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Project identification

1. Defra Project code: FD1926
2. Project title: Understanding and Predicting Beach Morphological Change Associated with the Erosion of Cohesive Shore Platforms
3. Contractor organisation(s):
   Royal Haskoning
   British Geological Survey
   University of Sussex
   Newcastle University
4. Total Defra project costs (agreed fixed price): £ 158,097.00
5. Project: start date .... 01 April 2005
   end date .... 31 March 2007

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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Background to the R&D Project

Cohesive shore platforms tend to be located in some of the most rapidly eroding coastal areas of the UK. The erosion and weathering of cohesive shore platforms has three often overlooked, but nonetheless critical, implications on the functioning of the wider coastal system. Firstly, the platform tends to regulate wave energy impinging on the toe of a sea cliff and, over time, the rates of platform downwearing tend to govern the rates of sea cliff recession. Secondly, platform morphology has an important relationship with beach form. Thirdly, platform downwearing processes release significant volumes of sediment into the wider coastal sediment budget system.

Cohesive shore platform behaviour also has critical implications for the performance of coastal defence schemes since downwearing rates also potentially affect: (i) effective water depth at the toe of shoreline structures, leading to increased loading conditions and overtopping volumes; and (ii) undermining of the toe of defences. The key control on all of the above behaviours and interactions is the rate of vertical lowering of the platform. This 'downwearing' rate, which integrates processes of marine erosion and subaerial weathering (e.g. wave erosion, freeze-thaw cycles, etc.), is influenced by the geology and geotechnical properties of the material, the wave climate and tidal regime, the effect of beach sediment cover and the amount of biological activity.

This research project has aimed to improve our technical understanding of the roles of the different parameters and processes that contribute to the downwearing of cohesive shore platforms through: (i) a detailed review of existing literature; (ii) innovative field work campaigns at two contrasting platform-beach sites, namely Warden Point (Kent) and Easington (Yorkshire); (iii) laboratory analyses of collected field samples; and (iv) a series of numerical model tests.

Results of the R&D Project

The field investigations and laboratory tests in this study have yielded the first direct measurements of key processes associated with the erosion of cohesive shore platforms in such detail in the UK. Results demonstrate that whilst a range of factors contribute to overall platform downwearing in some way, it is the incident wave energy and presence (or absence) of a beach that are by far the most significant factors. The tidal range, which influences where wave activity impinges on a profile and also influences wetting-drying cycles across the platform, and both biological activity and material strength are also processes of some importance.

Average platform downwearing rates of 18mm/yr and 42mm/yr were measured at Warden Point and Easington, respectively. These rates are much higher than originally anticipated and, to place them in some context, by far exceed typical allowances made for sea level rise in flood and coastal erosion risk management.

The erosion of cohesive shore platforms can sometimes have negative consequences for coastal engineering interventions. Continued platform lowering, in the absence of a substantial protective beach, can lead to exposure and ultimately failure of the foundation of coastal defence structures, for example. Elsewhere it is the consequences of the platform erosion on beach levels and cliff recession rates that are of concern to coastal managers. In essence, the possible management responses to such problems are limited to: (i) doing nothing; (ii) stopping or limiting the downwearing of the platform; or (iii) managing the consequences of the platform downwearing.

R&D Outputs and their Use

The main output from the study has been R&D Technical Report FD1926/TR. This report describes in detail the background context to the research project, its aims and objectives and the methodology used. It then provides a comprehensive review of existing literature of relevance to cohesive shore platforms before describing the methods and results from the field and laboratory investigations and numerical modelling tests at Warden Point and Easington. The report then draws these findings together to make key conclusions and preliminary management guidance. The report is intended to be used by both coastal scientists, interested in the innovative field, laboratory and modelling work that has been undertaken during the study, and coastal managers, interested in gaining an improved understanding of the processes governing the erosion of cohesive shore platforms, their interactions with beaches and sea cliffs, and appropriate management responses to the erosion processes.

In addition, scientific papers have been presented at the following conferences and published in the accompanying conference proceedings: Littoral Conference '04; Defra Flood and Erosion Risk Management Conference 2006; Institution of Civil Engineers International Coastal Management Conference 2007.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
   - the scientific objectives as set out in the contract;
   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Transfer).

Background Context

Cohesive shore platforms are developed in relatively non-resistant material and the irreversible erosion of these landforms plays a large part in controlling the functioning of the wider coastal system. In order to manage this coastal system most effectively, an improved understanding is required amongst coastal scientists and managers of the erosion and weathering processes governing the behaviour of these landforms, and also of their interactions with beaches and backing sea cliffs. This research project has aimed to improve our technical understanding of the roles of the different parameters and processes that contribute to the downwearing of cohesive shore platforms through:

- a detailed review of existing literature;
- innovative field work campaigns at two contrasting platform-beach sites in the UK;

- laboratory analyses of collected samples; and
- a series of numerical model tests.

The improved scientific knowledge gained from the study has been translated into preliminary 'best practice' guidance for coastal managers.

Objectives

The main purpose of the research was to provide a scientific grounding in cohesive shore platform erosion and to translate this into preliminary guidance to help decision makers implement effective management strategies along these types of shoreline. Specific objectives were to:

1. design and implement field programmes at two contrasting platform-beach sites along the United Kingdom coast to collect samples and gather *in situ* data on platform downwearing, geology and biology;

2. test the platform and beach samples in the laboratory for geotechnical, biological and textural parameters;

3. interpret and integrate the field data and the results of the sample tests into an overall assessment of platform weathering and erosion, and their relationships with platform and beach morphology;

4. collect current and historical data of the sites and neighbouring shorelines to describe their local geomorphological interactions and their role in larger coastal systems;

5. use the data, geomorphological descriptions and interpreted results to produce models of the sites;

6. produce a final report on the scientific results of the project and translate these into preliminary best practice guidelines regarding management of these shorelines;

7. draw conclusions relevant to practical shoreline management arising from the project, through cross-Theme exchange of results and an end user workshop.

The above objectives have been achieved during the study.

Literature Review

Cohesive shore platforms tend to be located in some of the most rapidly eroding parts of the UK, such as Holderness, Essex and Kent. The erosion and weathering of cohesive shore platforms has three often overlooked, but nonetheless critical, implications on the functioning of the wider coastal system since:

(i) the platform tends to regulate wave energy impinging on the toe of a sea cliff and, over time, the rates of platform downwearing tends to govern the rates of cliff recession;

(ii) platform morphology has an important relationship with beach form; and

(iii) platform downwearing processes release significant volumes of sediment into the wider coastal system.

Previous literature has investigated the function of cohesive shore platforms within the wider coastal system. There is general agreement that the rate of platform downwearing is a key control on the long-term rate of cliff recession. Effectively, the whole profile is considered in many cases to retreat uniformly while maintaining a relatively uniform cross-shore shape. Since most profiles are steeper towards their upper limits, the rate of downwearing of the upper platform is often greater than at the mid and lower platforms.

Cohesive platform profiles with very little overlying beach have been identified in the literature as being similar in shape to profiles of completely sandy beaches along the same shoreline. Previous model tests have revealed the criticality of the ratio between beach sediment thickness and beach particle size on platform behaviour, with low ratio relationships leading to exposure of the underlying platform and high ratios resulting in more stable beaches.

Cohesive shore platform behaviour also has critical implications for the performance of coastal defence schemes since downwearing rates also potentially affect:

(i) effective water depth at the toe of shoreline structures, leading to increased loading conditions and overtopping volumes; and

(ii) undermining of the toe of defences.

The key control on all of the above behaviours and interactions is the rate of vertical lowering of the platform. This 'downwearing' rate, which integrates processes of marine erosion and subaerial weathering, is influenced by the geology and geotechnical properties of the material, the wave climate and tidal regime, the effect of beach sediment cover and the amount of biological activity. The literature reveals eight key processes which can contribute to the overall rate of platform downwearing:

1. Abrasion by mobile non-cohesive surface sediment - where sand or gravel is 'dragged' across the platform's surface by wave or tidal action;

2. Mechanical wave erosion - the extent of which is governed by the shear strength of the platform's material relative to the applied stress of the incoming waves;

3. Biological processes - with burrowing playing a role in weakening the platform surface prior to mechanical erosion;

4. Desiccation and weathering - where repeated wetting and drying causes expansion and contraction of the upper layers of the platform, resulting in tensional fatigue and fracturing;

5. Physio-chemical effects - which can help improve resistance against erosion between clay particles through enhanced net attractive forces, caused by an increase in salt concentration in surface pore water;

6. Freeze-thaw cycles - which leads to frost weathering and increased material fatigue;

7. Stiffening of the fabric due to removal of overburden - caused by 'unloading' effects associated with recession of backing sea cliffs and consequent 'swelling' of the foreshore;

8. Softening of the fabric due to pressure fluctuations induced by waves - due to cyclic loading and unloading related to the passage of waves, again leading to material fatigue.

Despite the importance of these platform downwearing processes, the literature reveals somewhat limited understanding of the relative importance of each process and a real paucity of data relating to their integrated effect in the form of measurements of actual downwearing rates. Whilst measurements have previously been undertaken on rocky shore platforms and on unconsolidated inter-tidal mudflats, downwearing of cohesive shore platforms is poorly researched. Due to the intention of this study in filling this gap in understanding, a review was undertaken of techniques previously used to measure downwearing rates in other environments and the best aspects of some of these approaches were incorporated into the subsequent design and construction of a device to measure cohesive platform downwearing as part of the present study.

Field and Laboratory Investigations

Due to the absence of data relating to downwearing processes and rates on cohesive shore platforms, field and laboratory investigations were undertaken at two contrasting sites in the UK, namely (i) Warden Point, Isle of Sheppey, Kent; and (ii) Easington, East Riding of Yorkshire. These investigations included measurements of platform downwearing, beach morphology and geotechnical and sedimentary properties and were supported by wave transformation modelling.

At Warden Point the platform is wider and shallower than at Easington, and is covered by a much narrower and thinner fringing beach, in contrast to Easington where large sand bars are present and are observed to migrate along the coast. Being relatively lower in the tidal frame, the Easington platform is covered by every tide (and is not uncovered by neap tides), whilst only the highest spring tides fully covered the platform at Warden Point.

The average downwearing recorded on the shore platform at Warden Point over the measurement year (July 2005 to July 2006) was 17.63mm. The upper platform exhibited the greatest average downwearing (30.59mm), the upper middle platform considerably less (13.75mm) and the lower-middle platform the least (8.5mm).

Downwearing at Warden Point was greatest during the February to May 2005 period and, when considering the micro-scale topography, downwearing was much greater on raised areas than in the depressions.

At the Easington shore platform, downwearing rates averaged 41.93mm per year between July 2005 and July 2006. This is considerably greater than the rate recorded at Warden Point and is likely to be influenced by the sand bar/ord migration along the coast. The average annual downwearing rate at the mid platform (43.4mm) was marginally greater than at the lower platform (39.8mm). No measurements were possible at the upper platform location in July 2006 because the datum box was buried under >5m of beach sediment cover. It is postulated that such extensive beach material coverage is likely to have protected the platform against downwearing.

As at Warden Point, raised areas in the micro-relief experienced greater downwearing than depressions/micro-runnels.

At Warden Point five live fauna species were recorded, namely: American Piddock; Mud Shrimp; Bristle Worm; Sand Mason; and Acorn Barnacle. This is much less diversity than is typically recorded on platforms of other rock types (e.g. chalk and sandstone), but much greater than at Easington where only empty holes or dead shells of the White Piddock were observed (no live species were recorded during the life of the project). This lack of biological activity at Easington is presumably related to the volatility of the beach morphology, with the periodic covering by sand bars being a limiting factor on longevity of colonisation.

At Warden Point, the American Piddock and Mud Shrimp were found in greatest numbers. Peak colonisation of Mud Shrimp was found on the upper platform, with densities decreasing with seaward progression. In contrast, American Piddocks were observed in greatest numbers on the lower platform, near the MLWS mark. There was little difference in biological activity between the summer and winter surveys for all species except the Sand Mason, which declined in numbers in the winter.

The Mud Shrimp is likely to have weakened the upper platform at Warden Point, where it was recorded in greatest numbers, but only within the upper 1cm of platform surface. In contrast, the American Piddock, whilst coinciding with areas of lower downwearing rates, excavates far greater quantities of sediment and weakens the platform to a much greater depth (up to 10cm).

Although large quantities of algae were recorded on several surveys, the protection afforded to the platform is unlikely to have been great since most were attached to pebbles and not the platform surface itself.

No strong relationship could be found between cross shore variations in material strength and the field-measured downwearing rates, suggesting that whilst geotechnical properties are of importance other factors were more dominant controls on downwearing at the two field sites.

The profile surveying showed little change in beach and platform profile morphology at Warden Point between July 2005 and February 2006. In contrast, however, massive changes were recorded at Easington where, following the July 2005 survey, a sand bar covered the profile around November/December 2005, burying the platform over much of its length. The oblique shoreline-attached sand bars are separated along the Holderness coast by shoreline-oblique runnels known as ‘ords’. The profile changes recorded between the July 2005, March 2006 and July 2006 surveys are consistent with the southward passage of an ord across the site.

The inshore wave climate at Easington is considerably greater than at Warden Point, with near shore significant wave heights of up to 3.5m modelled (compared with up to 1.5m at Warden Point).

At Warden Point, the greatest influences on platform downwearing were biological processes and mechanical wave action. At Easington, wave action and beach morphology changes were the principal influences. Due to this finding, numerical modelling tests were run to focus on the importance of biological process at Warden Point and beach/platform interactions at Easington.

Numerical Modelling

Numerical modelling offers the potential for deeper understanding of shore morphology than would be possible based on a study involving field observations alone. This is because, once set up, models can be used to simulate responses over a range of timescales to various input scenarios. In the present study, the Soft Cliff and Platform Erosion (SCAPE) model has been used for such scenario testing. This has included a model representation of the study sites at Warden Point and Easington to investigate the roles of biological processes and beach morphology changes, respectively, and to explore, at a generic level, more fundamental questions about cohesive shore platform dynamics.

SCAPE is a systems-based model of the processes and interactions through which the profiles of cohesive shore platforms emerge over long timescales. The foreshore and lower cliff is represented by a series of longshore sections, each of which is composed of a stack of horizontally aligned erodible elements. The underlying equation for the retreat of each element comprises parameters representing the breaking wave conditions, tidal variations, profile slope, and insitu material strength. The model links together modules representing the above parameters with cliff recession and talus formation, sediment transport and beach behaviour.

At Warden Point, the site-specific SCAPE model was run to generate an emergent shore profile. The introduction of a small volume of beach material (per metre run) caused the upper foreshore to steepen such that the resultant model profile was notably higher in the tidal frame than the measured profile at this location. Some process that removes material from the shore was thought not to be represented in the model to cause such a result. Consequently, the model was re-run to test the sensitivity of the profile response to biological activity, with results yielding a modelled profile that was much more closely matched to the measured profile. It can therefore be concluded that the direct material removal and, more importantly, fabric weakening caused by biological activity (burrowing) plays a significant role in shaping the foreshore over long timescales at Warden Point.

A similar site-specific SCAPE modelling exercise was undertaken at Easington, although the representation of a beach across the cohesive shore profile was complicated by the atypical, perhaps unique, presence and cyclic behaviour of the oblique near shore sand bars and ords. Ultimately, the model represented the upper beach using a conventional empirical curve, with the sand bar represented by a bespoke vector fit to measured field data, with its migration represented by an annual antiphase sinusoidal fluctuation.

Whilst the modelling exercise did produce a reasonably good representation of the Easington foreshore, no firm conclusions could be drawn relating to the interaction between the beach, bar, ords and platforms. More success was achieved, however, with generic testing of beach/platform behaviour. In a series of model experiments a previously validated SCAPE model (developed at Walton-on-the Naze, Essex) was perturbed in various ways to explore the consequences for the profile and shoreline recession rate. The principal focus of these experiments was foreshore dynamic response to changes in beach volumes, caused either directly (e.g. replenished foreshores) or indirectly (e.g. foreshores managed through groynes) through management approaches.

Following introduction of a beach, the shoreline (measured by the cliff toe/upper platform junction) recession rate stopped initially, but then increased again over time. This was caused by the introduced beach material becoming progressively thinner and more widely dispersed across the profile. The benefits of (one-off) beach replenishment therefore were shown to diminish with time. A critical issue associated with this, therefore, is whether replenishment has any residual influence on the longer-term recession rates once its shorter-term benefits are expended. Through further model testing it was demonstrated that a highly non-linear relationship existed between beach volume and long-term recession rate. This means that engineering measures to increase beach volume will only have a lasting effect if the introduced volume is above a certain threshold, which is site-specific and dependent on tidal range, wave conditions and sea level rise.

Further model tests revealed that a decision to cease nourishment or allow groynes to fail, leading to reduced beach volumes, will result in an initially rapid rate of shoreline recession (i.e. 'catch-up'), with rates gradually returning over time to antecedent values. Consequently in these cases, the intervention works have no longer-term residual benefit once stopped or removed.

The effect of sea level rise on profile response was also investigated, with results indicating more rapid recession and an increasingly steep profile form for higher rates of sea level rise. This response is due to sea level rise progressively translating the portion of the profile that is subject to wave attack (and its profile flattening consequences) further landwards to higher elevations. Under higher rates of sea level rise, each elevation in the profile is flattened less as it is exposed to wave attack for shorter durations, meaning that the profile shape changes as it migrates landwards (in contrast to many widely applied assumptions that the form remains constant).

Conclusions and Preliminary Management Guidance

Previously, little work existed on the relative importance of erosion and weathering processes on cohesive shore platforms. The field investigations and laboratory tests in this study have yielded the first direct measurements of key processes and parameters in such detail in the UK. Results demonstrate that whilst a range of factors contribute to overall platform downwearing in some way, it is the incident wave energy and presence (or absence) of a beach that are by far the most significant factors. The tidal range, which influences where wave activity impinges on a profile and also influences wetting-drying cycles across the platform, and both biological activity and material strength are all processes of some importance (e.g. in resisting wave activity or in weakening the material strength in advance of mechanical erosion by waves). However, even these processes can be deemed of considerably lesser significance than the dominating wave conditions and nature of a covering beach.

From the field investigations, it is quite clear that interaction between the beach and the platform occurred at Easington, where migrating sand bars covered the platforms during part of the field campaign. The effect of this was two-fold. Firstly the upper platform was covered by an extensive volume of material which did not move significantly during the experiments. Here, the platform is likely to have been well protected by the beach. Lower down the platform, the more mobile sand bar coverage is likely to have contributed to the high downwearing rates through abrasion of the platform by the non-cohesive material.

Numerical model testing has further investigated these interactions and has demonstrated that the shore platform/beach interaction is an important regulator of landward shoreline recession.

Cohesive shore platforms are formed by processes of erosion. As this happens, material is released that constitutes an important, and often overlooked, component of the coastal sediment budget. These natural processes can, however, be problematic for coastal managers, who are faced with several issues related to the erosion of cohesive shore platforms. The erosion process can directly lead to loss of inter-tidal and sub-tidal habitat, which supports a range of faunal species, although it is recognised that such landforms are not as ecologically rich (in terms of either diversity or density) as other shore platform types (e.g. chalk, sandstone and other rock types) or other inter-tidal landforms (e.g. mudflats and salt marshes). Erosion processes can also expose and lead to the loss of sites of archaeological or geological importance. Further to this, erosion processes release material from the platform that constitutes an important, and often overlooked, component of the coastal sediment budget.

The erosion of cohesive shore platforms can also have negative consequences for coastal engineering interventions. Continued platform lowering, in the absence of a substantial protective beach, can lead to exposure and ultimately failure of the foundation of coastal defence structures, for example. Elsewhere it is the consequences of the platform erosion on beach levels and cliff recession rates that are of concern to coastal managers.

In essence, the possible management responses to such problems are to:

(i) Do nothing;

(ii) Stop or limit the downwearing of the platform; or

(iii) Manage the consequences of the platform downwearing.

The policy of ‘managed realignment’ (i.e. the removal of existing coastal defence structures) is also considered in the following discussion for completeness.

Do Nothing:

In situations where no cliff-top or foreshore assets are at risk from the processes, the irreversible downwearing of cohesive shore platforms does not necessarily cause a management concern, either directly or through its effects on beach levels or cliff recession rates. In such situations, the natural erosive processes should be allowed to continue since they release an important contribution of fine-grained material to the coastal sediment budget.

It is important to note that the adoption of a ‘Do Nothing’ policy will not, in the medium to long-term, necessarily result in a continuation of historic recession rates. This is because climate change, in particular accelerated sea-level rise, is expected to increase the erosion of cohesive shore platforms.

The use of predictive models, such as SCAPE, can provide managers with an indication of the scale of downwearing and cliff recession anticipated under different climate change scenarios so as to inform their decisions about whether or not the processes cause a longer-term risk to assets that are presently set-back from the current cliff edge. This predictive capacity can also be used to help inform land-use planning and development control activities.

Stop or Limit Downwearing of the Platform:

Where the downwearing of cohesive shore platforms, or the consequences of this process on beach levels or cliff recession, does cause a problem for cliff-top or foreshore assets, management efforts could be made to limit the downwearing rate. This is best achieved through the introduction of a protective covering of beach material across the platform. Such beach replenishment activities need to ensure a sufficient volume of material and regular maintenance (e.g. periodic ‘top-up’ replenishments) in order to remain protective and prevent enhanced erosion through processes of abrasion.

SCAPE modelling revealed that cohesive shore platforms respond dynamically to the introduction of a beach. This is important because it means that benefits seen shortly after beach building may not be sustained without increasing levels of investment. Over time the foreshore steepens, causing the beach to spread across it and become thinner. Ultimately the recession increases, and may return to pre-intervention rates.

The numerical models indicate that the critical threshold determining whether an artificial beach will reduce shoreline recession rates in the medium to long-term is how far it protects across the intertidal zone. If the beach provides some protection to the region between MLWN and MLWS and above then it will begin to have an effect on the equilibrium recession rate. If it does not extend this far then its benefits will only be transient. The further the beach extends beyond this level the more benefit it will bring.

Manage the Consequences of Platform Downwearing:

As an alternative to management of the platform downwearing process itself, a decision could be taken to manage its consequences using shoreline recession control structures. Typically, these may take the form of a seawall or revetment running along the toe of a sea cliff.

In such instances, it must be recognised that the downwearing of the fronting platform is likely to continue leading to:

- Increased wave loading on the defence structures as the water depth in front of them increases, due to both platform downwearing and sea level rise; and
- Decreased structural stability and increased risk of undermining of the foundations of the defence structures; and
- Narrowing of the intertidal zone, potentially leading to its disappearance.

When designing coastal defence structures, engineers incorporate an allowance in the design crest levels to account for predicted sea level rise over the design life of the scheme. Previous MAFF Flood and Coastal Defence Project Appraisal Guidance (MAFF, 1999) suggested an allowance be made of 6mm per year in the areas of the UK where cohesive shore platforms typically are located. More recent Defra Supplementary Guidance (Defra, 2006) has amended this linear allowance and recommends the following alternative arrangements for different future epochs for the east coast of England south of Flamborough Head (i.e. where both Easington and Warden Point are located):

- 1990 to 2025 4.0mm per year;
- 2025 to 2055 8.5mm per year;
- 2055 to 2085 12.0mm per year; and
- 2085 to 2115 15.0mm per year.

Such rates of sea level rise are often considered as significant when planning and designing coastal management responses, yet they are small in comparison to the rates of shore platform lowering measured at Warden Point and, particularly, Easington as part of the present study. Consequently, such downwearing rates should be incorporated into design aspects involving: (i) crest level design (e.g. through changes in overtopping volumes over time); (ii) calculation of wave loading forces on structures; and (iii) determination of foundation depths below existing, and predicted future, foreshore levels.

Managed Realignment:

If a decision is taken to cease or remove engineering interventions such as beach nourishment, groynes, seawalls or revetments to allow a coast to retreat the shoreline is likely to exhibit an initial ‘catch-up’. Coastal managers should anticipate and account for these high rates of recession, which occur whilst a state of equilibrium with the governing processes is re-established.

When considering this question it is useful to first estimate the coastline’s notional uninterrupted location, i.e. where it *would* be if the intervention had never been made. This can be found by multiplying the equilibrium recession rate prior to the intervention by the duration of the intervention. The numerical modelling work done within this study indicates the following:

- If the intervention protected the profile between MLWN and MLWS then the shoreline may not reach its uninterrupted location;
- If the intervention only protected higher elevations, *and* the coastal system is otherwise unchanged from its pre-intervention state then the shoreline is likely to catch up with its uninterrupted location; and
- The shoreline may retreat landward of its uninterrupted location if the coastal system has changed, for example if the beach volume has reduced, causing a more gently sloping foreshore.

The above issues are becoming increasing relevant as the policy of managed realignment is now being more pro-actively considered in the second round of Shoreline Management Plans for the coastline of England and Wales.

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

Balson, P.S., Brew, D.S., Charman, R.O., Hobbs, P., Moses, C.A., Pearson, S., Walkden, M. and Williams, R.B.G., 2006. Defra Conference on Flood and Coastal Erosion Risk Management 4th to 6th July 2006.

Brew, D.S.; Balson, P.S.; Pearson, S.; Hobbs, P.; Williams, R.; Robinson, D.; Moses, C. And Walkden, M., 2004. The implications of cohesive shore platform erosion for coastal management. Proceedings of Littoral 2004, Vol 2 (Aberdeen, Scotland), pp. 590-595.

Cooper, N.J.; Brew, D.; Balson, P.S.; Pearson, S.; Moses, C.A.; Williams, R.; Charman, R and Walkden, M., 2007. Erosion of cohesive shore platforms. Proceedings Institution of Civil Engineers International Coastal Management Conference, Cardiff, October 2007.

Defra, 2007. Understanding and Predicting Beach Morphological Change Associated with the Erosion of Cohesive Shore Platforms. R&D Technical Report FD1926/TR.