

# CELL 1 REGIONAL COASTAL MONITORING PROGRAMME

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**Key Words:** North East, Sediment Cell, Coastal Management

**Abstract:** Region-wide coastal monitoring is important to ensure that coastal management decisions are made based upon accurate and up-to-date information on coastal change. This paper presents the background to, and initial results from, the Cell 1 Regional Coastal Monitoring Programme, which covers the coastline between the Scottish Border and Flamborough Head in the North East Region.

## INTRODUCTION

This Regional Coastal Monitoring Programme covers approximately 300km of the north east coastline, from the Scottish Border (just south of St. Abb's Head) to Flamborough Head in East Yorkshire. This coastline is often referred to as 'Coastal Sediment Cell 1' in England and Wales (Figure 1). Within this frontage the coastal landforms vary considerably, comprising low-lying tidal flats with fringing salt marshes, hard rock cliffs that are mantled with glacial till to varying thicknesses, softer rock cliffs, and extensive landslide complexes.

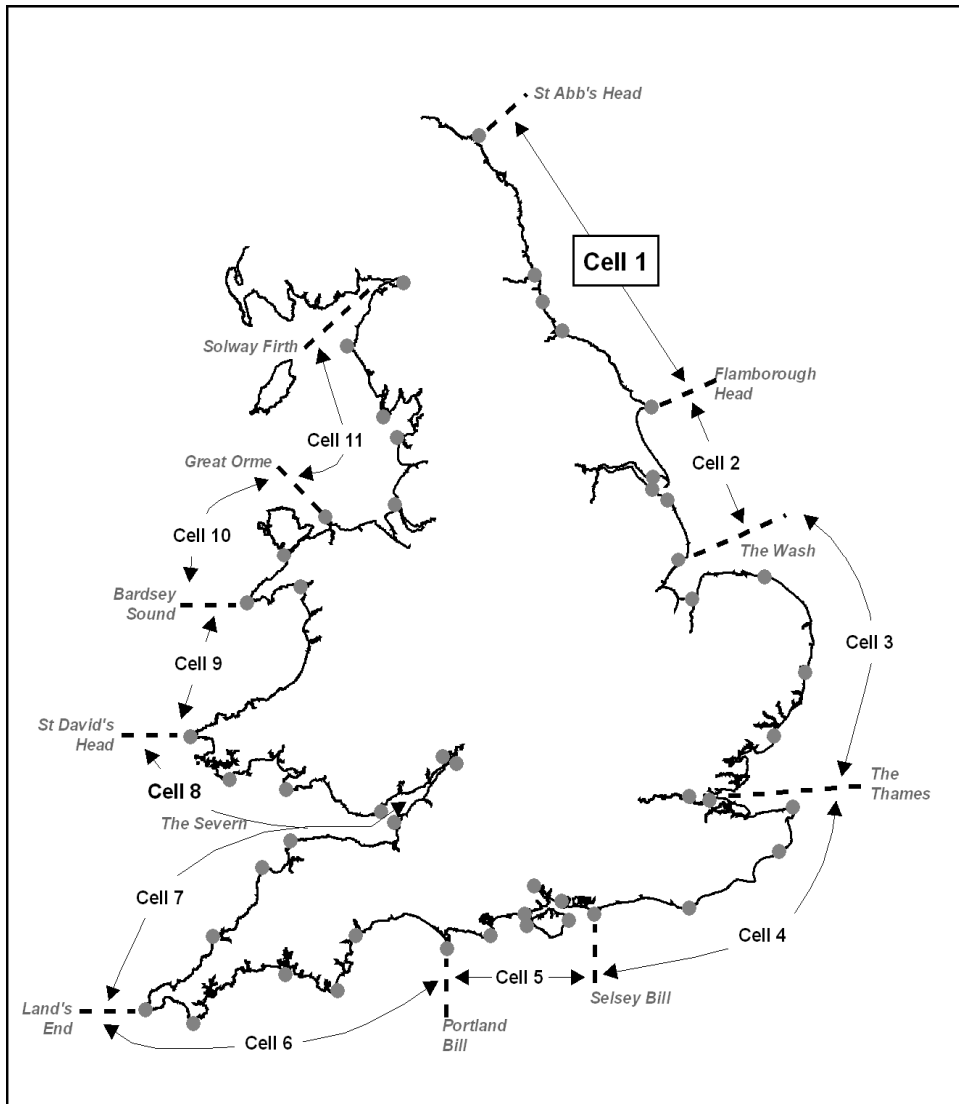


Figure 1. Coastal Sediment Cells around England and Wales (after Motyka and Brampton, 1993).

The programme commenced in its present guise in September 2008 and is managed by Scarborough Borough Council on behalf of the North East Coastal Group. It is funded by the Environment Agency, working in partnership with the maritime Local Authorities and other relevant bodies such as Natural England, and the National Trust.

The main elements of the Cell 1 Regional Coastal Monitoring Programme involve:

- beach profile surveys
- topographic surveys
- cliff top recession surveys
- bathymetric and sea bed characterisation surveys
- real-time wave data collection
- aerial photography
- walk-over surveys

This paper provides information on the background aims and objectives of the programme, presents some initial findings to date, and describes dissemination activities, including demonstration of how the data is already being used to help inform coastal management decisions in the region.

### **REGIONAL COASTAL MONITORING**

Coasts can be highly dynamic environments. In order to assess and appropriately manage the risks from coastal erosion and sea flooding, maritime Local Authorities and the Environment Agency, together with other organisations with related responsibilities, have recognised the need for regional coastal monitoring programmes to improve the long-term and wide-scale understanding of coastal processes and shoreline change across coastal cells. Robust coastal management decisions can truly be identified with confidence when a long-term region-wide understanding of processes and shoreline change is available, through a purpose-designed monitoring programme.

Put simply, regional coastal monitoring programmes need to provide core essential data that are subsequently used to continuously improve understanding of coastal processes and shoreline change in order to inform decisions relating to a large number of management issues, including the assessment of coastal erosion and sea flooding risk and the selection of relevant long-term management policies or options to manage such risk, including providing advice essential for future adaptation in response to climate change.

The data provided through regional coastal monitoring programmes will also help enable the set-up, calibration and verification of numerical models that are used in initiatives such as Tidal Flood Forecasting Systems and physical coastal process assessments, thereby improving confidence in their outputs. These data are also used to reduce uncertainty in design assessments for capital schemes, fine-tune operational and maintenance regimes, and enable post-project evaluation of specific schemes to be interpreted within a broader context.

In essence, regional coastal monitoring programmes routinely and systematically provide essential data that enables the various maritime Local Authorities and the Environment Agency to appraise, identify and deliver cost-effective, technically feasible, and environmentally acceptable and relevant solutions to a wide range of coastal erosion and sea flooding risk management problems.

The particular advantages of such a region-wide understanding are:

- **Delivery of continuous improvement in shoreline management** – by continually building knowledge and understanding of how the coast behaves and evolves, the philosophy of Defra's Shoreline Management Plan Guidance (i.e. not just to repeat 'business as usual', but to enhance the coastal process understanding and its role in Shoreline Management Plan (SMP) production) will be delivered.
- **Selection of the most suitable SMP policies or Coastal Strategy options** – by providing improved coastal data more quantitative information on mechanisms and rates of coastal

change will mean that uncertainties are reduced and consequently policies or options will be selected that have greater sustainability in the longer-term.

- **Improved phasing of schemes** – improved understanding of the behaviour of the coastal systems will mean that schemes can be constructed at more appropriate timings, avoiding implementation earlier than they need be, under an overly precautionary approach, or later than they should have been, under a purely reactive approach involving emergency works.
- **Improved scheme design** – reduced uncertainties and improved measured data from the nearshore zone will mean that defences will be better designed to particular marine parameters, such as more appropriate crest levels to reduce overtopping risk, or foundation levels to reduce undermining risk from beach level changes.
- **Enhance operational management and maintenance regimes** – the context provided by the regional coastal monitoring data to local activities will provide opportunities in terms of operational management and maintenance regimes that are more tailored to local issues, such as seasonal beach level fluctuations, and also the implications of wider scale changes, such as longer term trends of erosion or accretion.

### **AIMS AND OBJECTIVES**

The aim of the North East Coastal Monitoring Programme is to provide better understanding on the coastal processes and the locations, rates and mechanisms of shoreline change at key locations between the Scottish Border and Flamborough Head.

Recognising that 'one size does not fit all', rather than simply mirroring programmes from other coastal areas of the UK, the programme has specifically been designed to gain further insight into areas of risk and uncertainty that were identified in the following Shoreline Management Plans (SMP) which between them cover the entire Cell 1 frontage:

- Northumberland and North Tyneside SMP2 (Royal Haskoning, 2009)
- River Tyne to Flamborough Head SMP2 (Royal Haskoning, 2007)

The design of the Cell 1 Regional Coastal Monitoring Programme therefore reflects the nature and magnitude of the uncertainties in the coastal erosion and sea flooding risks in the North East Region.

The selection of appropriate monitoring techniques and suitable data collection frequencies took into consideration the following:

- anticipated extent and mechanisms of change in cliff top position, based on understanding of underlying solid geology and overlying drift geology;
- behaviour of dunes and beaches, based on seasonal and longer-term historic observations;
- magnitude and variation in coastal forcing conditions, such as waves, tides and surges;
- composition of shoreline and nearshore sediments and their dynamism;
- extent of development in areas of coastal change, recognising that much of the north east coastline is rural but that there are some key urban and industrial areas;
- the anticipated behaviour of the coastal cell under future climate change; and
- the availability of complementary data from other sources (e.g. Environment Agency, Port Authorities, CEFAS Wavenet).

The intention is that by collecting and analysing coastal monitoring data our understanding of the way in which this coastal cell functions will improve and the resulting information will be used to provide effective and sustainable coastal management decisions into the future, informing any coastal strategies and schemes emerging from the above SMP2s, and the future SMP3 in around 10 years.

**PROJECT PARTNERS**

The North East Coastal Monitoring Programme is being undertaken as a partnership between the following authorities:



**Note:** From 1<sup>st</sup> April 2009, Berwick-upon-Tweed Borough Council, Alnwick District Council, Wansbeck District Council, Castle Morpeth Borough Council and Blyth Valley Council became part of a unitary Northumberland County Council and Easington District Council became part of a unitary Durham County Council.

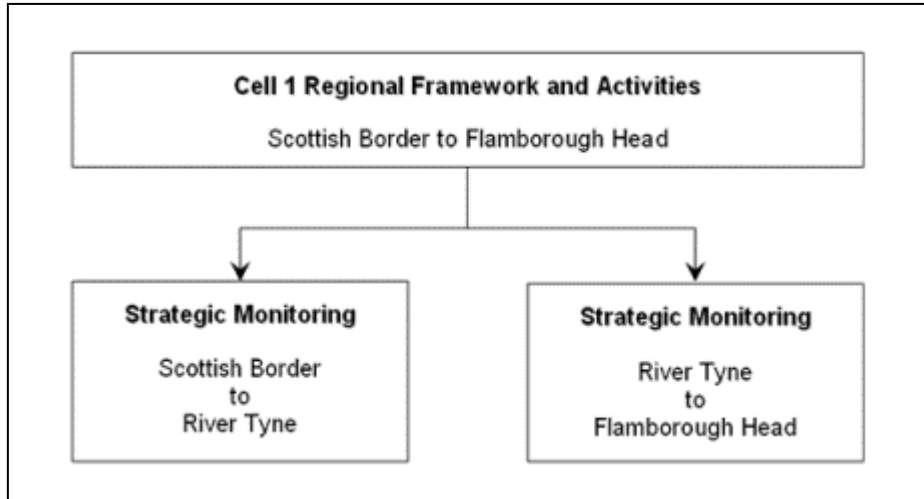
The data collection, analysis and reporting is being undertaken as a partnership between the following organisations:



## PROGRAMME DETAIL

Within the programme, there are three main components:

- Cell-wide Regional Framework and Activities
- Strategic Monitoring: Scottish Border to River Tyne
- Strategic Monitoring: River Tyne to Flamborough Head



### Cell 1 Regional Framework and Activities

This part of the programme provides an overarching framework within which the two strategic programmes are set. This ensures a general consistency of approach to data collection (e.g. standard specifications), data management (e.g. metadata documentation), and data analysis (e.g. annual cell-wide overview reporting).

The adopted approach also provides the basis for cost-effectively undertaking those activities which extend across the whole of Coastal Sediment Cell 1, such as aerial photography and wave data collection and analysis, and website development and maintenance for data dissemination.

This aspect of the programme comprises:

- Real-time wave data collection offshore from Whitby and Newbiggin (commencing later in 2009)
- Aerial photography (to be flown spring 2010 and at suitable intervals thereafter)
- Data management and website updates (ongoing)
- Cell 1 Overview Reporting (annual)

### Strategic Monitoring: Scottish Border to River Tyne

Although the North East Coastal Monitoring Programme started in its present guise in September 2008, strategic monitoring along the coastline between the Scottish Border and the River Tyne has been in place since April 2002.

This programme has been fine-tuned over the years and comprises:

- 'Full Measures' survey of 96 beach profile lines in autumn of each year
- 'Partial Measures' survey of 39 beach profile lines in spring of each year
- Topographic surveys along Holy Island causeway in autumn each year
- Topographic surveys along Alnmouth Beach in spring and autumn each year
- Cliff top surveys at Newbiggin Bay Caravan Park in spring and autumn each year
- Cliff top surveys at Sandy Bay Caravan Park in spring and autumn each year
- Analytical Report (annually, winter)
- Update Report (annually, spring)
- Walk-over surveys of coastal defences, cliffs, dunes and beaches (every 2 years)
- Inspection Report and update of National Flood and Coastal Defence Database (every 2 years)

### **Strategic Monitoring: River Tyne to Flamborough Head**

This programme commenced in September 2008 (although some local surveys pre-date this and these have been incorporated into the programme) and comprises:

- 'Full Measures' survey comprising beach profiles, topographic surveys and cliff top surveys in autumn of each year
- 'Partial Measures' survey comprising beach profiles, topographic surveys and cliff top surveys in spring of each year
- Analytical Report (annually, winter)
- Update Report (annually, spring)
- Bathymetric and sea bed characterisations surveys (scheduled for summer/autumn 2009)
- Walk-over surveys of coastal defences, cliffs, dunes and beaches (every 2 years, except for along Scarborough Borough Council's frontage which is annual due to the higher erosion risks that exists here)
- Inspection Report and update of National Flood and Coastal Defence Database (every 2 years, except for along the Scarborough Borough Council's frontage which is annual)

### **KEY FINDINGS TO DATE**

As the Cell 1 Regional Monitoring Programme only commenced in its present guise in September 2008, it is too early to provide any findings at the present time. However, the strategic monitoring component covering the Scottish Border to the River Tyne has been running prior to the present programme since April 2002, providing over seven years of data. From these data, which will remain ongoing under the Cell 1 Regional Monitoring Programme, useful findings have already been derived.

Some of the most notable shoreline changes have been observed along the beaches and sand banks around the mouth of the River Tweed estuary. Ongoing easterly migration of the channel separating the sand banks at the mouth alters exposure conditions at the shore. Within the inner estuary low beach levels and a very notable 2m erosion of the dune face have been recorded in response to this over the past year. Similarly, along the adjacent open coast, beach lowering also seems to be linked with changes in exposure associated with channel migration. Increased beach lowering could in turn lead to increased overtopping or undermining of defences. Both of these findings have important implications for current land use development proposals in this area, which should now allow suitable buffers to account for the changing risk conditions.

Elsewhere, beach levels have been observed to be highly seasonally dependent. In numerous locations upper beach berms and healthy beach levels are recorded during the post-summer surveys, with often low levels and flatter profiles recorded along profiles in post-winter surveys. The effect of major storms also seems to cause quite dramatic responses, with some record low beach levels being measured in surveys following significant events.

The north east coast has a heavy industrial heritage. The effects of this are noted in this paper by the examples of data from two locations, one in Lynemouth Bay and the other in Newbiggin Bay.

There are extensive slag banks composed of colliery spoil and other industrial waste fronting the toe of dunes and low cliffs to the north of Lynemouth Power Station. Spoil from Ellington Colliery was tipped onto the beach and foreshore for many years, advancing and subsequently maintaining the position of the shoreline in the bay through this 'beach feeding'. These activities finally ceased with closure of the colliery in 2005. The data derived from the monitoring programme is enabling the response of the shoreline to these changes to be quantified. Where the slag banks remain located above the limit of marine activity, such as towards the north of Lynemouth Bay, they are presently stable, but the fronting beach changes are quite rapid, causing lowering of levels and reductions in beach width (Figure 2). If these processes continue, the presently stable slag banks will become subject to marine conditions in the mid term.

Further towards the centre of Lynemouth Bay, the slag banks front a coal stocking yard. Here the banks are presently eroding, with around 2m landward retreat between October 2007 and 2008 (Figure 3). The effect is that a much steeper seaward face to the slag bank now exists, and this is likely to erode further due to unstable conditions as well as ongoing marine processes. These slag banks are also shown in Figures 4 and 5 captured during the 2-yearly walk-over survey inspections in summer 2008.

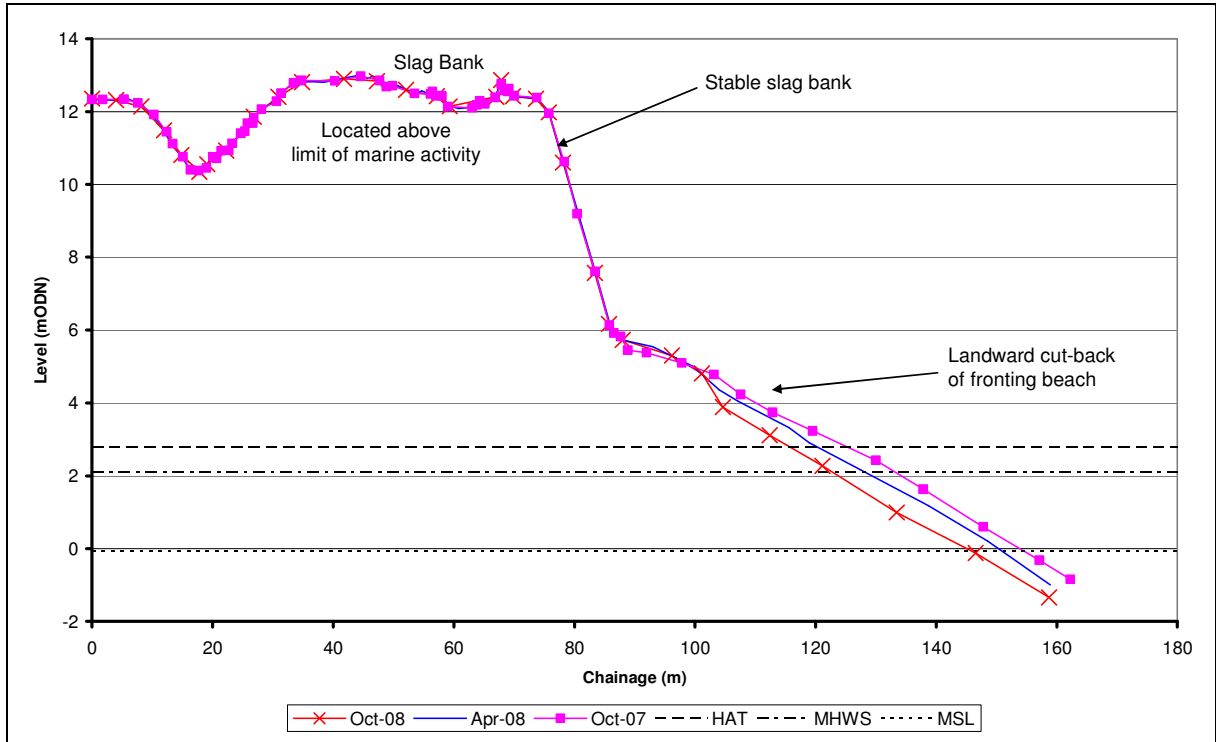


Figure 2. Profile changes in northern Lynemouth Bay

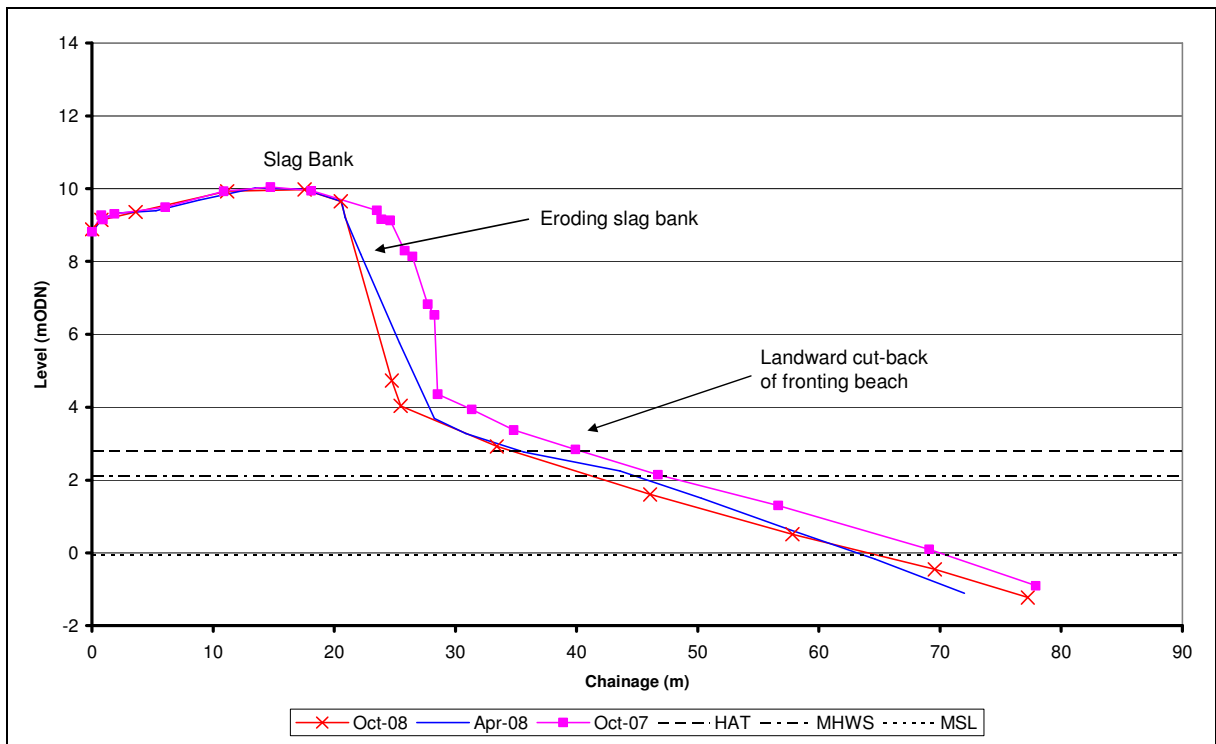


Figure 3. Profile changes in central Lynemouth Bay



**Figure 4. Slag Bank in northern Lynemouth Bay located high up the beach profile**



**Figure 5. Slag Bank in central Lynemouth Bay subject to marine processes**



Beaches within Newbiggin Bay have suffered badly from subsidence associated with historical coal mining activities that affected the offshore area and headlands that control the bay, coupled with ongoing erosion due to marine processes. Over the record of recent monitoring, this has resulted in the toe of the sea wall that protects Newbiggin-by-the-Sea becoming exposed and undermined. In response to this, a major capital coastal defence scheme was constructed in 2007, comprising foreshore sand recharge and the construction of an offshore breakwater. This restored the beach levels to very healthy volumes. Since scheme completion, the beaches have been adjusting to prevailing tidal and wave conditions and there appears to be measurable redistribution of sediment from southern and central sections to the north of the bay. Ongoing monitoring will particularly focus on better understanding these responses. These changes are shown in Figure 6. The capital scheme, completed in 2007, is shown in Figure 7.

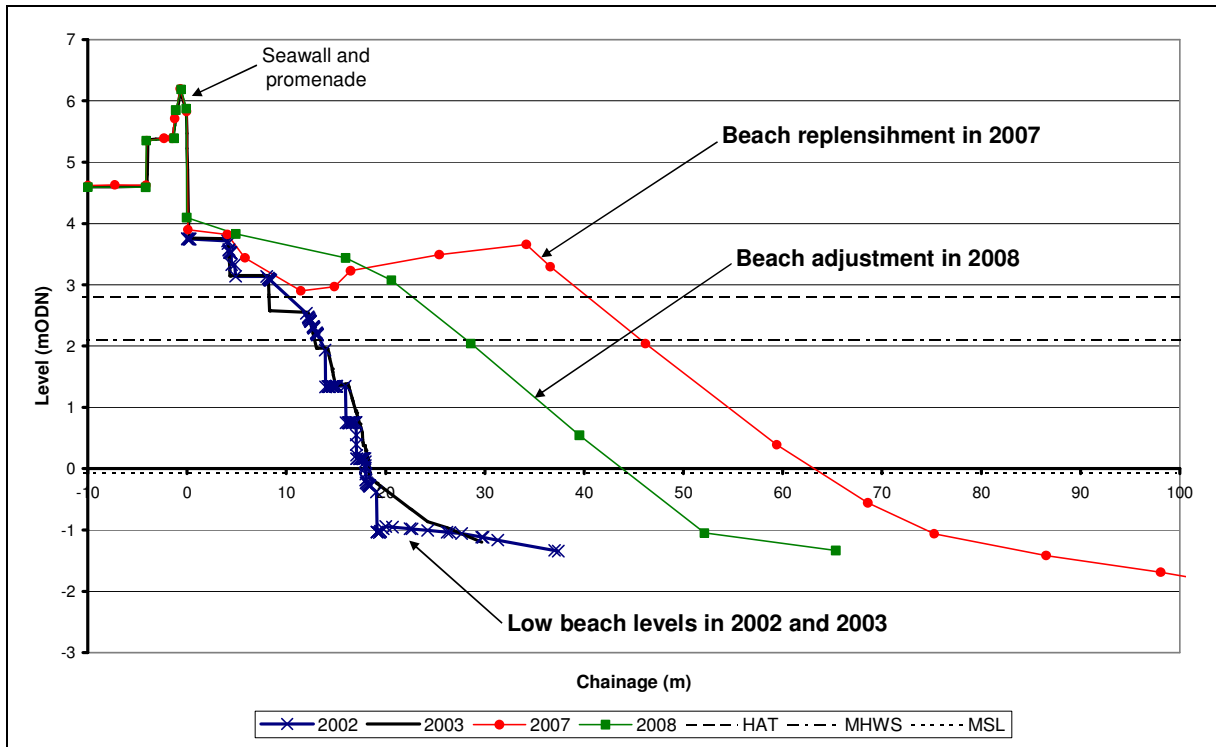


Figure 6. Profile changes in Newbiggin Bay.



Figure 7. Newbiggin Bay Coast Protection Scheme: Offshore Breakwater (left) and Replenished Beach (right)

## DISSEMINATION

Data and reports derived from the Cell 1 Regional Coastal Monitoring Programme are being made available for purposes of consultancy and research studies. These can be downloaded from the project website (Figure 8). Further details of the website will be presented at the conference.

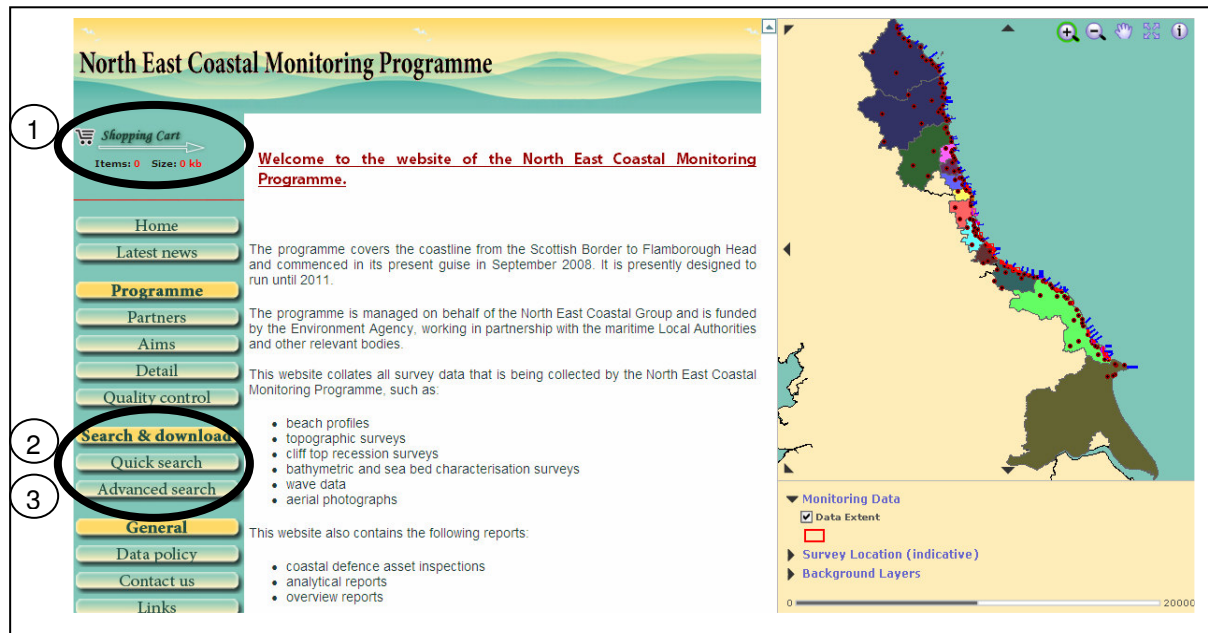


Figure 8. Coastal Monitoring Programme Website

Figure 9 shows that data and reports can be downloaded using a Quick Search or Advanced Search facility and loaded into a 'shopping cart'. The data and reports can be downloaded from the website free of charge, although users are asked to register and agree to Terms & Conditions of Use.

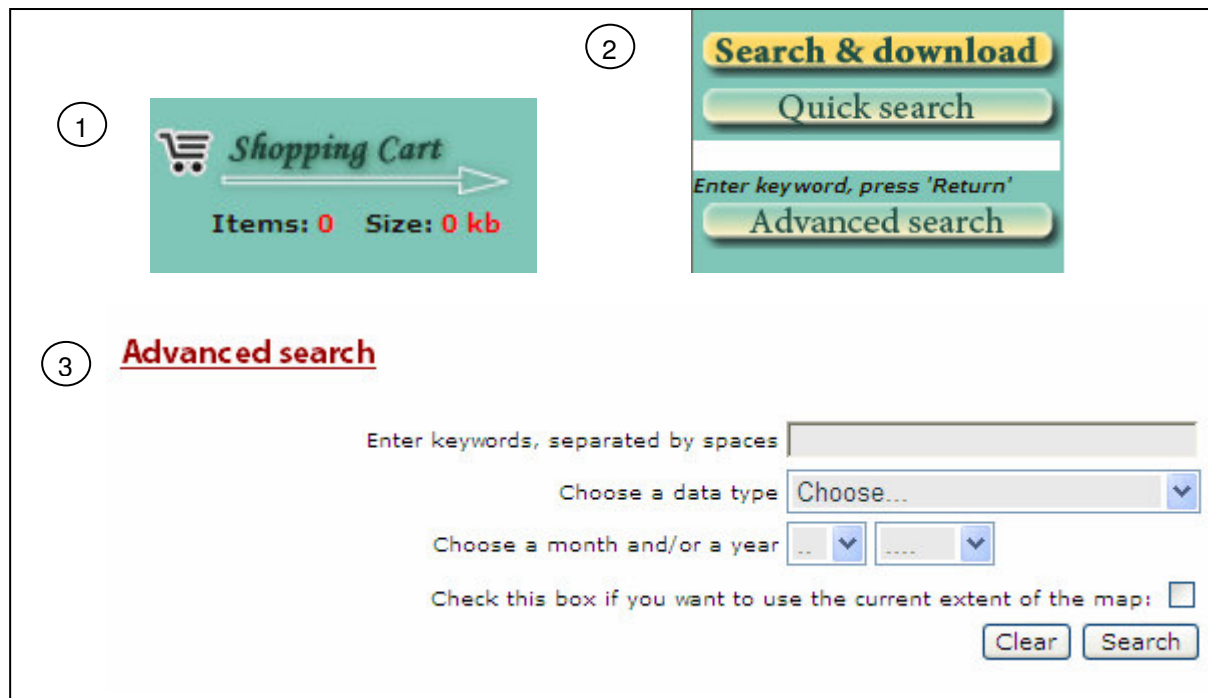
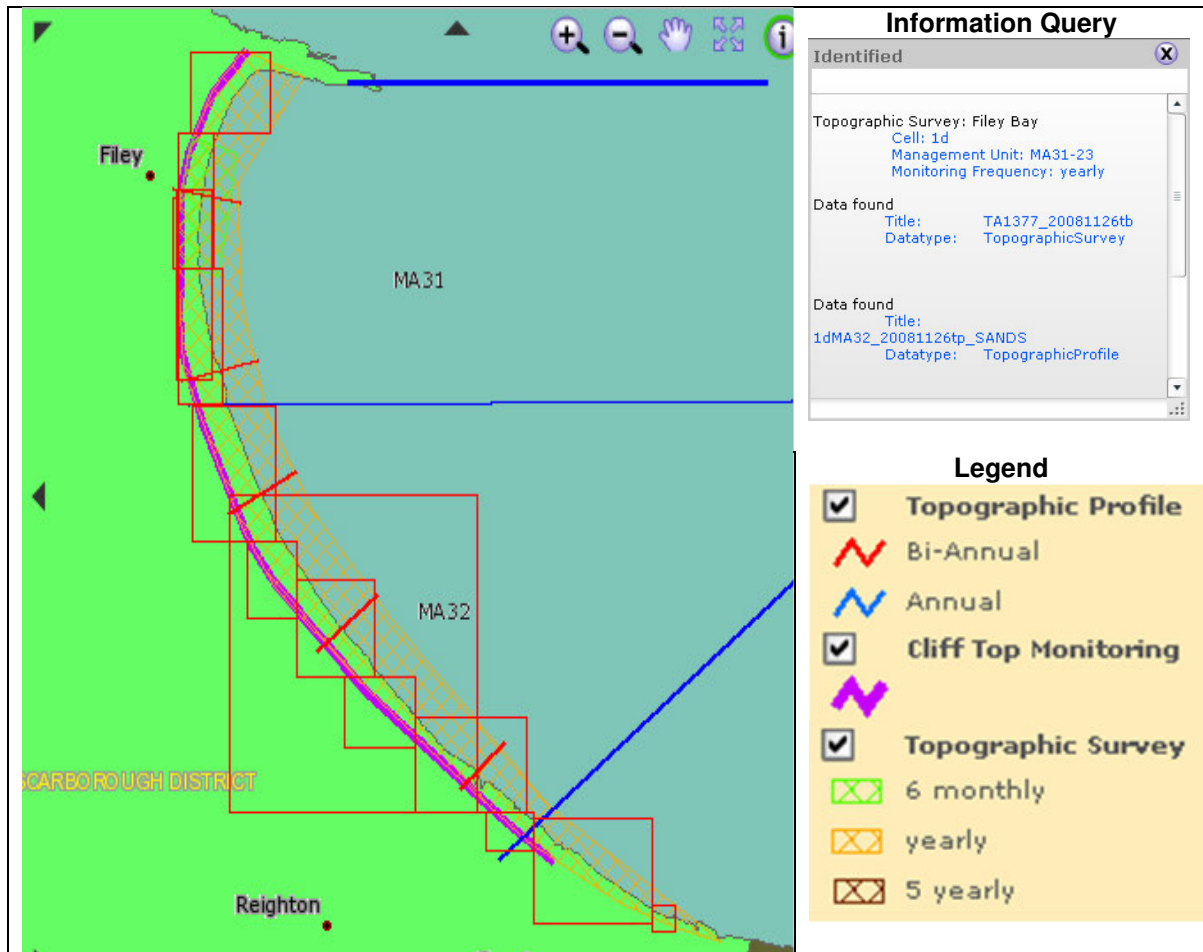


Figure 9. Website Search and Download Facilities

The map seen on the right hand side of Figure 8 is interactive, enabling zoom and pan operations and information queries, and can also be used to view the locations of the datasets, as shown in Figure 10.



**Figure 10. Interactive Website Mapping**

### DATA USAGES

To date, data emerging from the Cell 1 Regional Monitoring Programme have been used in a number of coastal management applications, despite the programme only running in its present form since September 2008.

- 'Analytical' reports have informed the Local Authorities and Environment Agency on seasonal trends in beach behaviour and areas of cliff and dune recession;
- 'Walk-over Inspection' reports have provided assistance in prioritising ongoing maintenance regimes and helped the Local Authorities fulfil their High level Targets with respect to reporting on coastal defence condition into the National Flood and Coastal Defence Database;
- A Rapid Geomorphological Assessment, informed by beach profile and walk-over inspection data, has been undertaken at Embleton Bay to advise The National Trust on the longevity of bungalows located on the dune ridge given ongoing coastal erosion and climate change;
- Beach profile, cliff top survey, aerial photography and walk-over survey data have been used as part of the post-project evaluation of the Trow Quarry Coastal Defence scheme near South Shields.
- Beach profile data (going back to April 2002) have been used to inform erosion rates used in the Northumberland and North Tyneside SMP, which has in turn informed the National Coastal Erosion Risk Mapping project.

## **CONCLUSIONS**

The Cell 1 Regional Coastal Monitoring Programme demonstrates how a large-scale monitoring programme can be designed to meet the specific issues and uncertainties of the coastline in a particular region. It is important to recognise that different regions of the UK have different characteristics, for example underlying geology, land use development, sediment composition, geomorphological evolution, and 'one size does not fit all' when it comes to the appropriateness of monitoring.

The monitoring that has been undertaken to date in the North East Region has already contributed to a number of applied coastal management initiatives, but still remains at a very early stage of its development. The real benefits of regional-scale monitoring arise when decadal scales of change can be identified from the long-term records, as is now starting to be possible with data from the Environment Agency Anglian Region's Programme which commenced in 1991.

## **ACKNOWLEDGEMENTS**

The authors would like to thank other partner organisations involved with the Cell 1 Regional Coastal Monitoring Programme across the North East Region and other members of our Project Team.

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