Assessing and monitoring coastal and climate change

Coastal risk management requires high quality information to support effective decision-making; it relies upon an understanding of coastal processes at work and the effects that these processes have on shoreline evolution. Monitoring provides an invaluable data source for coastal scientists and engineers alike. It also provides a basis for the design and development of coastal defence and landslide remediation works as well as encouraging greater confidence in efficient design of civil engineering works. Future requirements for remediation works can be predicted using monitoring data which may change the risk management philosophy from a reactive to a more pro-active one.

There are a wide range of monitoring techniques available relating to the coastline, while others have wider applications across a number of fields. Monitoring techniques can be airborne or space-borne as well as ship-borne or ground-based. The categories of information needed to assess coastal change include data on waves, wind, tides, currents, coastal slopes and cliffs, geology, geomorphology, hydrogeology, ecology, vegetation, bathymetry and land use.

Airborne and space-borne techniques are used widely to capture data and to provide coverage of special features, or where these techniques are either more practical or efficient than landbased methods. These techniques are often referred to as 'remote sensing' as they gather data from a distance beyond the immediate vicinity of the sensor device. The main airborne techniques used for remote sensing of the coastal environment include Interferometric Synthetic Aperture Radar (IfSAR or InSAR), Light Detection And Ranging (LiDAR), Airborne multispectral (MS) camera systems, Airborne thermal infra-red radiometers (TIR), and Hyperspectral sensors (Channel Coast Observatory Website, 2005).

Space-borne techniques refer to sensors that are mounted on-board a spacecraft (space shuttle or satellite) orbiting the earth. The main form of space-borne remote sensing is from satellite imagery, of which there are two main types, Moderate Resolution Satellite and High Resolution Satellite. Ship-borne techniques, for example bathymetric surveys, side-scan sonar and grab sampling are limited to the marine environment and collect data on the changes and rates of change of dynamic sediments below Low Water, changes and rates of erosion of fixed bedrock below Low Water, the identification of small-submerged features, which may affect sediment transport processes, changes within offshore sediment sinks, and habitat mapping to name just a few. Ground-based techniques take the form of topographic surveys, via levelling, a total station theodolite or global positioning system (GPS), although the method used may vary from site to site.

Once the raw data has been collected, numerous models are available to further analyse and predict shoreline change. Modelling techniques can either be in the form of a mathematical or numerical model which can be used to predict the volume of sediment transported alongshore as a function of the wave height, period and obliquity; or a computational model. Computational models can be used to analysis and predict sediment transport whilst other packages are available to model coastal change and erosion. Computational hydrodynamic models are site specific and range from lower resolution regional models to high-resolution local models. A hydrodynamic model could be run during extreme events to try to predict how sediments might move within a given area (Bradbury, 2004).

In relation to unstable coastal slopes and cliffs ground movement monitoring forms an integral part of instability investigation and ongoing management. It provides a means of accurately and objectively gauging the stability conditions of unstable or potentially unstable cliffs and slopes; it can also fulfil an important role in assessing risk. The objectives of instability monitoring include:

- providing information to assist landslide investigation;
- determining the rate and scale of ground movements particularly in vulnerable locations;
- identifying links between ground movement, rainfall and ground water levels that can be used to develop a methodology for landslide forecasting;
- provide early warning in areas where movements could affect life and property;
- monitoring the effectiveness of landslide management strategies. In addition, instrumentation can help deduce mechanisms of failure as well as assisting in design verification, construction control, quality control, performance of structures and provide legal protection against claims from owners of properties adjacent to construction sites.

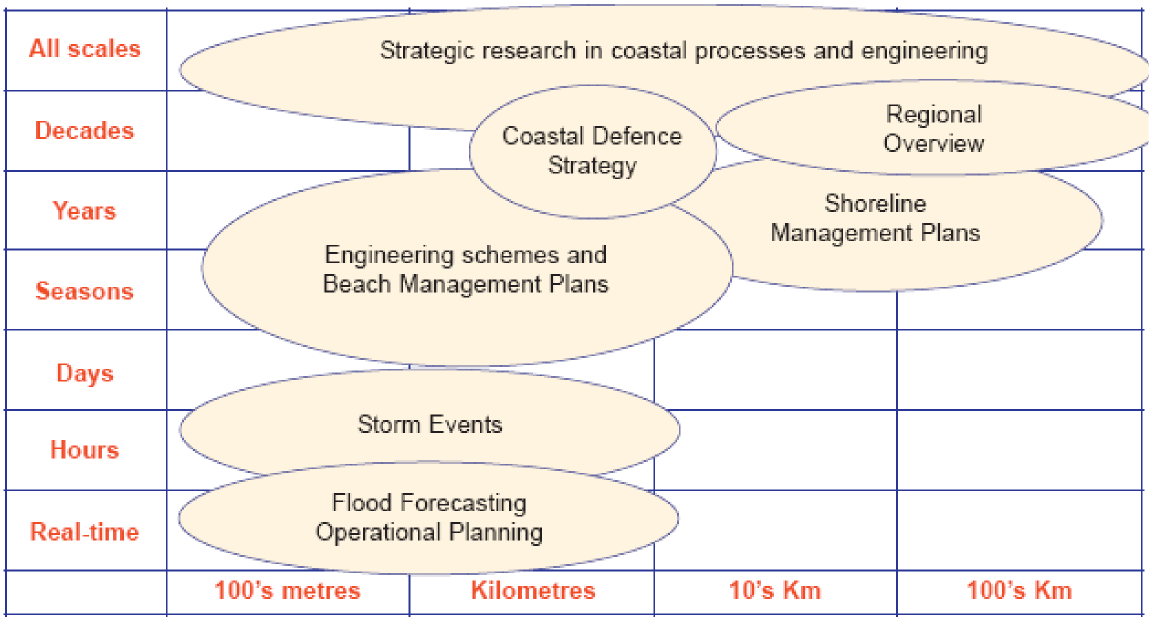
Strategic Coastal Monitoring

In England the strategic regional coastal monitoring programme commenced in August 2002; an initiative involving 31 Local Authority and Environment Agency partners in south-east England. The programme, which is grant-aided by Defra, has now extended across England with the aim of providing a consistent, repeatable and cost effective method of monitoring the coast to inform coastal risk management. In December 2008 a project board for the national monitoring programme was established to develop and implement the programme from 2011 onwards.

Large scale coastal monitoring programmes such as this provide a systematic approach to collection, management and analysis of data for strategic and operational management of coastal erosion and flood risk. The programmes are risk-based and integrate the requirements of operating authorities with coastal defence responsibilities at both strategic and operational levels. Technical and financial benefits are evident at a range of temporal and spatial scales.

A remarkable data set has been compiled so far which has enabled identification of a number of significant systematic patterns of strategic regional significance. Optimisation of beach management has been based successfully upon regional monitoring programme data. The programmes provide valuable insights into the performance of coastal systems and engineering works at a broad scale, with the high level of detail normally associated with much more localised programmes (Bradbury et al., 2007).

Coastal monitoring data are needed at a variety of temporal and spatial scales to allow robust assessments and prediction of coastal evolution (Figure 6.4). For example, strategic management initiatives such as Shoreline Management Plans and regional assessments require an understanding of large-scale evolution at spatial scales of the order of tens to hundreds of kilometres (i.e. sediment process cells), and temporal scales of the order of decades. In contrast, more localised issues such as development and maintenance of beach management schemes, typically require more detailed and localised data over a distance of a few kilometres. Short-term incident management (such as flood forecasting and storm event response) requires localised real-time and short-term data, based on changes over a period of several hours. Validation and development of generic management tools, however, such as predictive models, may benefit from data at all temporal and spatial scales.



The need for better prediction of large scale coastal evolution relates particularly to impending problems arising from sea level, rainfall and wave climate changes, in context with the need for sustainable SMP policies. Broad scale studies can provide information about mean shoreline trends and identify fluctuations from these trends but, at present, the ability to predict large scale coastal evolution is severely limited by the lack of long-term strategic coastal monitoring data. The inability to carry out robust assessments at broad scales has been criticised and has highlighted the need for a strategic approach to regional monitoring (Bradbury et al., 2007).

A strategic approach to monitoring provides a basis for capturing the data required to make reliable assessments of processes and to predict future changes. The accuracy of predictions improves dramatically with an extended length of records and hence long-term data sets (ideally 20-30 years duration) are required, with data collected at a variety of spatial and temporal scales, to provide optimal decision-making. This aim lay behind the risk-based design of a national monitoring programme, providing a tiered framework of data collection and analysis that enables detailed information to be filtered and cascaded to a range of potential applications. A major benefit of this integrated approach is that data is collected once and potentially may be used many times. A wide range of observation techniques and analysis procedures have been integrated; observation techniques include Light Detection and Ranging (LiDAR), bathymetric, RTK GPS topographic and aerial surveys, ecological mapping, and wave and tide monitoring. Consistent survey specifications, measurement and analysis techniques are used throughout the region.

Large scale coastal monitoring programmes have been established or are being planned for all of the English coast. Technical and financial benefits are evident at a range of scales, including regional overviews, strategic planning, operational management and strategic research.

The programmes include:

- topographic beach surveys
- hydrographic nearshore bed surveys
- aerial photography
- LiDAR (Light Detection and Radar)
- hydrodynamic data (waves and tides)
- remote sensing

Topographic survey programmes are carried out by specialist survey firms or Local Authority inhouse survey teams using state-of-the-art Real Time Kinematic GPS, similarly bathymetric surveys are conducted by a combination of Local Authorities and commercial survey firms.

Regular training events are arranged on data management and surveying techniques; these have been well attended by Local Authority and Environment Agency staff. All data are managed and archived at the Channel Coastal Observatory, Southampton, and other regional centres. Expertise is made available to all authorities for data interpretation with data being provided to each authority in a format which is tailored to each authority's individual needs.

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