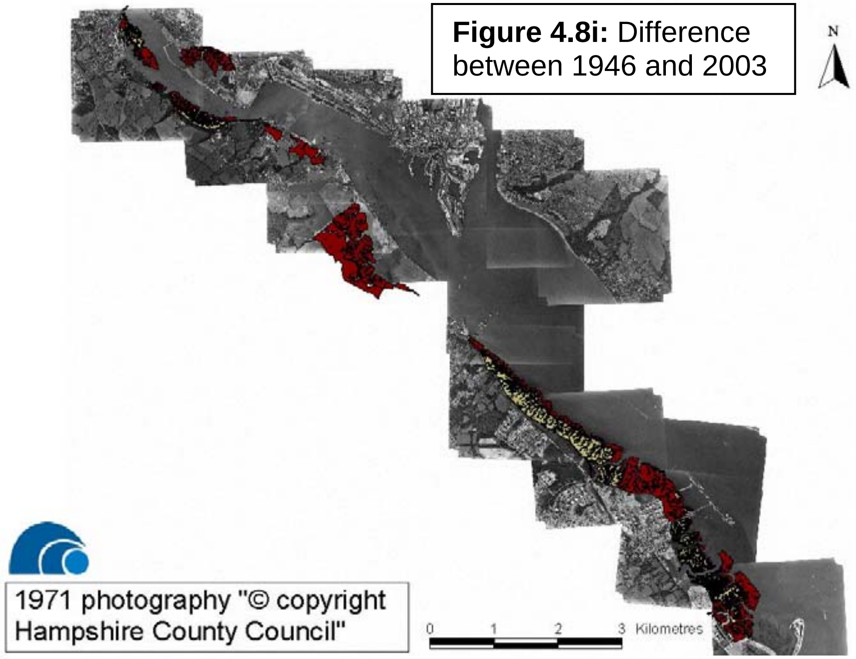


Figure 4.8i: Difference between 1946 and 2003

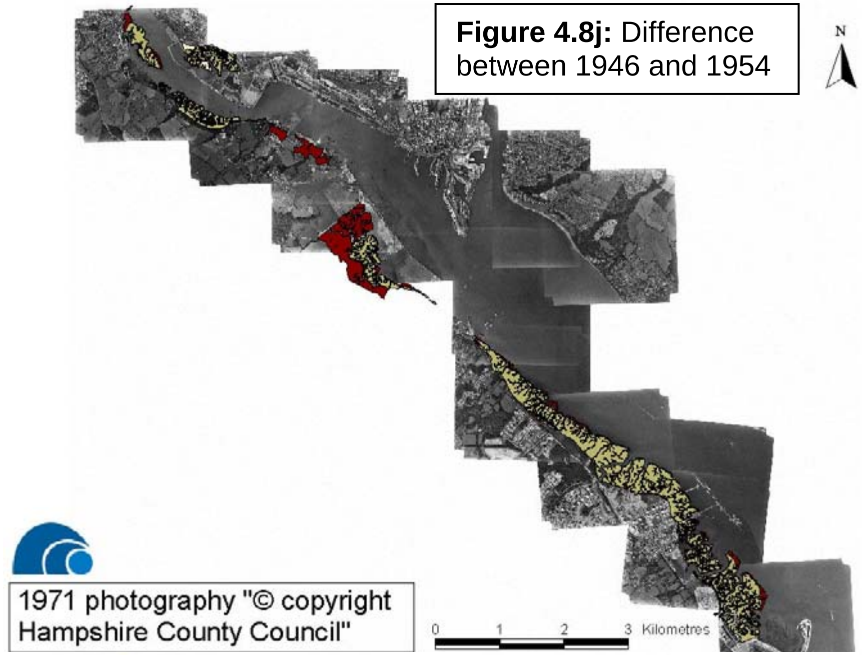


Figure 4.8j: Difference between 1946 and 1954

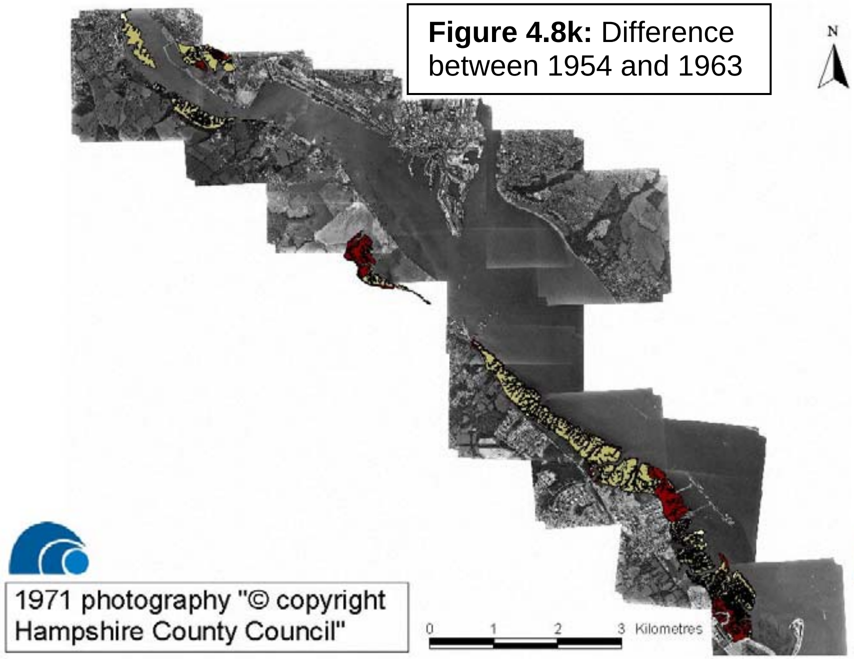


Figure 4.8k: Difference between 1954 and 1963

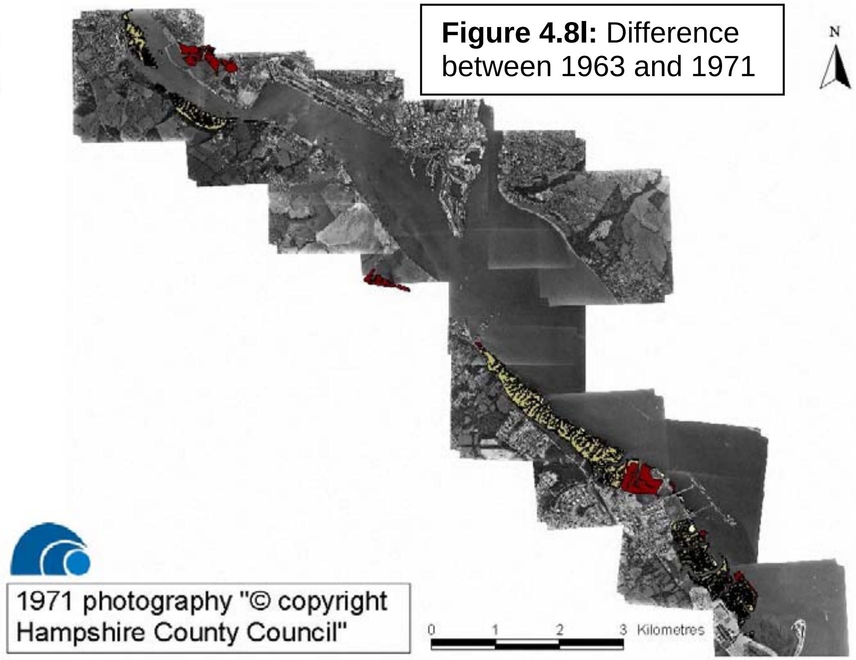


Figure 4.8l: Difference between 1963 and 1971

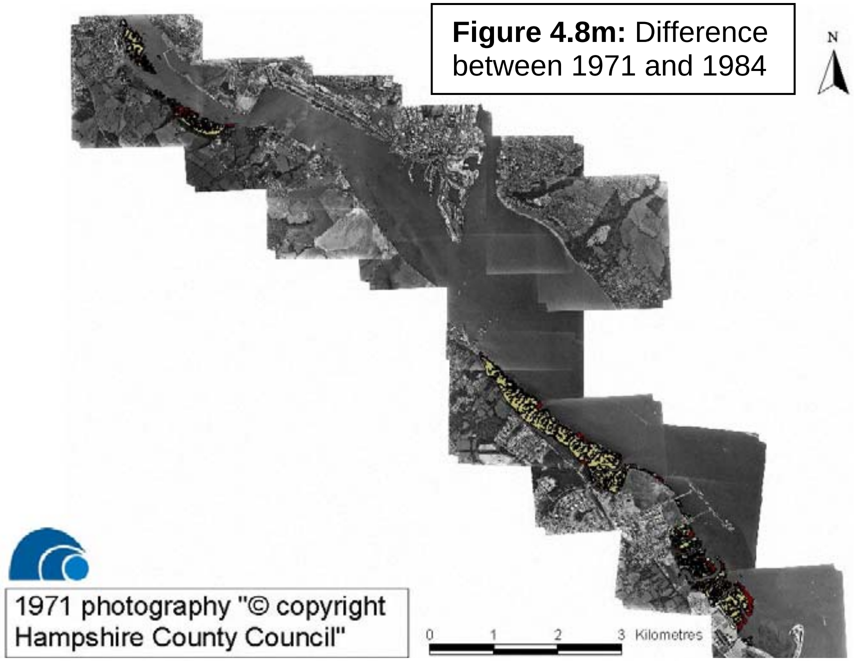


Figure 4.8m: Difference between 1971 and 1984

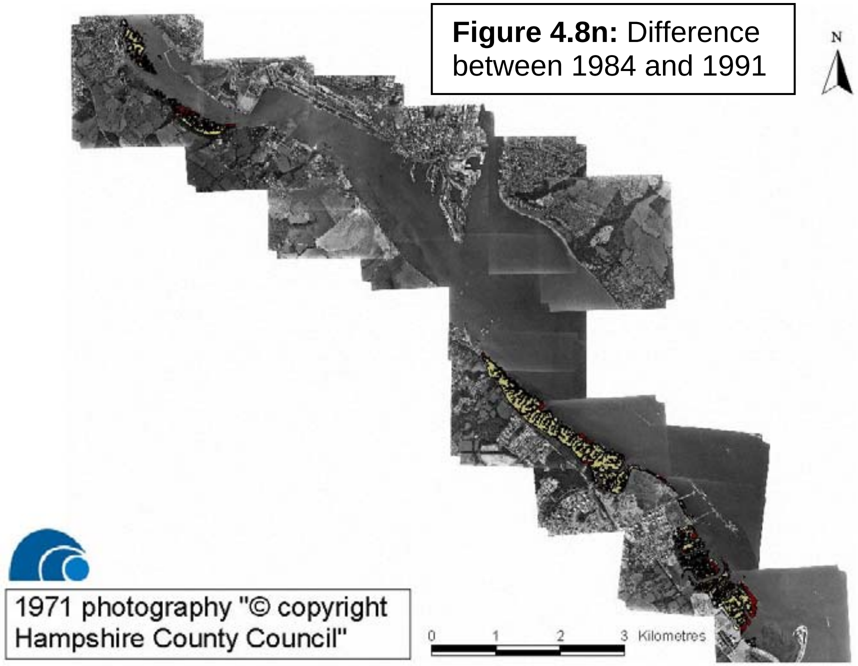


Figure 4.8n: Difference between 1984 and 1991

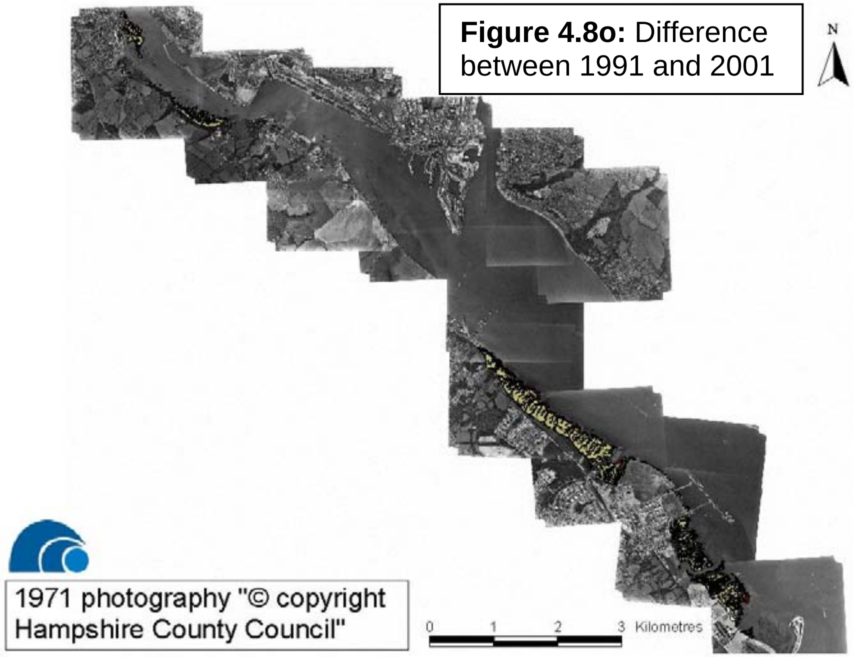


Figure 4.8o: Difference between 1991 and 2001

4.2.7.2 Predicted inter-tidal change

The area selected for LTEI calculations at Southampton Water, for comparison with the HPI is shown on Figure 4.8p.

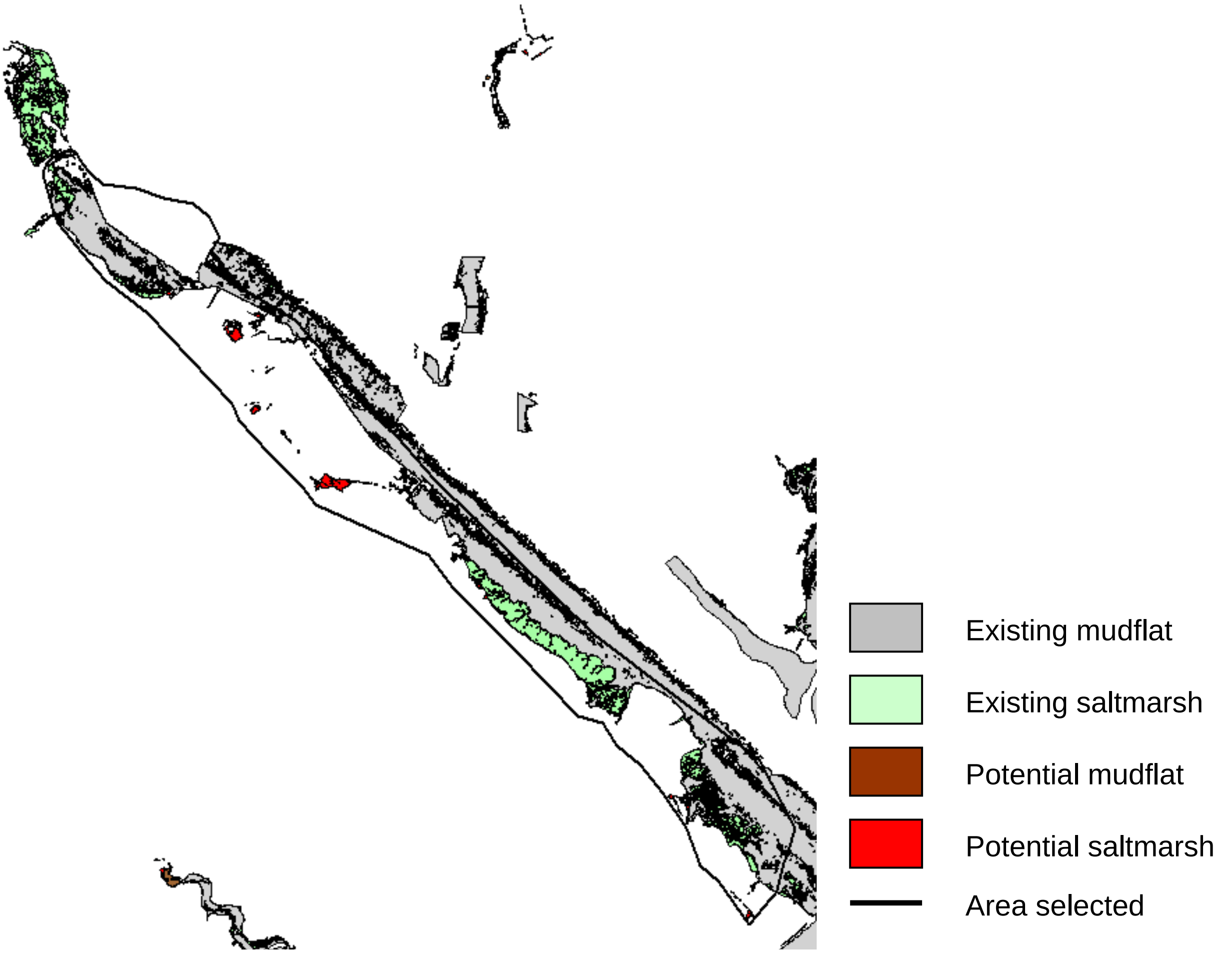
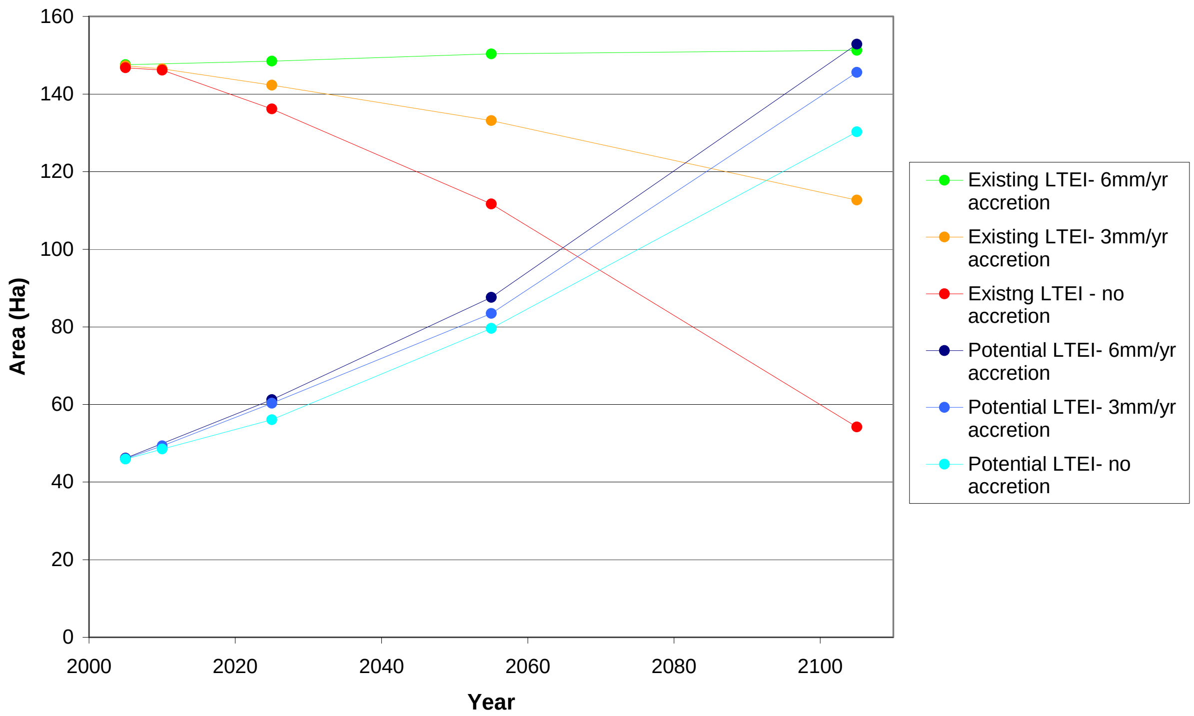


Figure 4.8p: Area selected for LTEI calculations at Southampton Water

Projected changes are presented for the “existing” management scenario (seawards of the seawall) and for “potential” increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for saltmarsh (Graph 4.7b), for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios. Mudflat is not presented because the topographic data did not reach MLWS for Southampton Water.



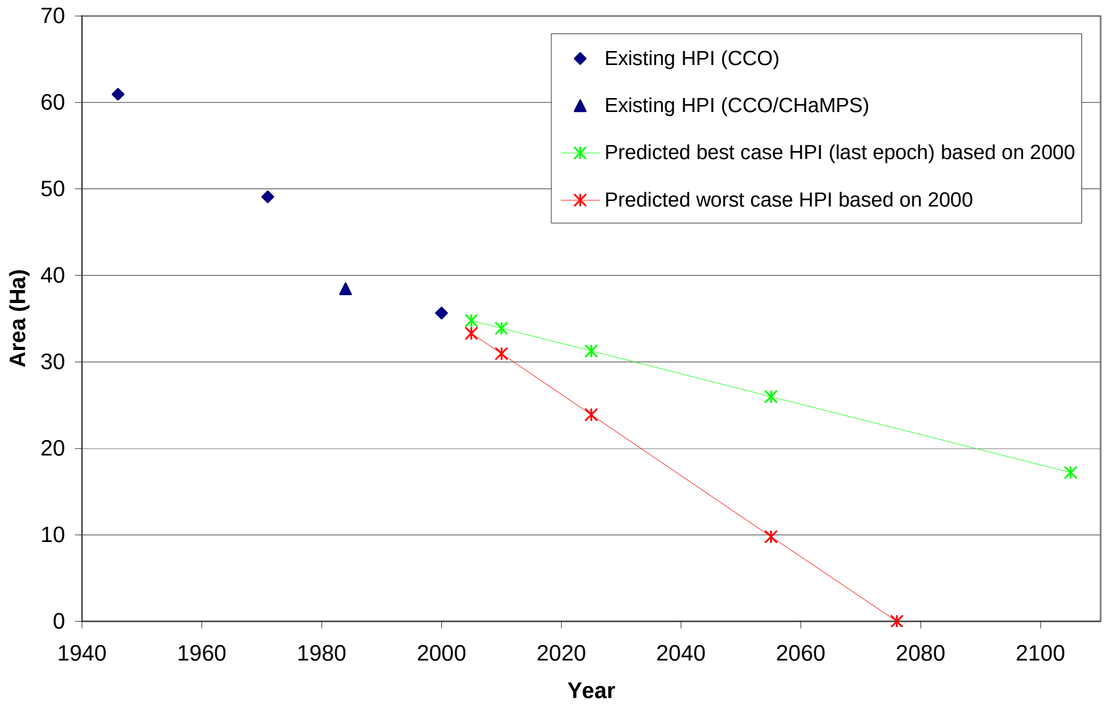
Graph 4.7b: "Existing" and "potential" predicted saltmarsh extent at Southampton Water (based on LTEI)

Results show saltmarsh evolution under the existing management regime slightly decrease through time for scenarios with no sediment accretion and 3mm sediment accretion per annum (Graph 4.7b). In the event of re-alignment, saltmarsh has the potential to almost replace the same amount lost (Graph 4.7b).

4.2.8 Hamble

4.2.8.1 Historical saltmarsh change

The total saltmarsh extent is shown for 1946, 1971, 1984 and 2000 for the Hamble (Graph 4.8a, Table 4.10 and Figures 4.9). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015. Losses exclude reclamation.



Graph 4.8a: Historical and predicted saltmarsh extent in the Hamble (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss (excluding reclamation)	
				% loss	% loss per year	% loss	% loss per year
1946	61.0	CCO					
1971	49.1	CCO	**1946-1971**	19.5	0.8	8.5	0.3
1984	38.5	CCO/CHaMP	**1971-1984**	21.6	1.7	12.5	1.0
2000	35.7	CCO	**1984-2000**	7.3	0.5	7.3	0.5
			1946-2000	41.5	0.8	23.0	0.4

Table 4.10: Saltmarsh extent in Hamble (based on HPI)

The areas of reclamation in the Hamble, from 1946, are shown in Figure 4.9a.

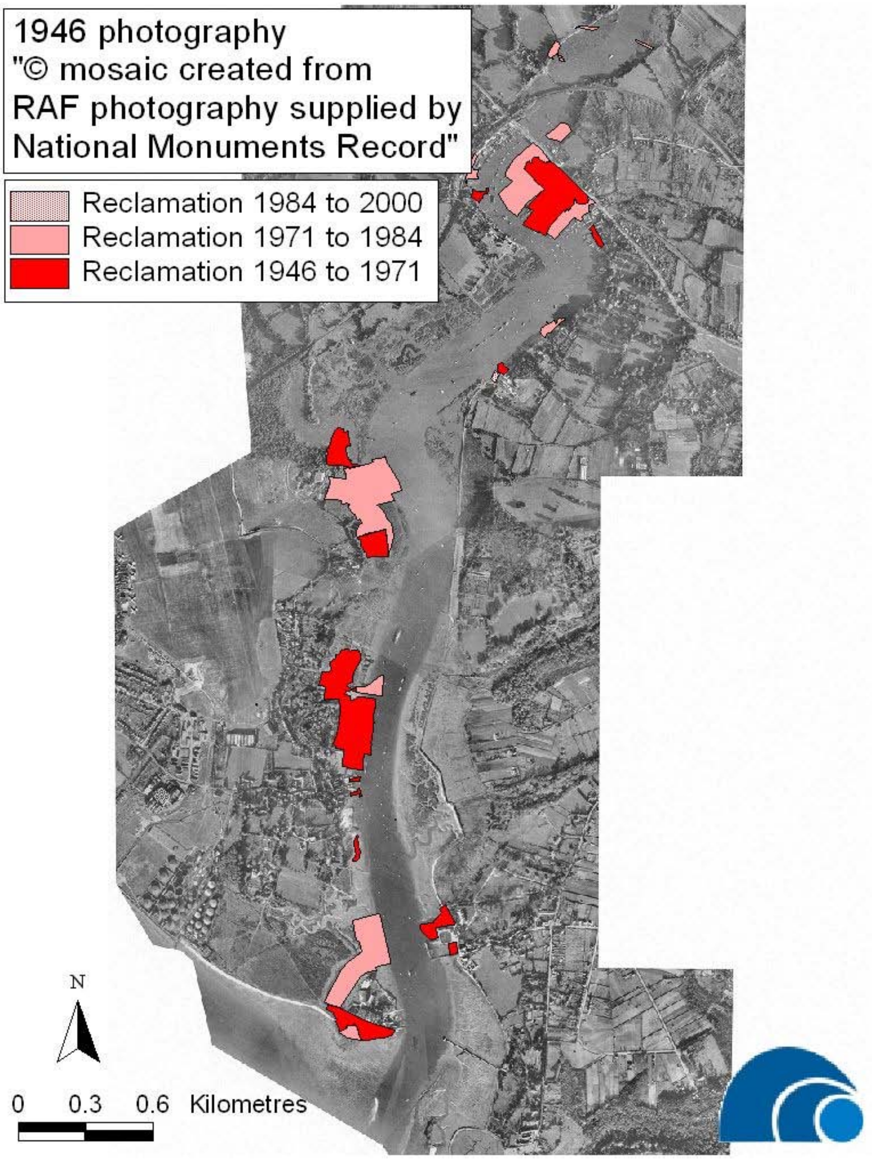


Figure 4.9a: Reclamation in the Hamble since 1946 (based on HPI)

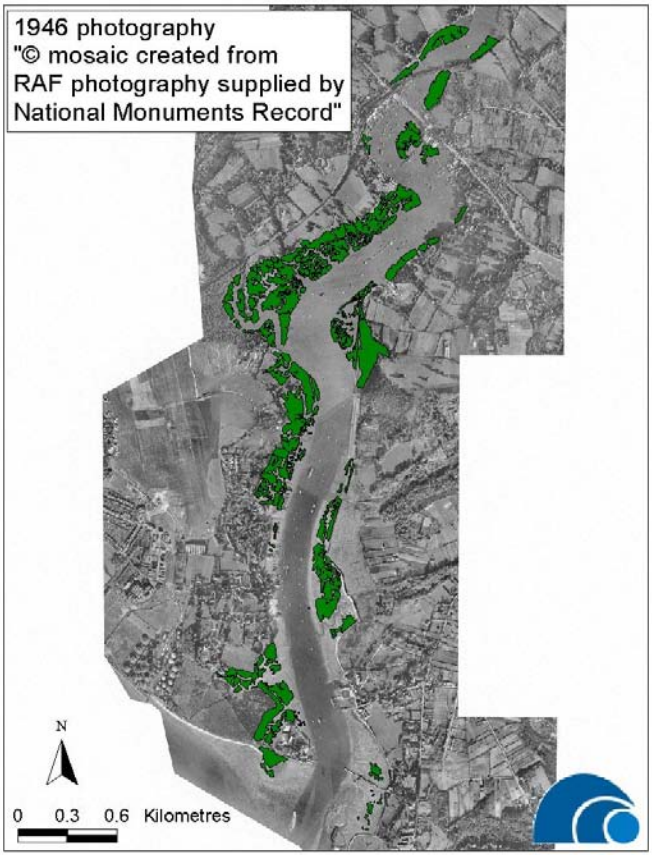


Figure 4.9b: 1946 Saltmarsh extent

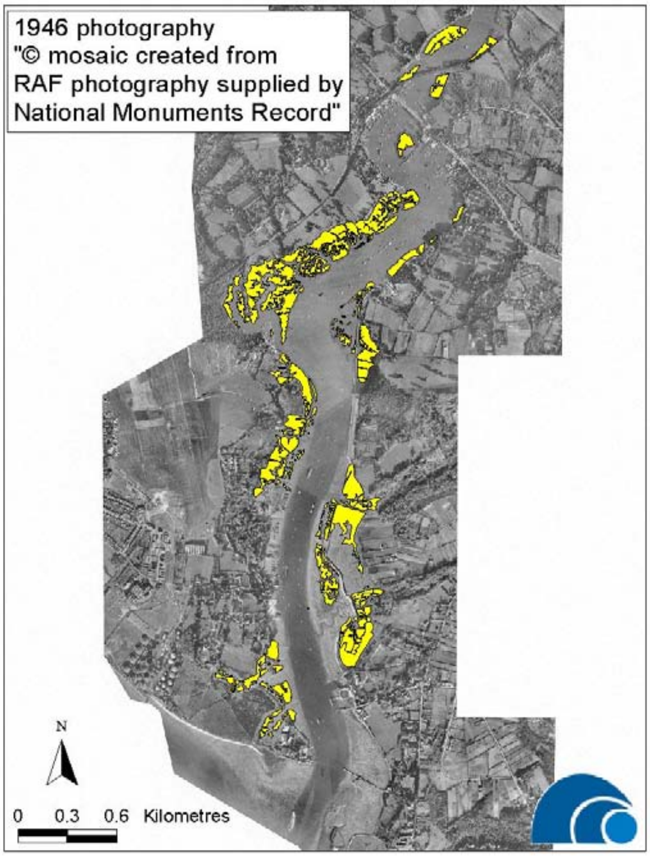


Figure 4.9c: 1971 Saltmarsh extent

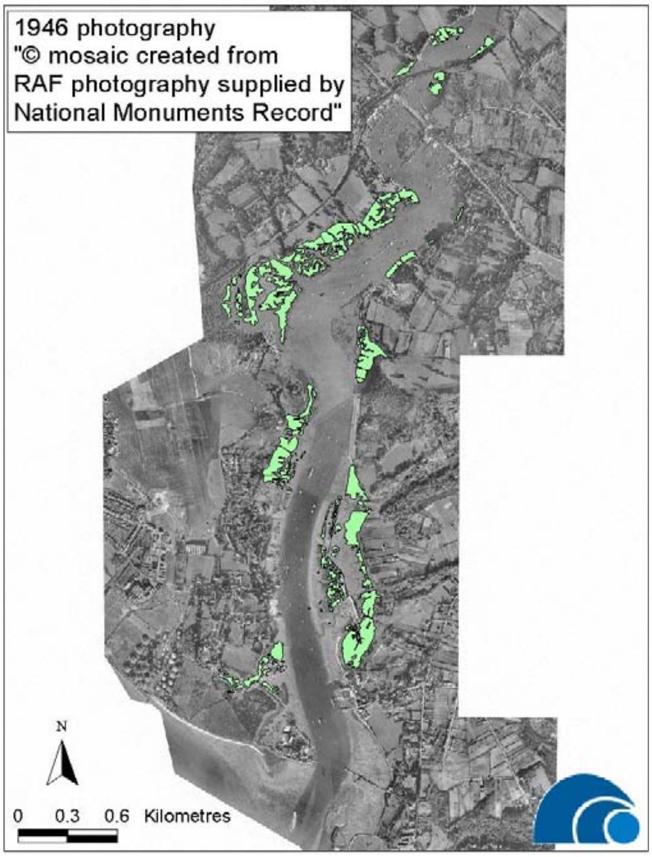


Figure 4.9d: 1984 Saltmarsh extent

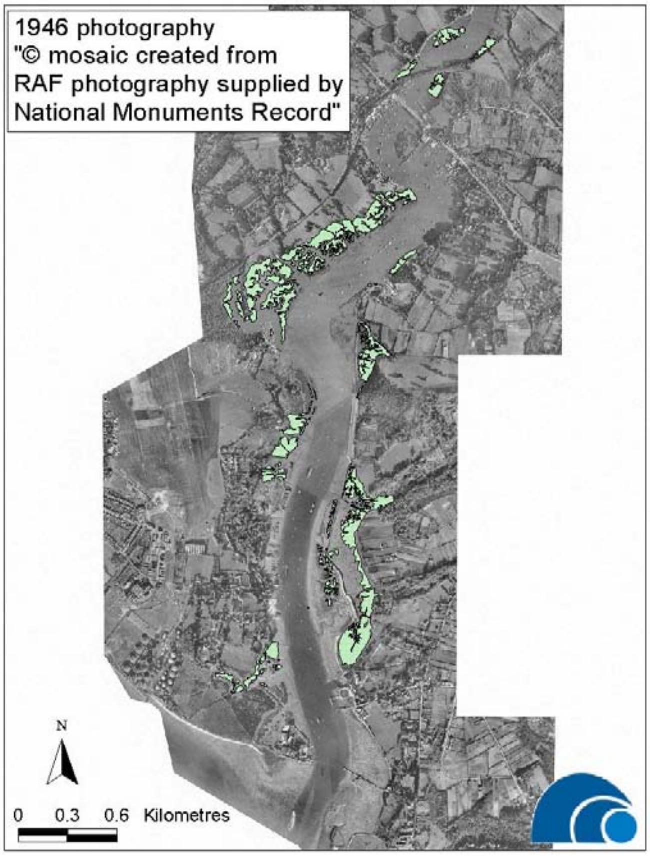


Figure 4.9e: 2000 Saltmarsh extent

1946-2000 (Figure 4.9f and Table 4.10)

Changes between 1946 and 2000, indicates losses of 41.5% including reclamation and 23% excluding reclamation. This equates to 0.8% and 0.4% loss per annum, respectively (Table 4.2). Like Southampton Water, the loss, excluding reclamation is remarkably low (0.4% per annum) compared to the rest of the north Solent where the range is 0.2% (Pagham Harbour) to 1.5% (Pitts Deep and Sowley and Langstone Harbour) per annum for the epoch 1946 to 2001.

1946-1971 (Figure 4.9g and Table 4.10)

The lowest rate of saltmarsh loss, excluding reclamation, occurred during this epoch (0.3% per annum). Reclamation increases the total loss to 0.8% per annum. The relatively low loss is attributed to the area of gain at Bunny Meadows (see Figure 4.9c). Edge erosion is the dominant natural process.

1971-1984 (Figure 4.9h and Table 4.10)

This decade saw the greatest amount of loss excluding reclamation (1% per annum) and the greatest total loss (1.7% per annum) in the Hamble. Edge erosion is the dominant natural process.

1984-2000 (Figure 4.9i and Table 4.10)

Between 1984 and 2000, the River Hamble had the lowest total saltmarsh loss (0.5% per annum) as reclamation was minimal. Again, edge erosion is the dominant natural process.

The following Figures (4.9f – 4.9i) show the spatial change in saltmarsh extent for the various epochs in the Hamble.

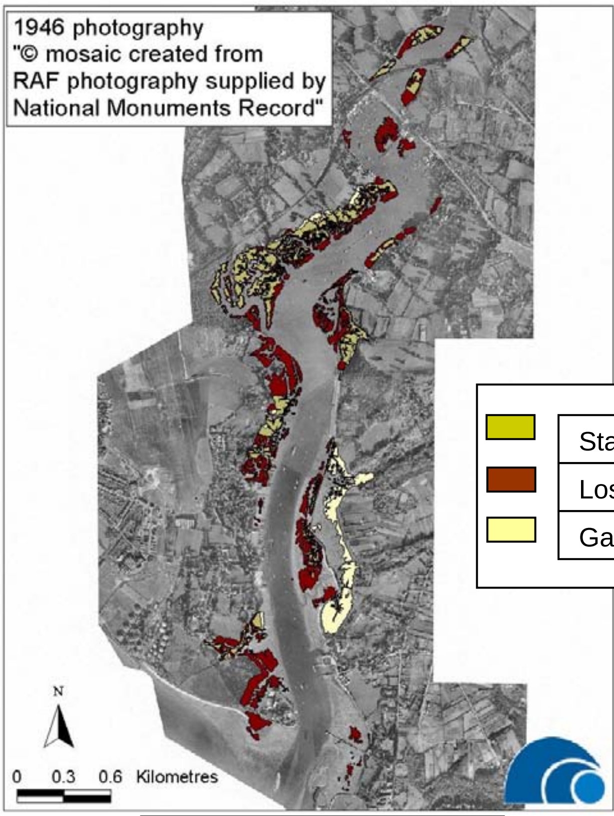


Figure 4.9f: Difference between 1946 and 2000

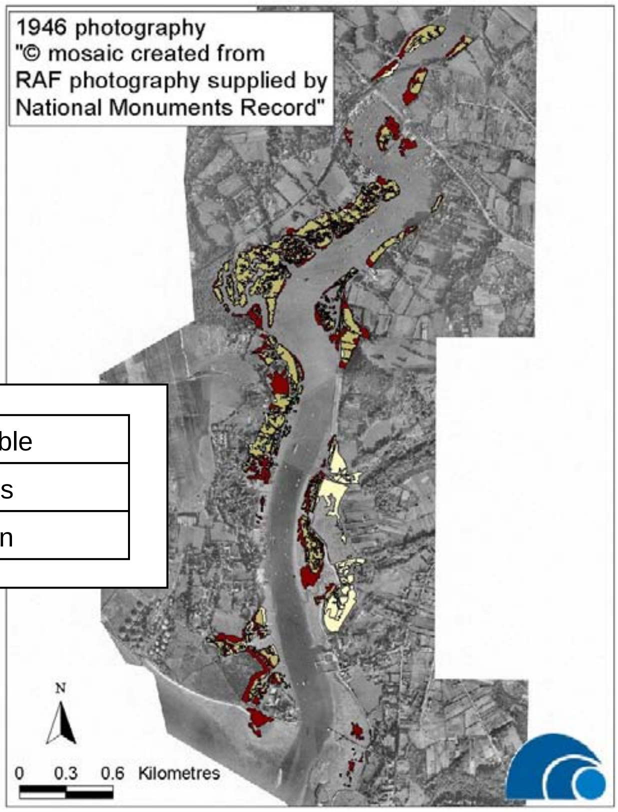


Figure 4.9g: Difference between 1946 and 1971

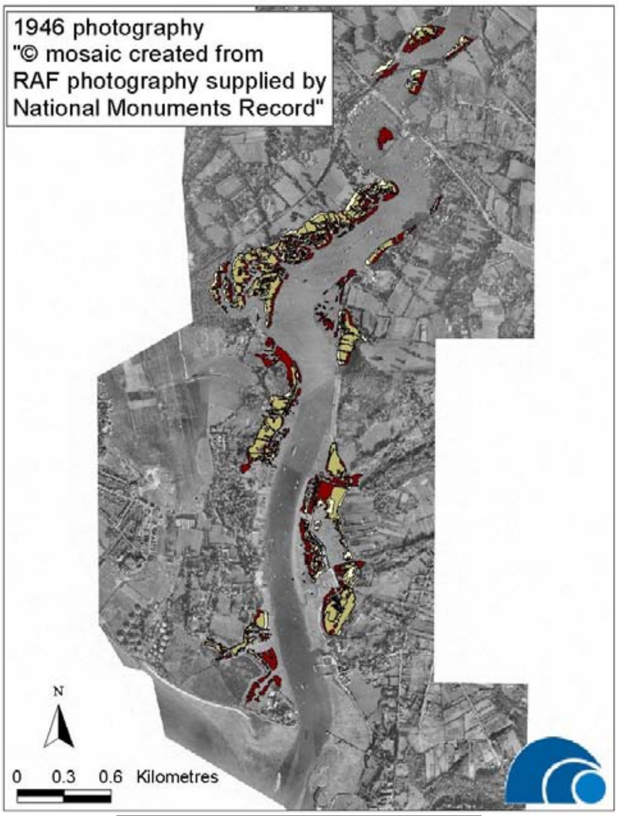


Figure 4.9h: Difference between 1971 and 1984

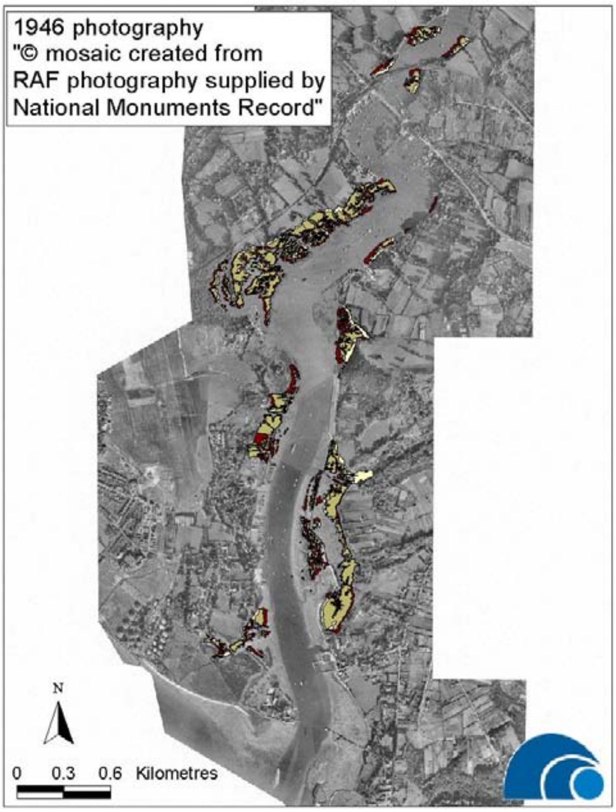


Figure 4.9i: Difference between 1984 and 2000

4.2.8.2 Predicted inter-tidal change

The area selected for LTEI calculations at the Hamble, for comparison with the HPI is shown in Figure 4.9j.

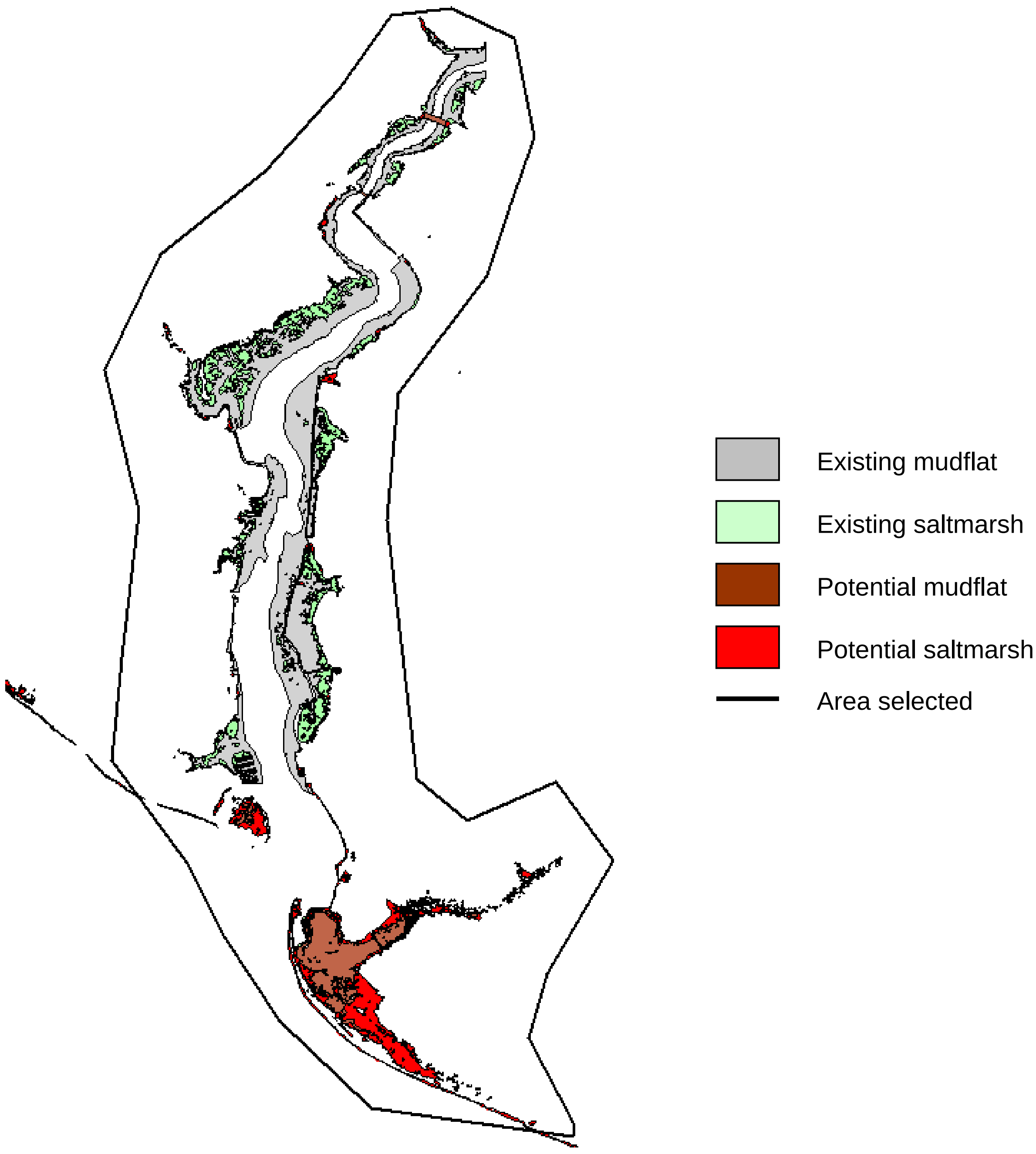
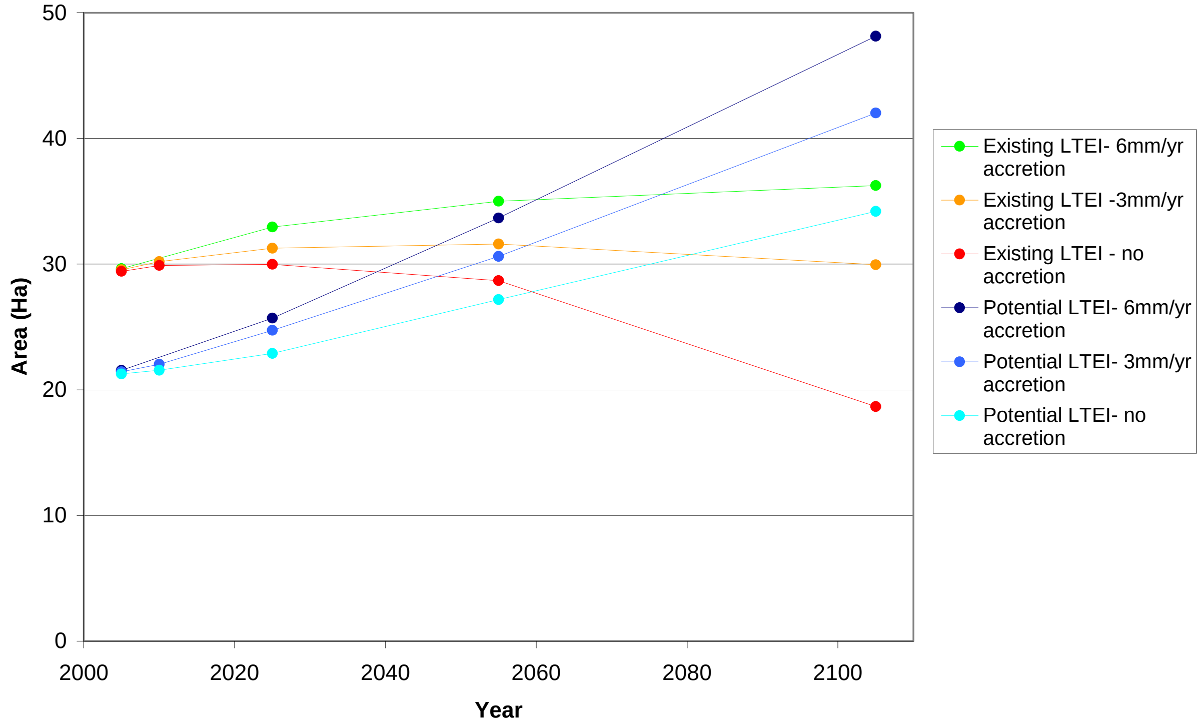


Figure 4.9j: Area selected for LTEI calculations within Hamble

Projected changes are presented for the "existing" management scenario (seawards of the seawall) and for "potential" increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for saltmarsh (Graph 4.8b) for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios.



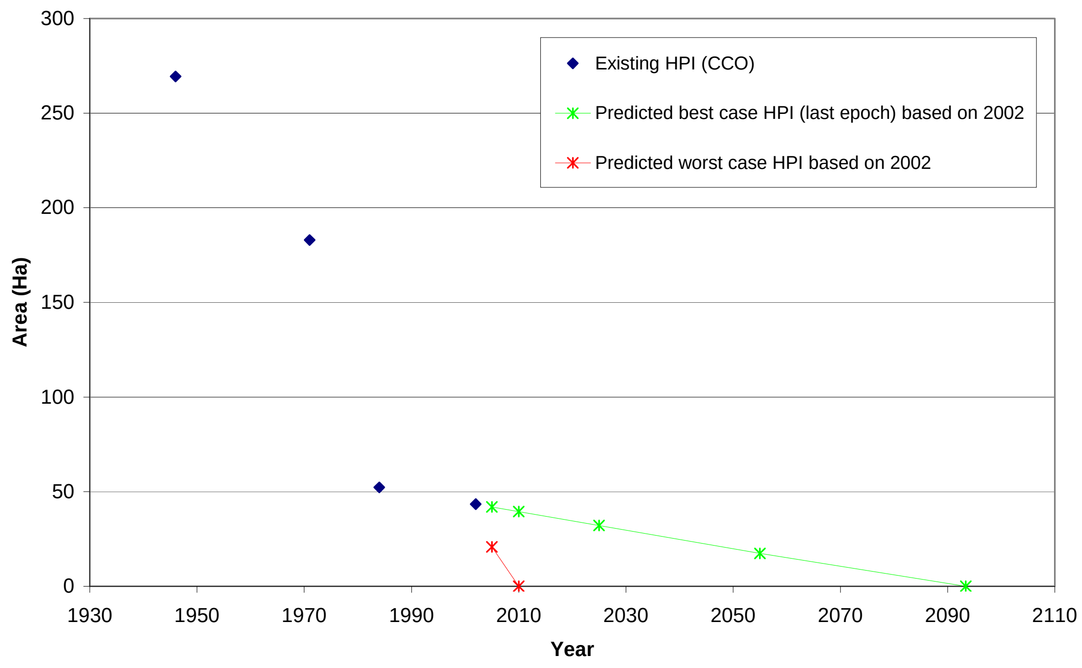
Graph 4.8b: "Existing" and "potential" predicted saltmarsh extent within Hamble (based on LTEI)

Results show saltmarsh evolution under the existing management regime slightly decrease through time for scenarios with no sediment accretion and 3mm sediment accretion per annum (Graph 4.8b). In the event of re-alignment, saltmarsh has the potential to almost replace the same amount lost (Graph 4.8b).

4.2.9 Portsmouth Harbour

4.2.9.1 Historical saltmarsh change

The total saltmarsh extent is shown for 1971, 1984 and 2002 for Portsmouth Harbour (Graph 4.9a, Table 4.11 and Figures 4.10). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015. Losses exclude reclamation.



Graph 4.9a: Historical and predicted saltmarsh extent in Portsmouth Harbour (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss (excluding reclamation)	
				% loss	% loss per year	% loss	% loss per year
1946	269.4	CCO					
1971	183.0	CCO	**1946-1971**	32.1	1.3	20.0	0.8
1984	52.3	CCO	**1971-1984**	71.4	5.5	53.6	4.1
2002	43.4	CCO	**1984-2002**	16.9	0.9	16.9	0.9
			1946-2002	83.9	1.5	59.7	1.1

Table 4.11: Saltmarsh extent in Portsmouth Harbour (based on HPI)

The areas of reclamation in Portsmouth, from 1946, are shown in Figure 4.10a.

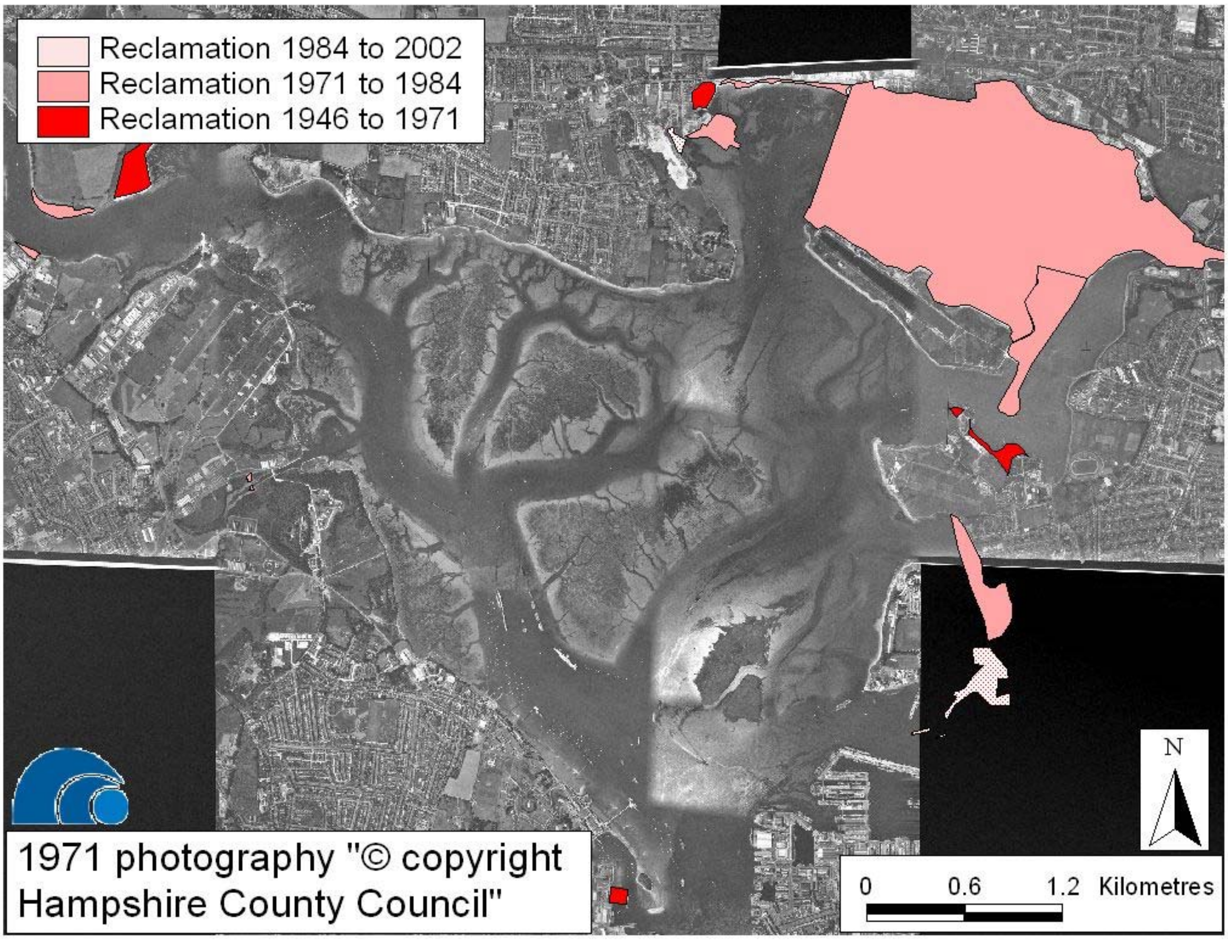


Figure 4.10a: Reclamation in Portsmouth Harbour since 1946 (based on HPI)

The following Figures (4.10b – 4.10e) show the spatial change in saltmarsh extent for the various epochs in Portsmouth Harbour.

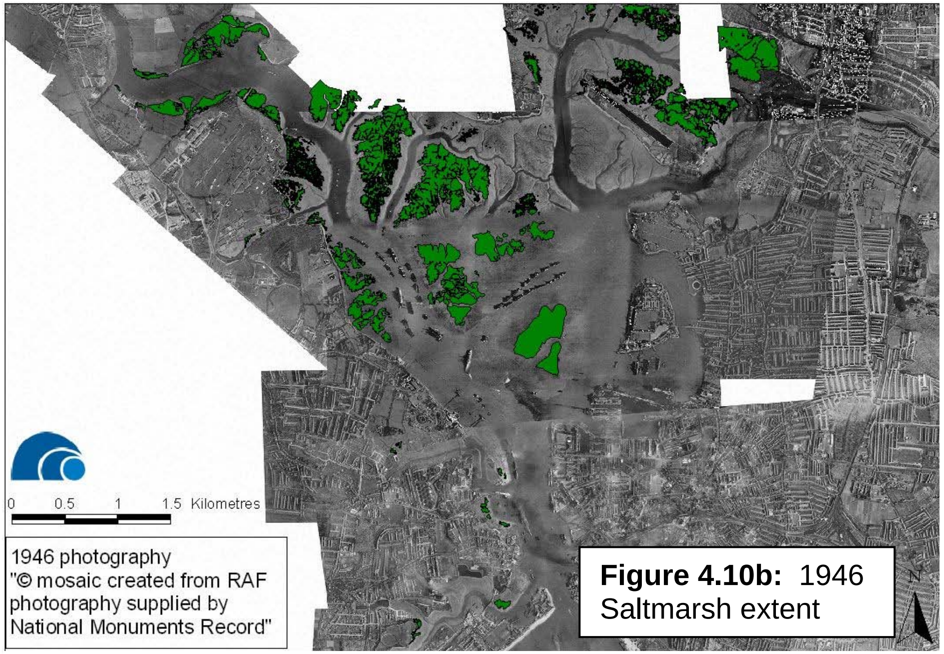


Figure 4.10b: 1946 Saltmarsh extent

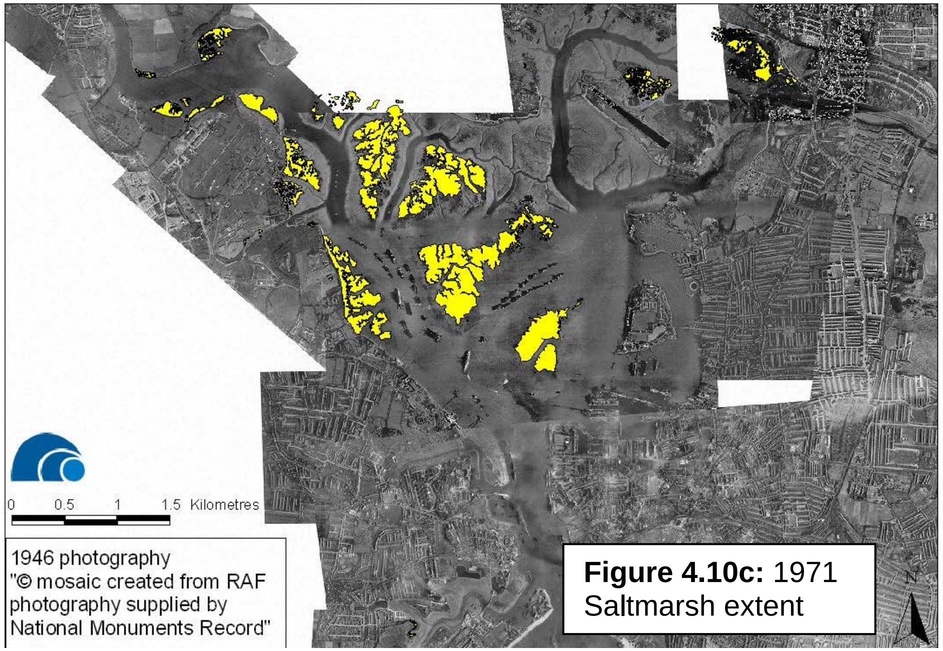


Figure 4.10c: 1971 Saltmarsh extent

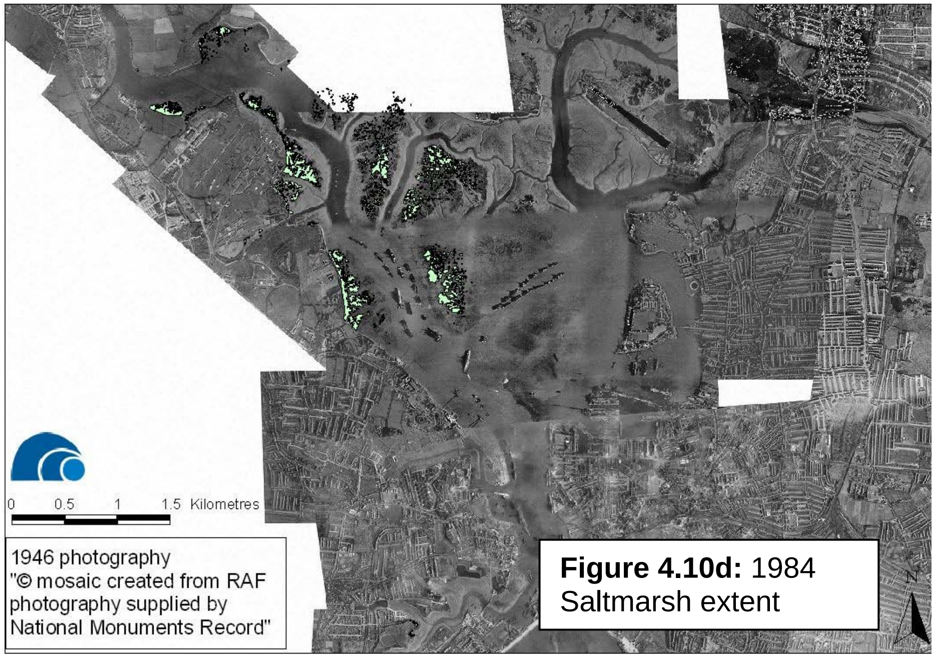


Figure 4.10d: 1984 Saltmarsh extent

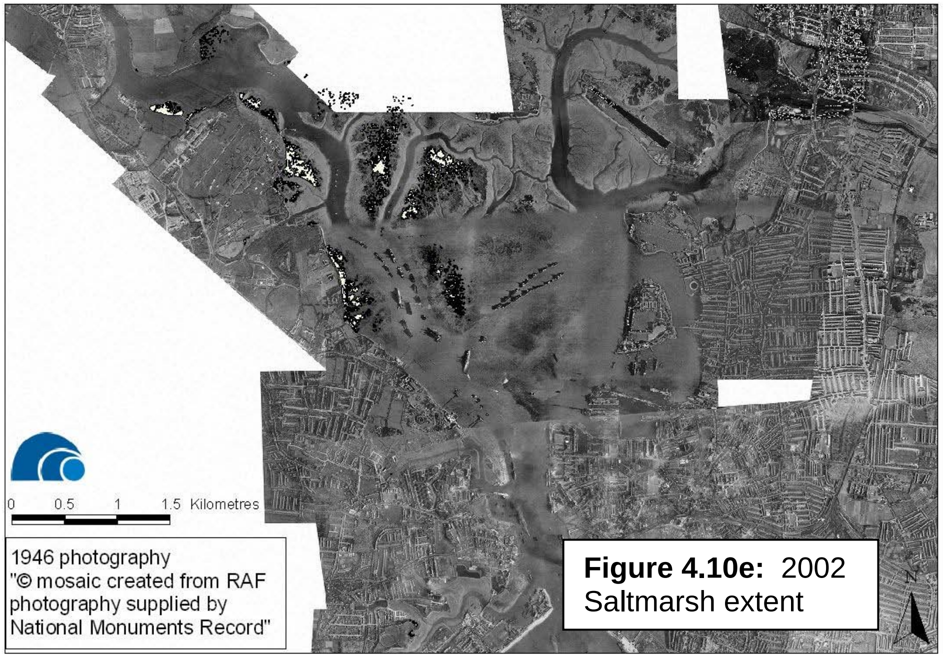


Figure 4.10e: 2002 Saltmarsh extent

1946-2002 (Figure 4.10f and Table 4.11)

Between 1946 and 2002 the data shows 84% total saltmarsh loss, which equates to 1.5% per annum. This is a similar rate of loss to Pitts Deep and Sowley in the west Solent and Langstone Harbour. The decline in saltmarsh has occurred throughout the Harbour through edge erosion and internal dissection. 28% of the total loss between 1946 and 2002 can be attributed to reclamation.

1946-1971 (Figure 4.10g and Table 4.11)

Changes between 1946 and 1971, indicates 32% loss which equates to 1.3% per annum (Table 4.11). Reclamation of Port Solent in the north-east side of the harbour started by 1946, however, the saltmarsh still remained in 1971. Therefore the saltmarsh classed as being reclaimed was spilt between the two epochs; 1946-1971 and 1971 -1984.

In general, loss is particularly focused on the north of the harbour, which underwent edge erosion. The area of "gain" is actually caused by poor quality photography for 1946, whereby the tide is too high and therefore conceals any saltmarsh.

1971-1984 (Figure 4.10h and Table 4.11)

There was an overall loss of 71% (5.5 % per annum) between 1971 – 1984. If reclamation is excluded then this value decreases to 4% per annum which is still extremely high. Loss during this epoch is the second highest throughout the north Solent. Langstone Harbour underwent the highest rate of loss, being 6.4% per annum between 1963 and 1971.

1984 -2002 (Figure 4.10i and Table 4.11)

The fragmented marshes continue to suffer edge erosion but at a much lower rate of 0.9% per annum. This is the lowest rate of annual saltmarsh loss for all the epochs at Portsmouth Harbour.

The following Figures (4.10f – 4.10i) show the spatial change in saltmarsh extent for the various epochs in Portsmouth Harbour.

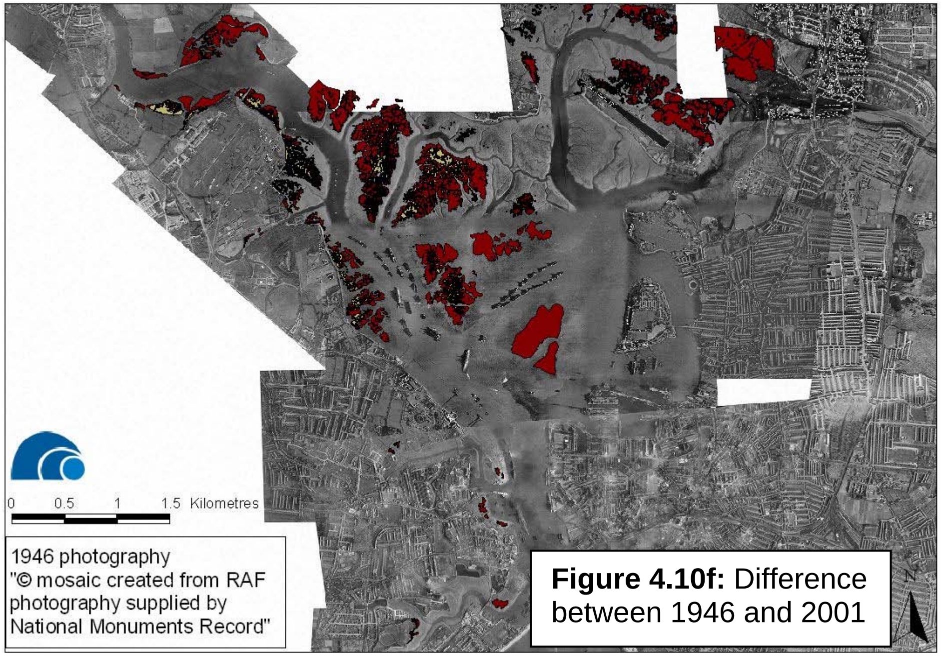


Figure 4.10f: Difference between 1946 and 2001

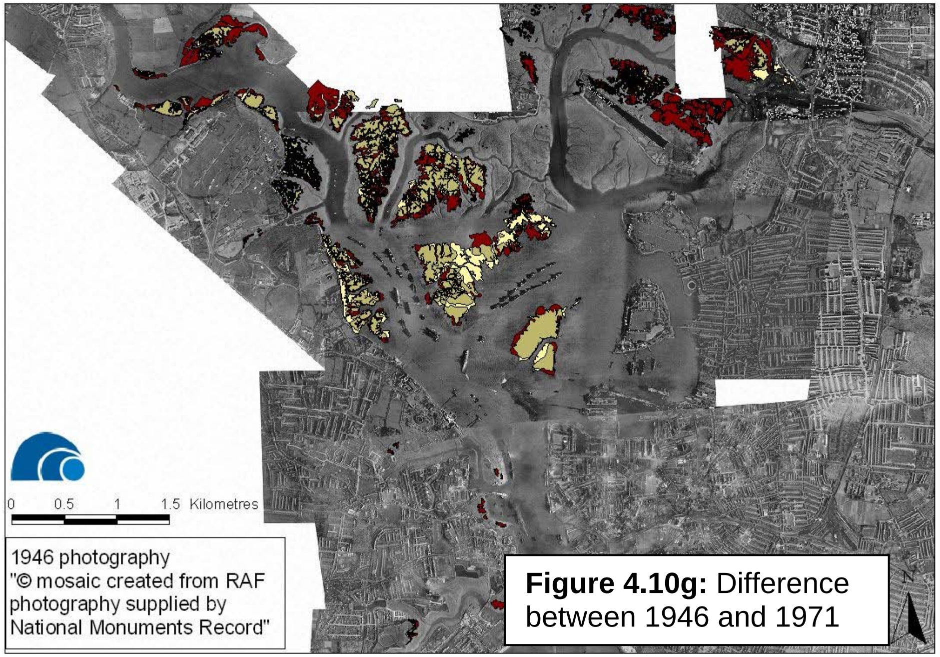


Figure 4.10g: Difference between 1946 and 1971

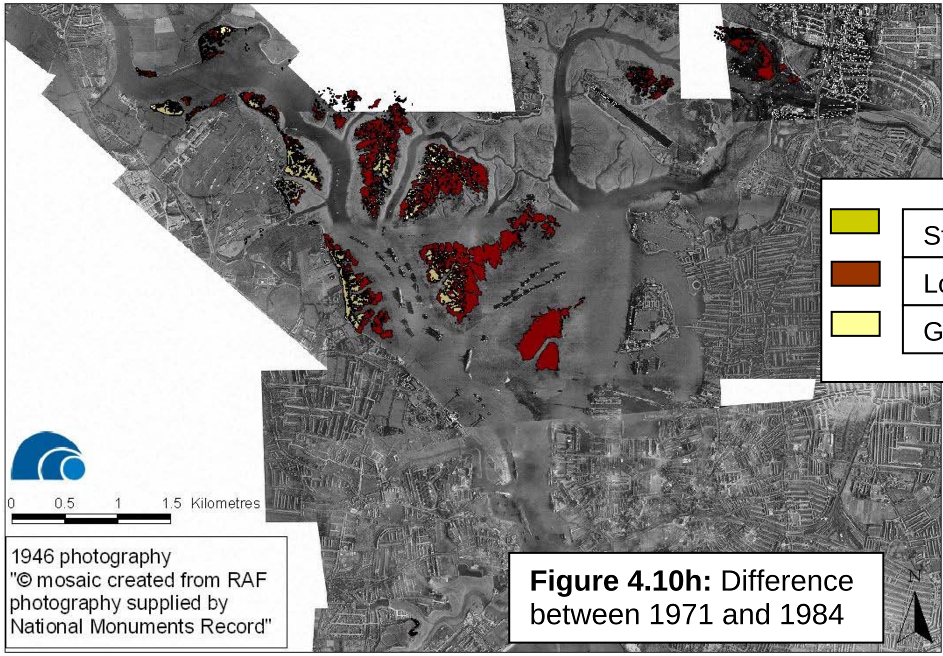


Figure 4.10h: Difference between 1971 and 1984

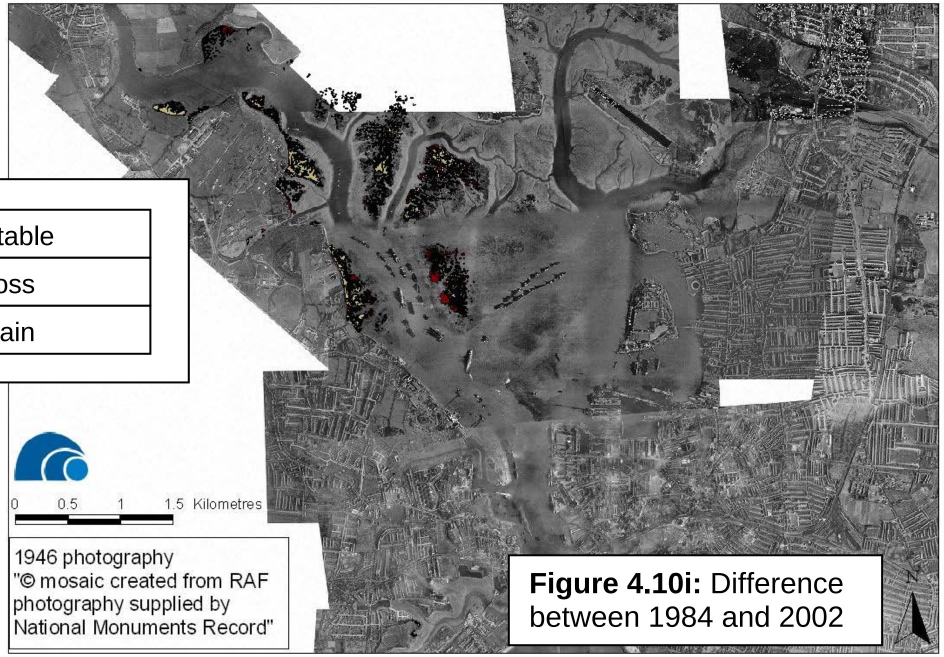


Figure 4.10i: Difference between 1984 and 2002

4.2.9.2 Predicted inter-tidal change

The area selected for LTEI calculations at Portsmouth Harbour, for comparison with the HPI is shown in Figure 4.10j.

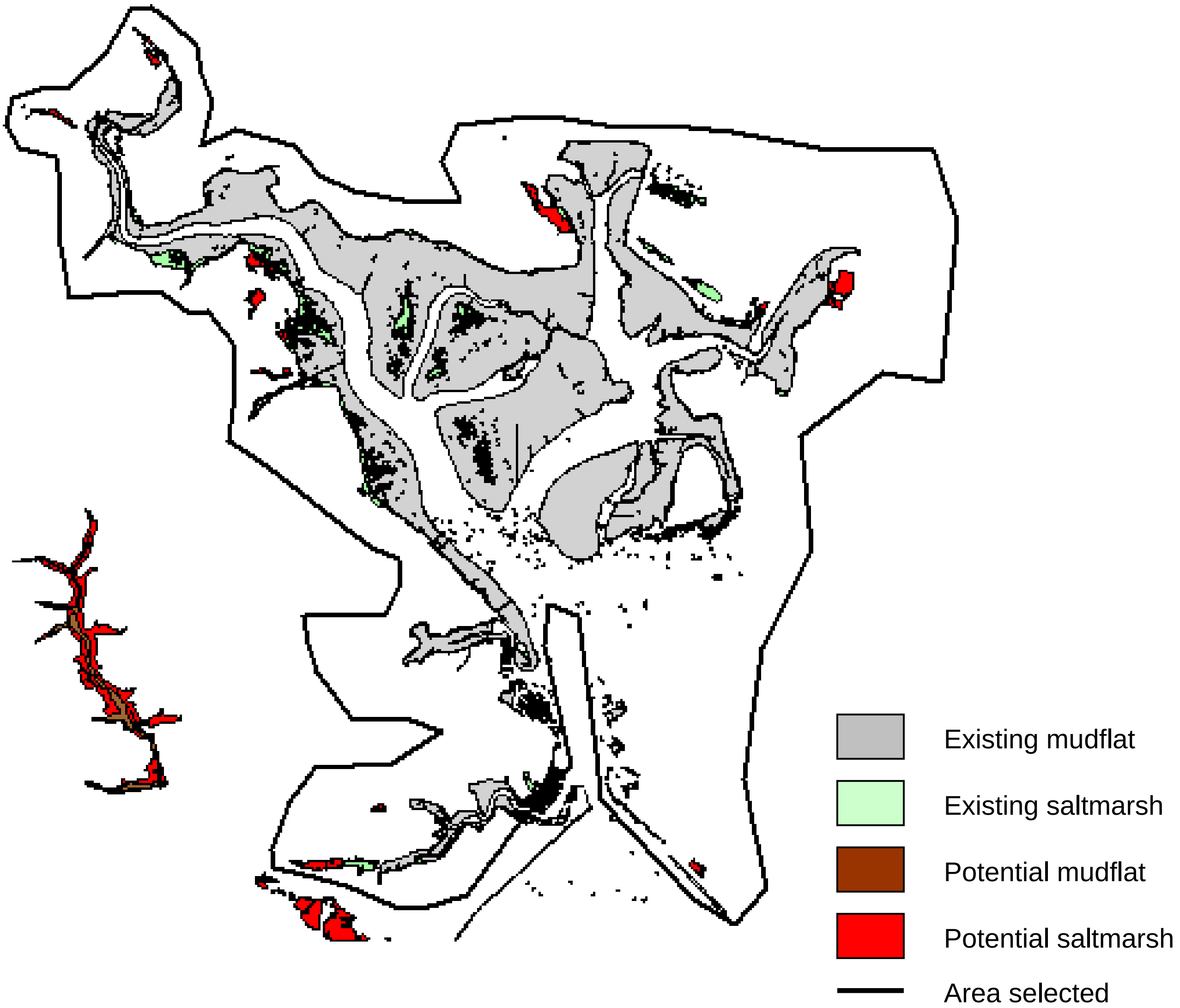
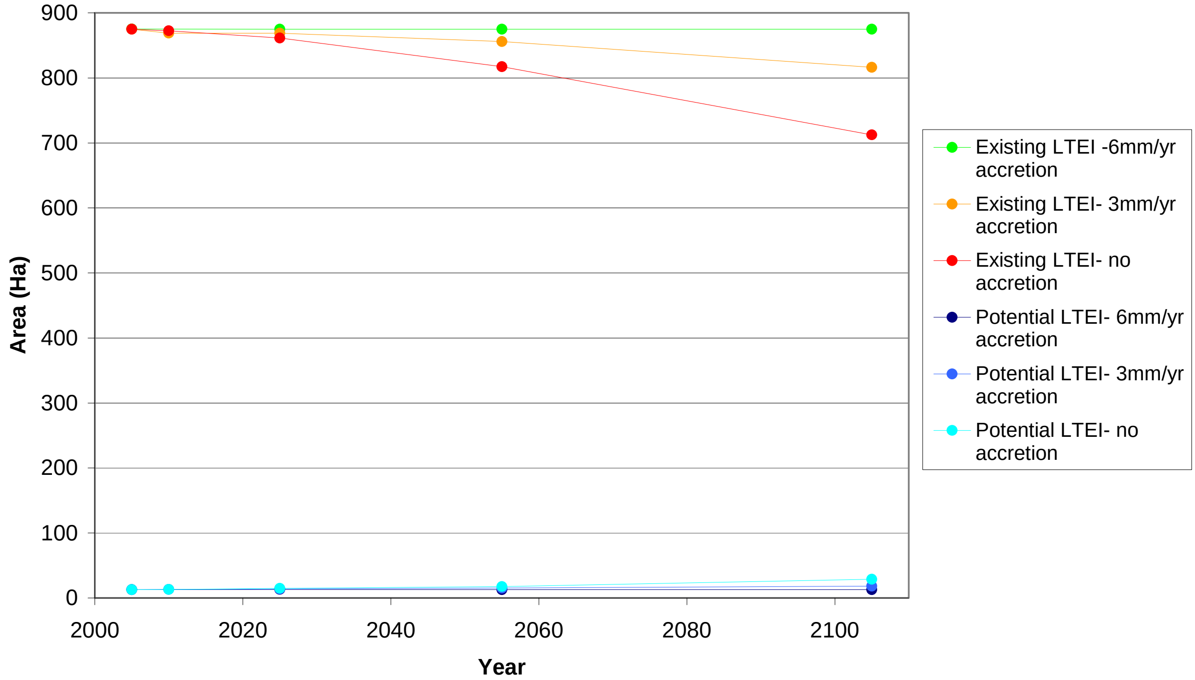
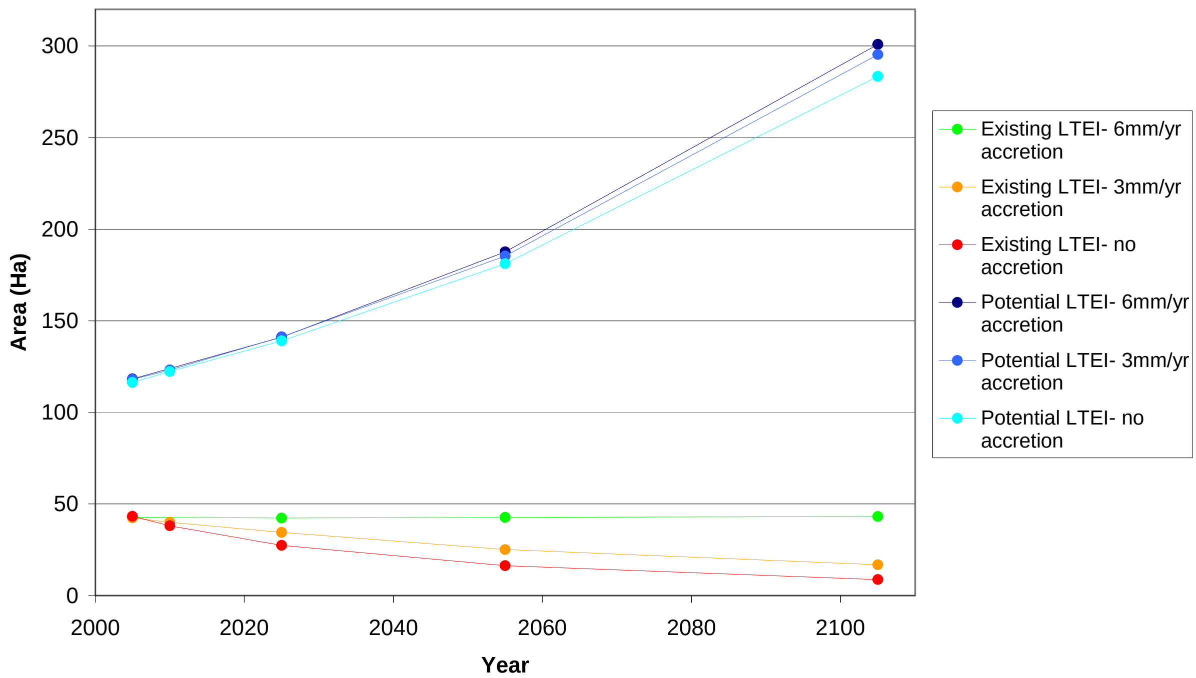


Figure 4.10j: Area selected for LTEI calculations within Portsmouth Harbour

Projected changes are presented for the “existing” management scenario (seawards of the seawall) and for “potential” increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for mudflat (Graph 4.9b) and saltmarsh (Graph 4.9c), for the situation now, 5, 20, 50 and 100 years time for no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios.



Graph 4.9b: "Existing" and "potential" predicted mudflat extent within Portsmouth Harbour (based on LTEI)



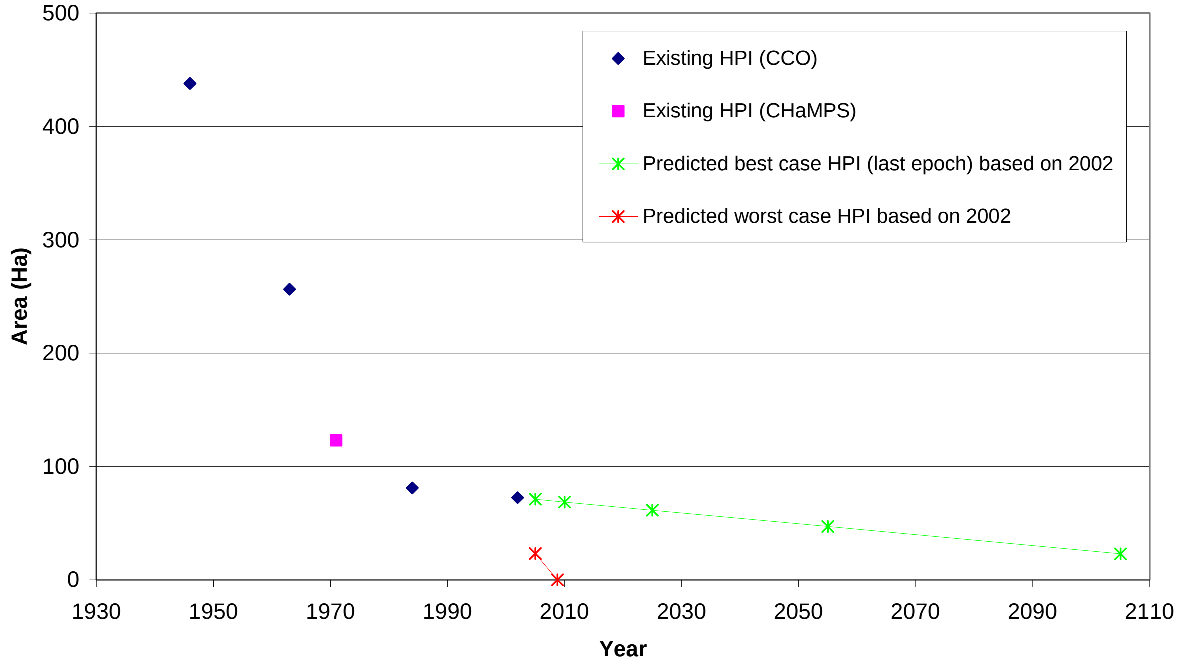
Graph 4.9c: "Existing" and "potential" predicted saltmarsh extent within Portsmouth Harbour (based on LTEI)

Results show mudflat and saltmarsh evolution under the existing management regime slightly decrease through time (Graph 4.9b and 4.9c respectively). In the event of re-alignment, saltmarsh has the potential to almost triple over the next 100 years (Graph 4.9c).

4.2.10 Langstone Harbour

4.2.10.1 Historical saltmarsh change

The total saltmarsh extent is shown for 1946, 1963, 1971, 1984, 2001, and 2002 in Langstone Harbour (Graph 4.10a, Table 4.12 and Figures 4.11). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015. Losses exclude reclamation.



Graph 4.10a: "Existing" saltmarsh extent in Langstone Harbour (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss (excluding reclamation)	
				% loss	% loss per year	% loss	% loss per year
1946	438.0	CCO					
1963	256.5	CCO	**1946-1963**	41.4	2.4	41.4	0.1
1971	123.0	CHaMP	**1963-1971**	52.0	6.5	51.3	6.4
1984	81.2	CCO	**1971-1984**	34.0	2.6	32.4	2.5
2001	75.3	CHaMP	**1984-2001**	7.2	0.4	7.2	0.4
2002	72.5	CCO	**2001-2002**	3.7	3.7	3.7	3.7
			1946-2002	83.4	1.5	82.6	1.5

Table 4.12: Saltmarsh extent in Langstone Harbour (based on HPI)

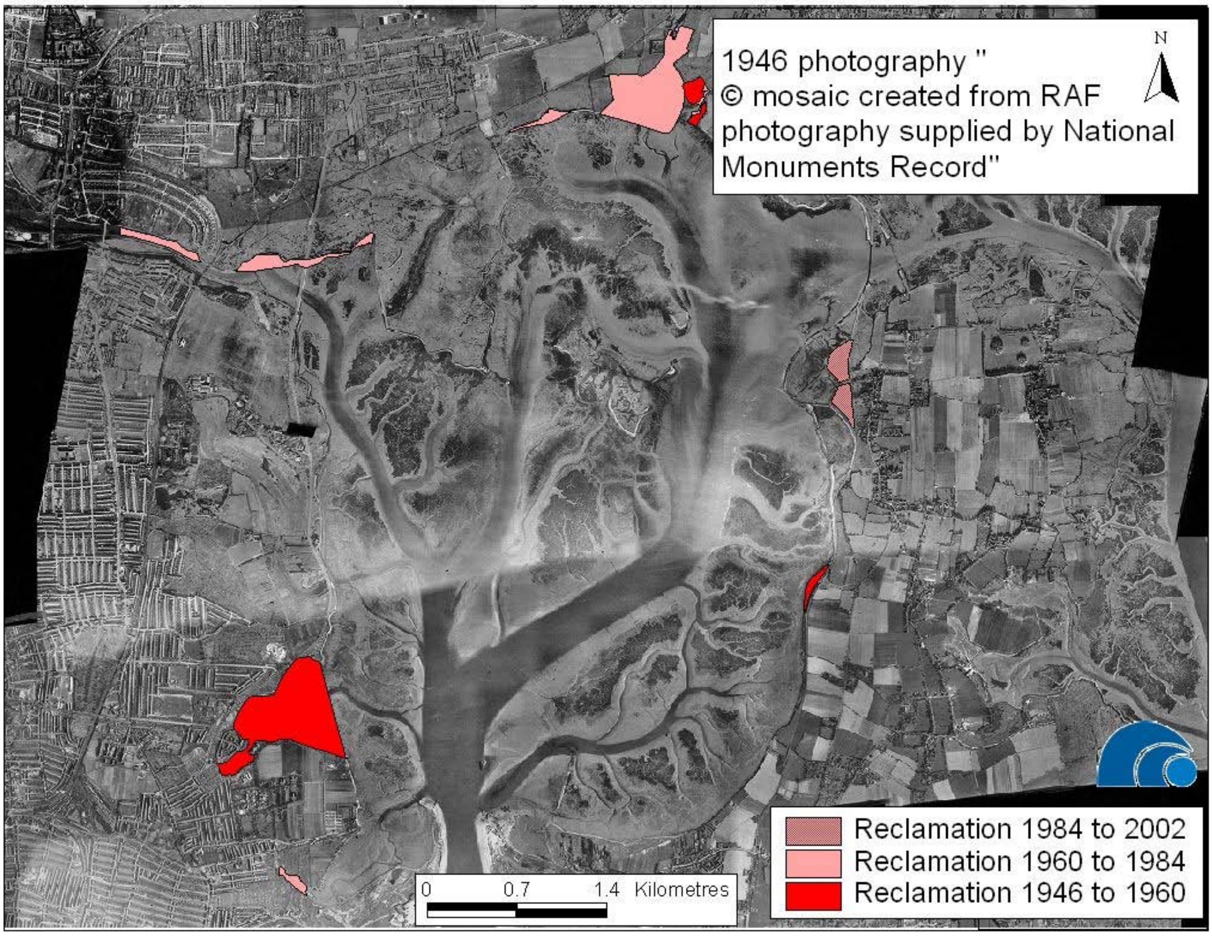


Figure 4.11a: Reclamation in Langstone Harbour since 1946 (based on HPI)

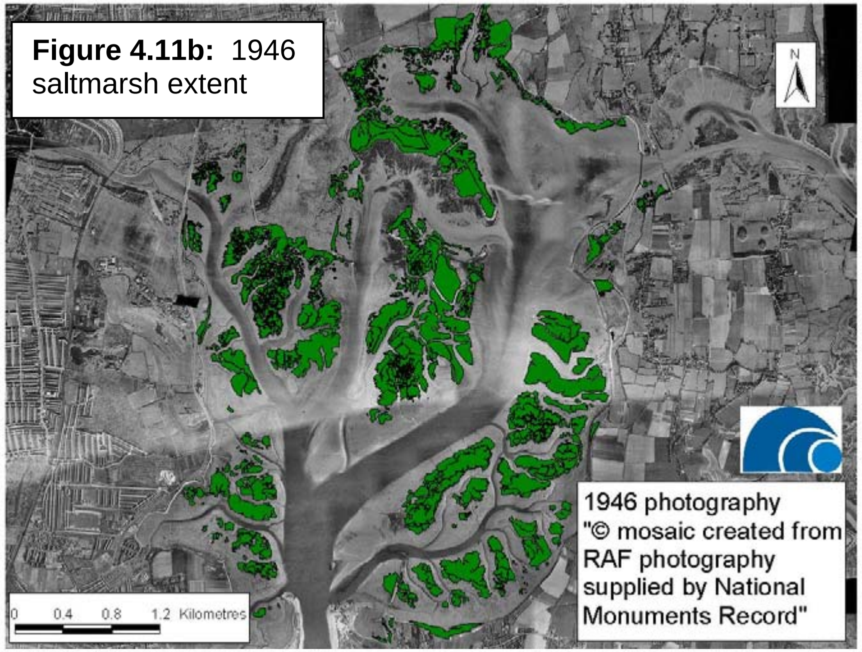


Figure 4.11b: 1946 saltmarsh extent

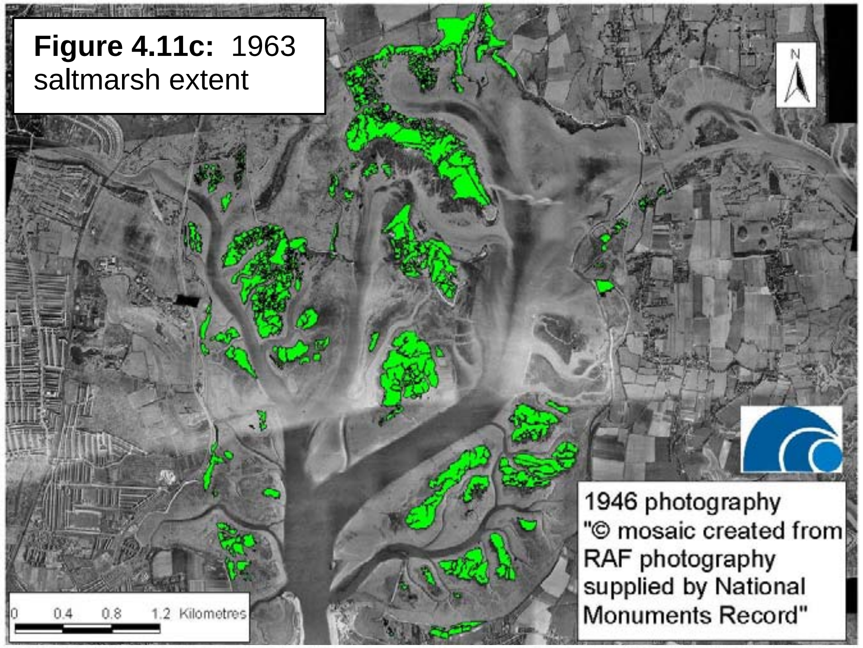


Figure 4.11c: 1963 saltmarsh extent

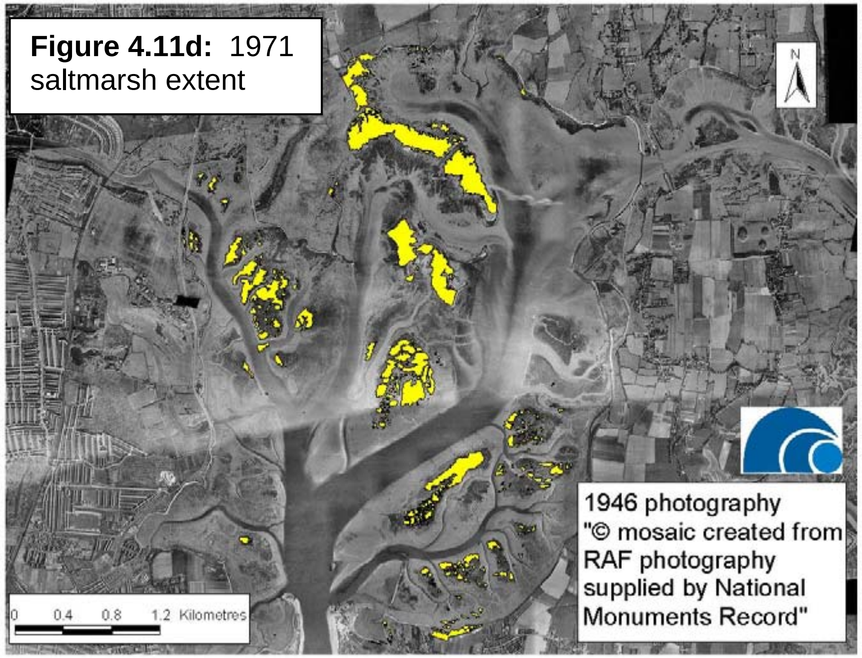


Figure 4.11d: 1971 saltmarsh extent

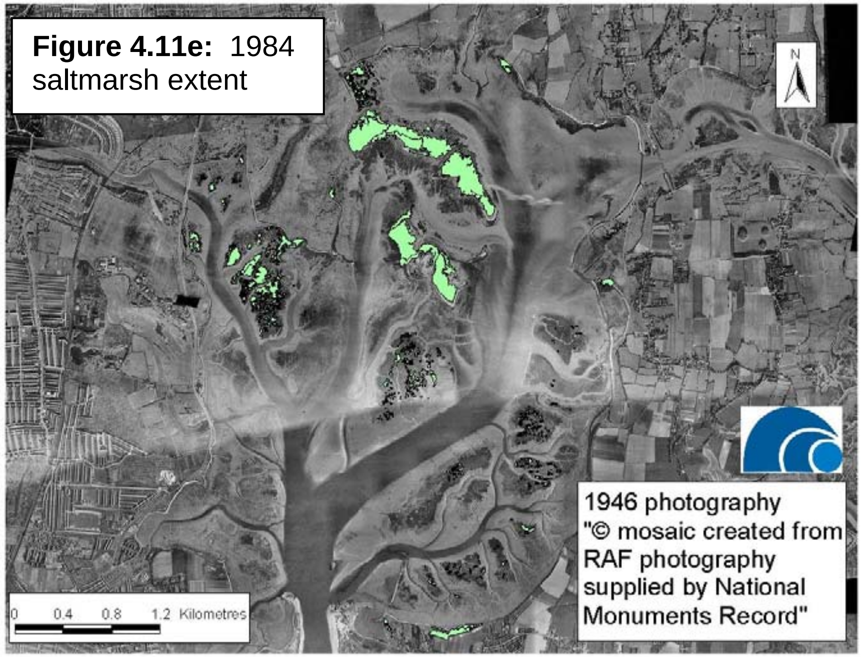


Figure 4.11e: 1984 saltmarsh extent

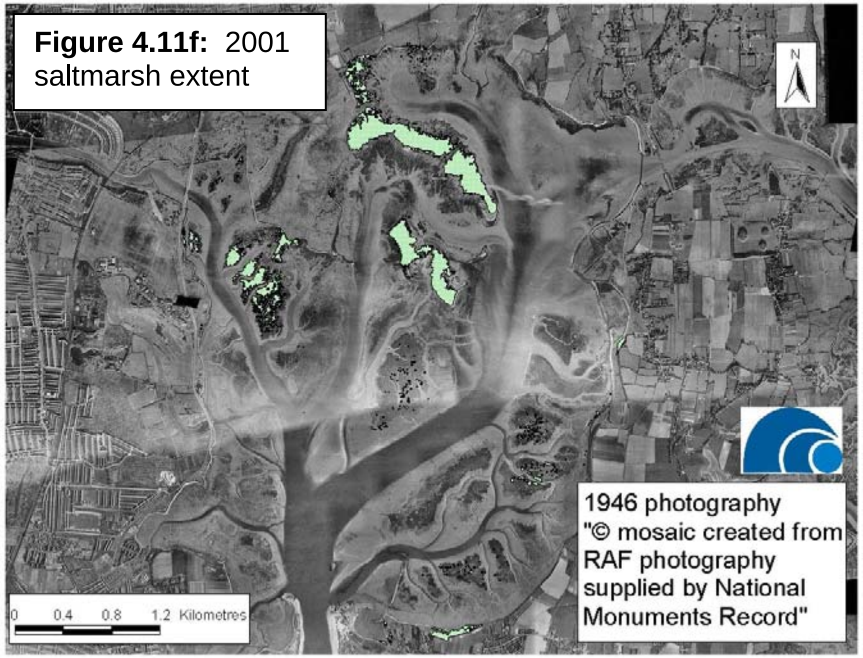


Figure 4.11f: 2001 saltmarsh extent

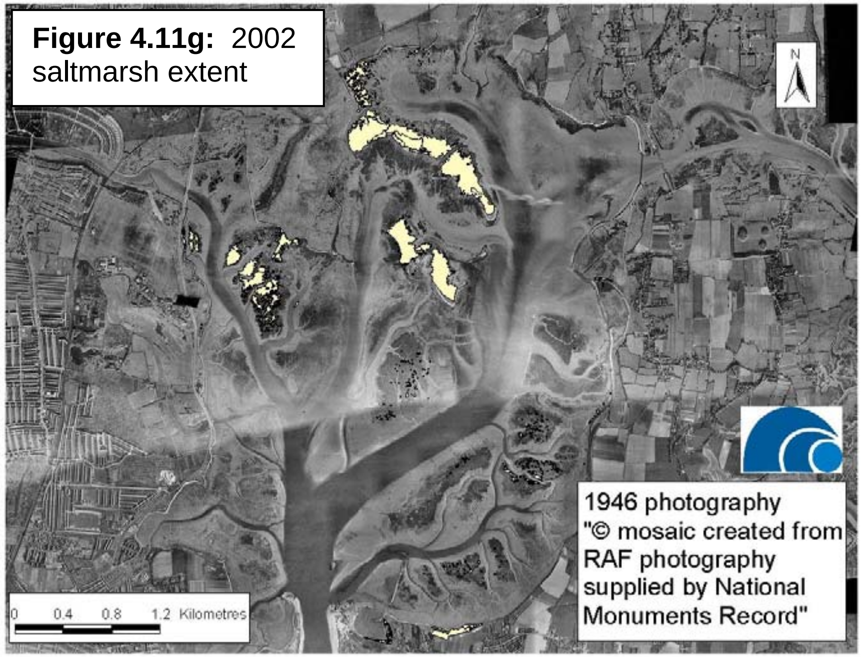


Figure 4.11g: 2002 saltmarsh extent

1946-2002 (Figure 4.11h and Table 4.12)

Between 1946 and 2002 the data shows 83% saltmarsh loss, this equates to 1.5% per annum. This is similar to Pitts Deep and Sowley in the west Solent and Portsmouth Harbour, east Solent. The decline in saltmarsh occurred throughout the harbour but most extensively in the southern and middle sections, with only small stable areas remaining in the north. Edge erosion and internal dissection are the dominant erosive processes. The data also suggests small areas of gain in the north east of the harbour.

1946-1963 (Figure 4.11i and Table 4.12)

The data for this epoch indicates 41% saltmarsh loss between 1946 and 1963, which equates to 2.4% per annum. Again, the loss occurred throughout the Harbour with a focus in the southern and middle sections. It would appear that the south-east part of the harbour has undergone drastic edge erosion, which is surprising given the sheltered nature of the harbour.

1963-1971 (Figure 4.11j and Table 4.12)

The area of saltmarsh has been halved (52%) between 1963 and 1971 from 258 ha to 123 ha. This is the highest rate of loss for all the epochs, equating to 6.5% loss per annum. The decline can be seen throughout the Harbour with large areas lost from the top northern corner and along the south west and eastern edges. It appears that edge erosion continues to be dominant.

1971-1984 (Figure 4.11k and Table 4.12)

This epoch shows large losses of 34% since 1971, which equates to 2.6% per annum. The main areas of erosion are in the south, centre and north-west corner of the harbour.

1984-2001 (Figure 4.11l and Table 4.12)

There is a reduction in the rate of saltmarsh loss between 1984 and 2002. The total area of saltmarsh reduced from 81 ha in 1984 to 75 ha in 2002. This is the lowest rate of annual saltmarsh loss (0.4%) for all the epochs at Langstone Harbour. This decline has occurred mainly in the centre and west of the harbour. This low rate of loss is contrary to the high rates of loss in the west Solent during this epoch.

2001-2002 (Figure 4.11m and Table 4.12)

The final decade shows the greatest stability (58 ha) concentrated to the north of the harbour. The most recent data from 2005 (not shown), suggests that there may be a change in the current trend, with a slight increase in saltmarsh area, 76 ha compared to 73 ha in 2002. Once subjectivity, time of year the photography was flown and photography contrast are taken into account, it is difficult to deduce whether the saltmarsh is recovering or indeed, the loss is levelling off. A time period of approximately 5-10 years is required, rather than 3 years (2002 – 2005), to confirm this. Digitizing the 2008 Regional Monitoring ortho-rectified photography should provide a better indication.

The following Figures 4.11h – 4.11m, show the spatial change in coverage between 1947 – 2002, 1947 – 1963, 1963 – 1971, 1971 – 1984, 1984 – 2001 and 2001 – 2002 in Langstone Harbour.

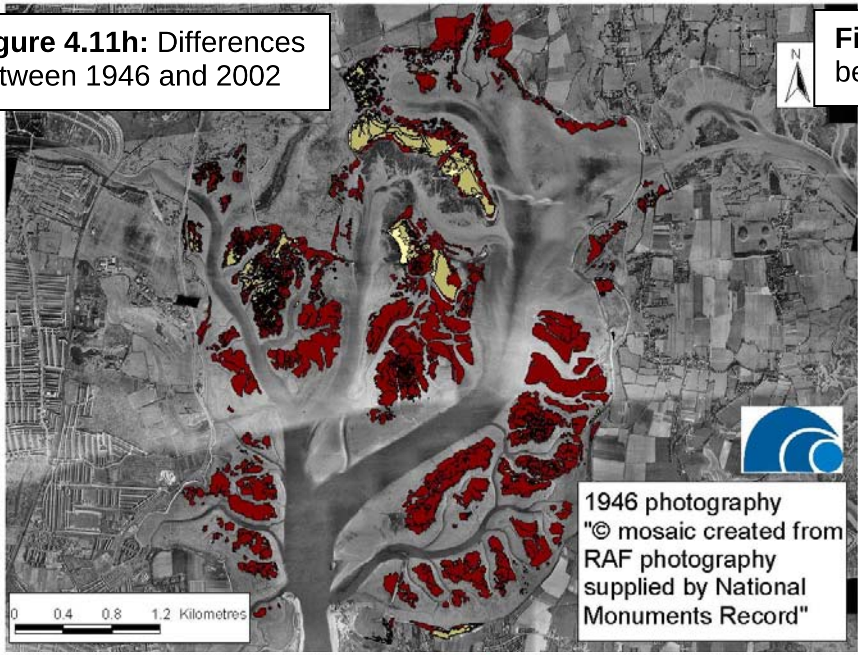


Figure 4.11h: Differences between 1946 and 2002

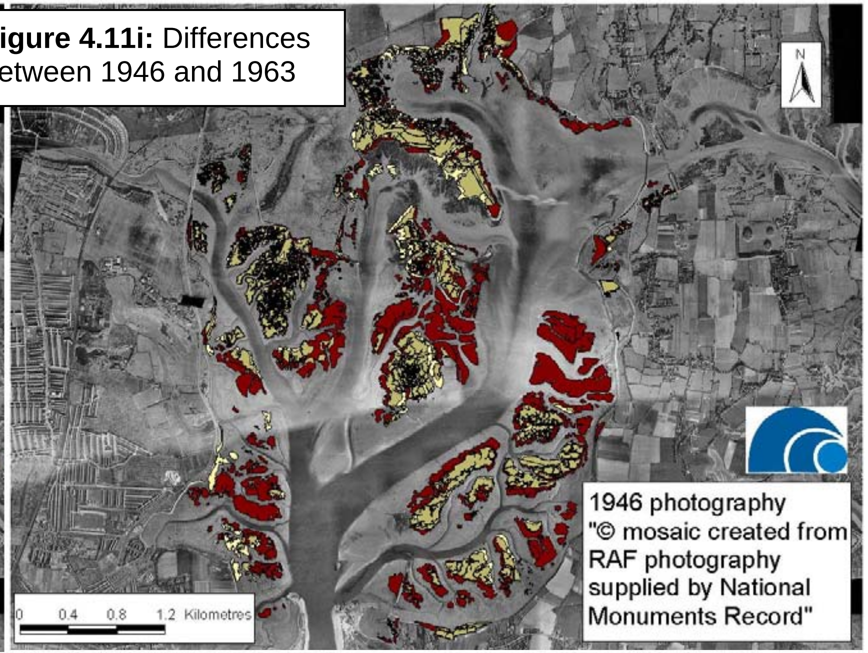


Figure 4.11i: Differences between 1946 and 1963

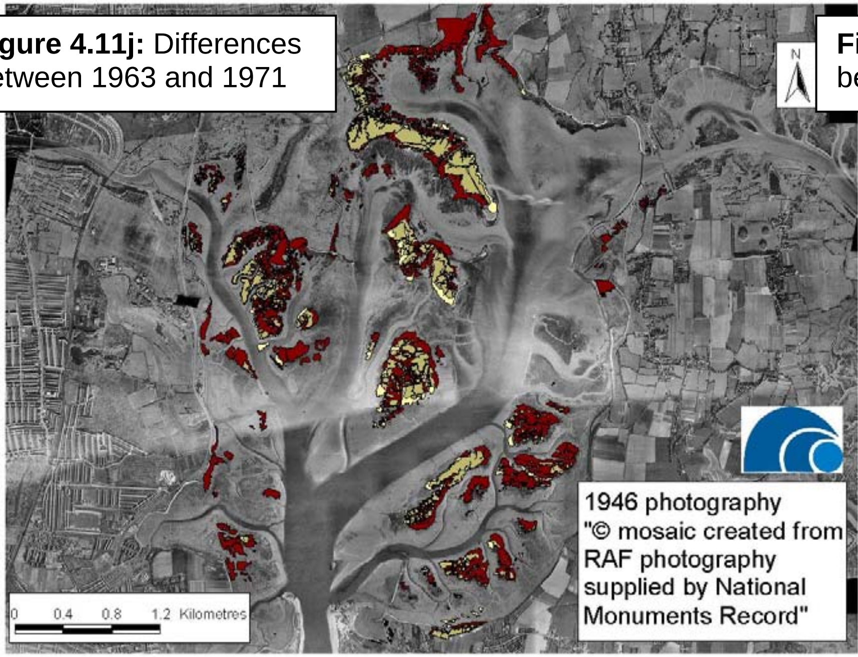


Figure 4.11j: Differences between 1963 and 1971

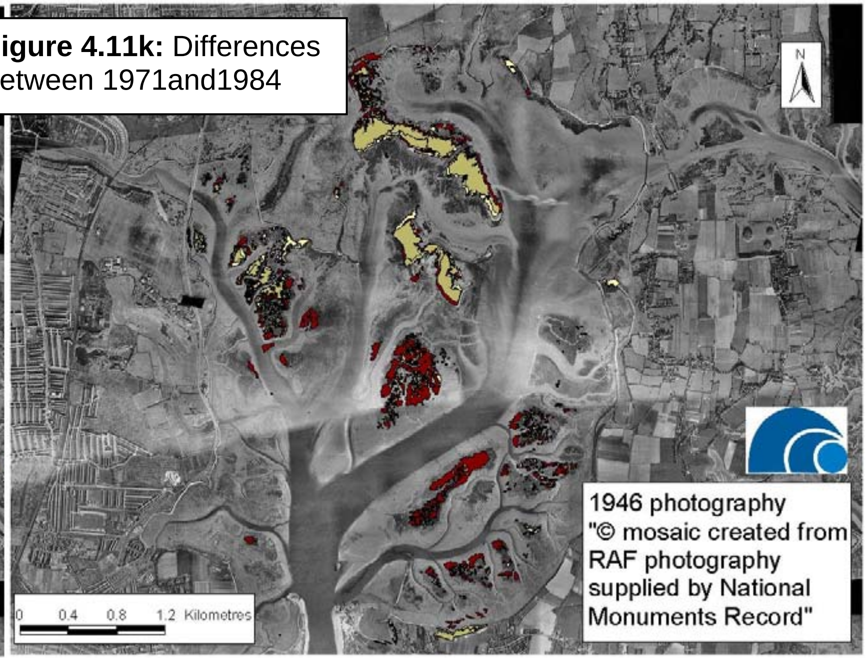


Figure 4.11k: Differences between 1971and1984

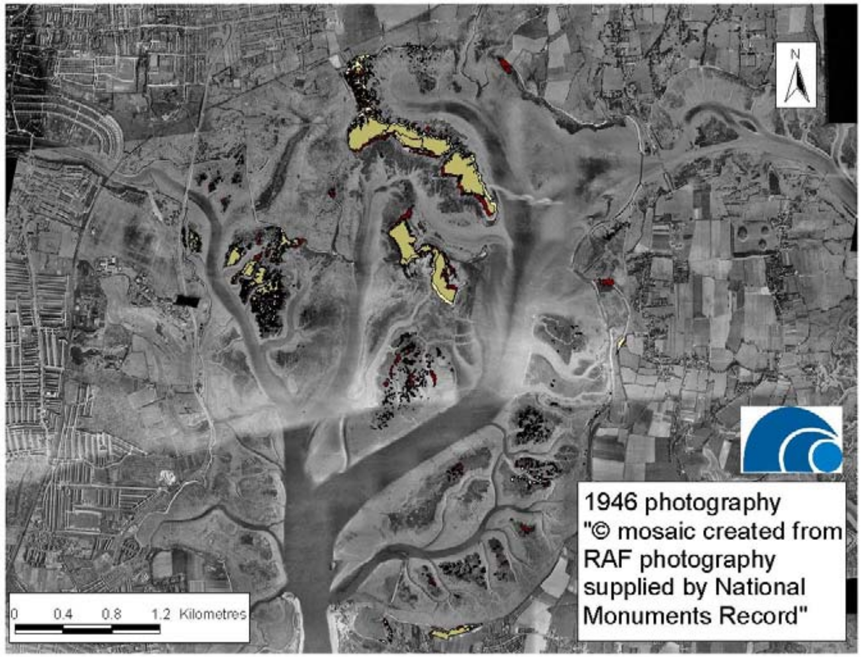


Figure 4.11l: Differences between 1984 and 2001

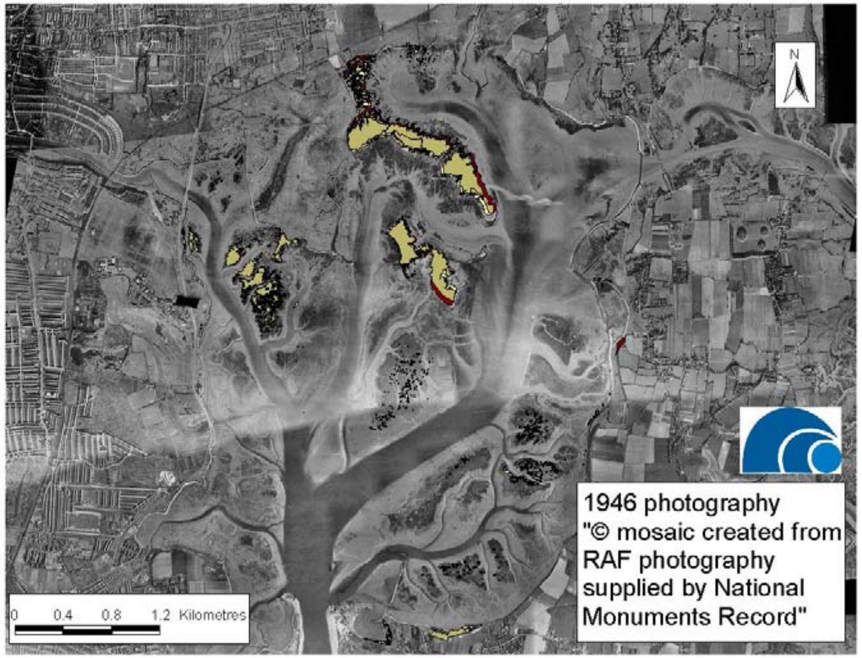


Figure 4.11m: Differences between 2001 and 2002

Stable

Loss

Gain

4.2.10.2 Predicted inter-tidal change

The following Figure 4.11n shows the area selected for LTEI calculations at Langstone Harbour for comparison with the HPI.

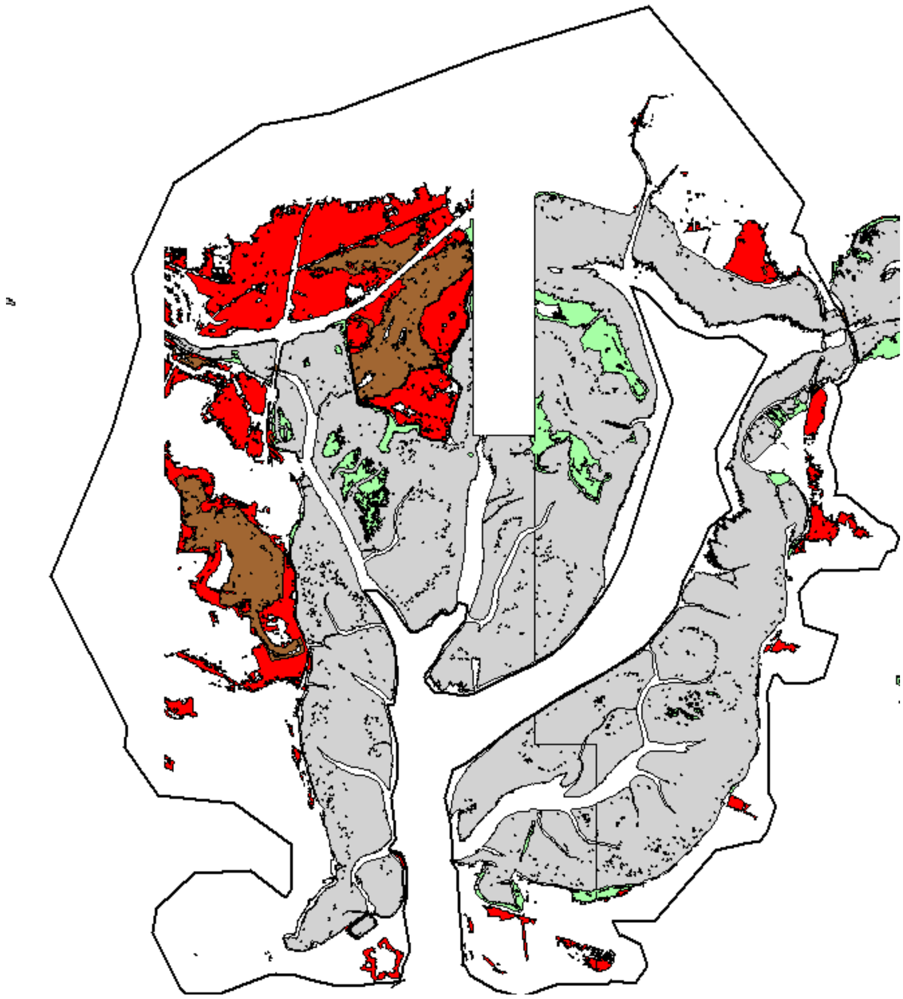
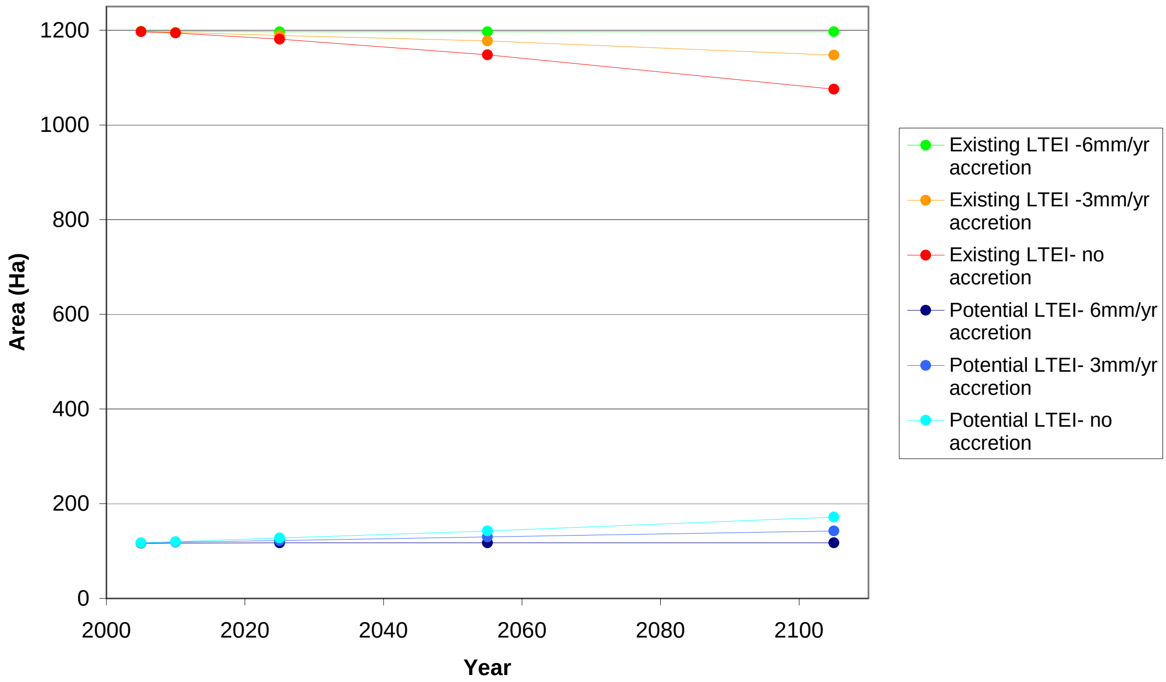
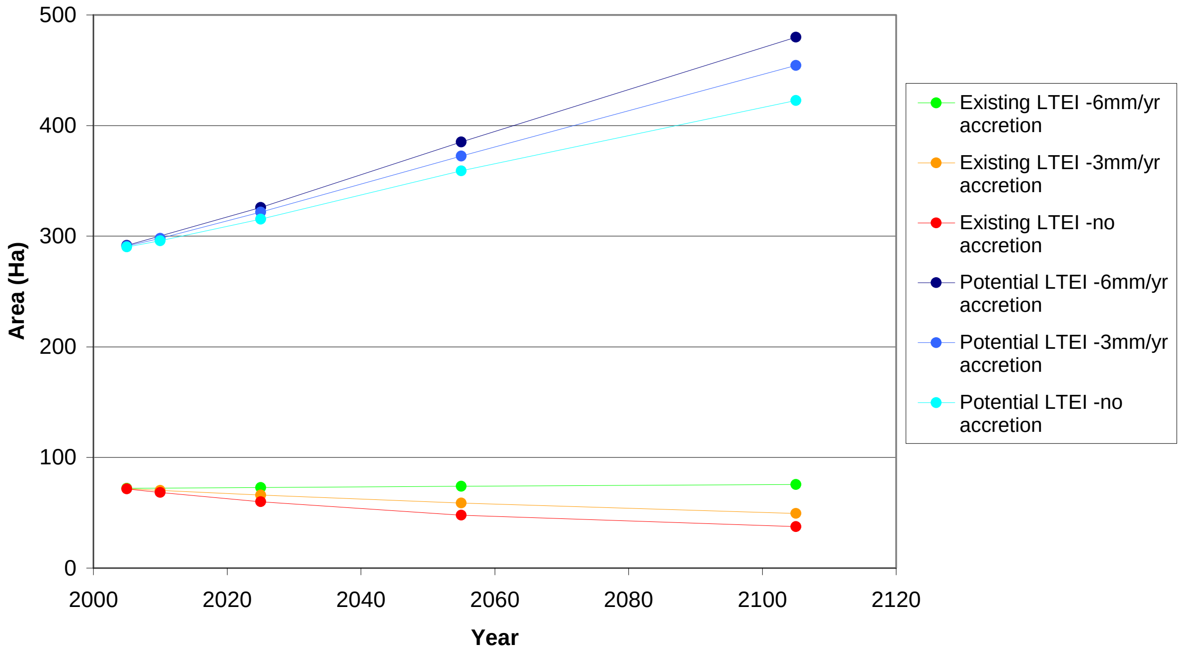


Figure 4.11n: Area selected for LTEI calculations at Langstone Harbour

Projected changes are presented for the “existing” management scenario (seawards of the seawall) and for “potential” increases in habitat areas arising from re-alignment (landwards of the seawall). Results are presented for mudflat (Graph 4.10b) and saltmarsh (Graph 4.10c), for the situation now, 5, 20, 50 and 100 years time for the no sediment accretion, 3mm and 6mm sediment accretion per annum LTEI scenarios.



Graph 4.10b: "Existing" and "potential" predicted mudflat extent in Langstone Harbour (based on LTEI)



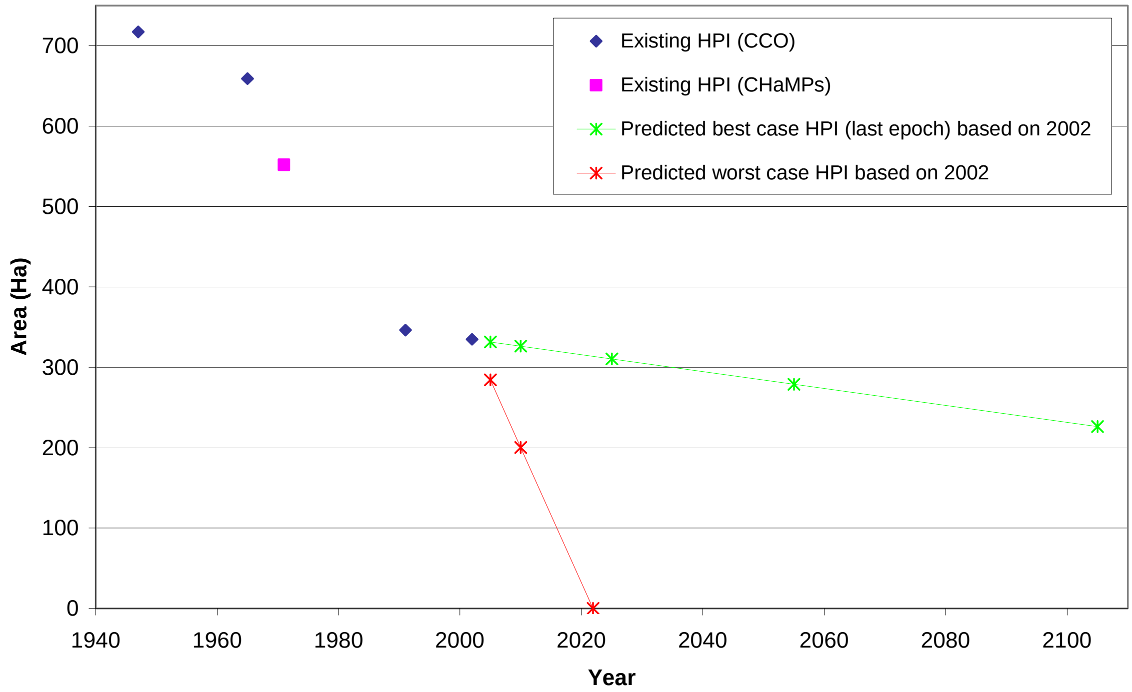
Graph 4.10c: "Existing" and "potential" predicted saltmarsh extent in Langstone Harbour (based on LTEI)

Results show mudflat and saltmarsh evolution under the existing management regime slightly decrease through time (Graph 4.10b and 4.10c respectively). In the event of re-alignment, saltmarsh has the potential to increase over the next 100 years (Graph 4.10c).

4.2.11 Chichester Harbour

4.2.11.1 Historical saltmarsh change

The following show the total saltmarsh extent for 1946, 1965, 1971 (CHaMP), 1991, and 2002 in Chichester Harbour based on the HPI (Graph 4.11a, Table 4.13 and Figures 4.12). The best, worst and last epochs were extrapolated for 2005, 2025, 2055 and 2015. Losses exclude reclamation.



Graph 4.11a: Saltmarsh extent in Chichester Harbour (based on HPI)

Year	Area (Ha)	Data Source	Period	Total Loss		Loss (excluding reclamation)	
				% loss	% loss per year	% loss	% loss per year
1946	717.3	CCO					
1965	659.1	CCO	**1946-1965**	8.1	0.5	8.1	0.5
1971	552.1	CHaMP	**1965-1971**	16.2	2.7	15.3	2.6
1991	346.4	CCO	**1971-1991**	37.3	1.9	37.3	1.9
2002	334.8	CCO	**1991-2002**	3.3	0.3	3.3	0.3
			1946-2002	53.3	1.0	52.5	1.0

Table 4.13: Saltmarsh extent in Chichester Harbour (based on HPI)

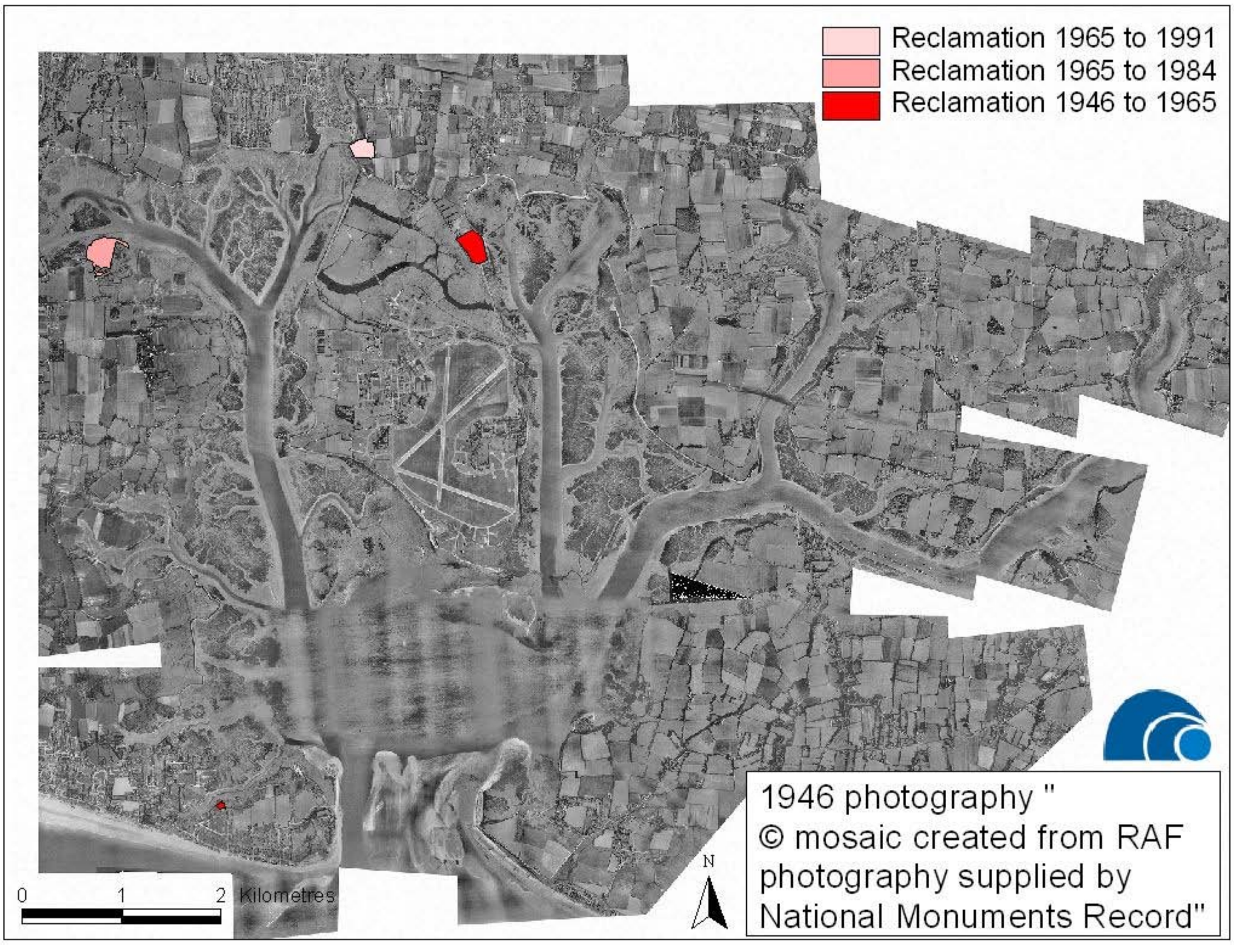


Figure 4.12a: Reclamation in Chichester Harbour from 1946 (based on HPI)