5th Western Australian State
COASTAL CONFERENCE 2009
Whose Coast Is It?
adapting for the future

WACoast—A Knowledge Base for Coastal Managers

13B:
Analysis of Knowledge:
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Sirius Room

PRESENTER:

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Abstract

The Geological Survey of Western Australia recognizes the importance of geology and geomorphology as the framework underpinning decisions in the coastal zone and has recently completed a survey of the coast between Lancelin and Cape Naturaliste. The survey has characterised the geomorphology and geology of the nearshore, foreshore, and backshore at a high level of detail using the 'Smartline' mapping concept. Additional datasets include a detailed assessment of the 198 beaches in the study area, a large-scale geomorphological map of the coastal zone, and an atlas of aerial-oblique photographs of the coast.

The results of the study are aimed at coastal engineers, planners, managers and organizations that are involved in developing and implementing coastal management plans. The data provide a sound scientific basis for decision making and should be applied to underpin strategic coastal planning and management decisions.

Introduction

A significant proportion of Western Australia's population lives within a very few kilometres of the coast, and the coast is the most popular location for tourism and recreation. However, the coast has many other demands placed on it—it is, for instance, where large industrial complexes, power stations and ports are located. The coast is a dynamic environment that continually adjusts to the effects of weather, tides, seasons and climate change. The coastal area cannot withstand too much misuse because it is inherently unstable and liable to change.

As a result of the dynamic nature of the coast, beach erosion is a serious problem in a few areas and much of the immediate hinterland is degraded because of the sometimes indiscriminate way access to the beach has been established. Nevertheless, there is a general feeling that there is still considerable development potential along the coastal strip.

The Intergovernmental Panel on Climate Change has released a number of reports detailing the extent of predicted sea-level rise throughout the present century (Pachauri and Reisinger, 2007). These and other scientific and research reports predict that southwest Western Australia is particularly at risk to the impacts of climate change, principally because of the area's low tidal range and generally low, sandy coastline. Future coastal erosion potentially threatens coastal assets such as roads, urban, commercial and industrial development, and tourism and recreation infrastructure.

Because of this, it is important to understand the nature of the coastline and assess its susceptibility and vulnerability to erosion. The complexity of shoreline behaviour requires that the entire coastal system be taken into account when developing coastal management plans. This necessitates an integration of coastal geomorphology and susceptibility to erosion with data from coastal dynamics and nearshore sediment budgets. All these attributes directly affect the evolution of the coast.

This paper reports on the WACoast study, which was completed in early 2009 by the Geological Survey of Western Australia. A key objective of the study was to collect fundamental, baseline geological and geomorphological data of the open coastline of the southern Swan Coastal Plain between Lancelin and Cape Naturaliste. This information will provide those involved in all aspects of coastal planning and management with an improved awareness of the strategic value of coastal geology and geomorphology as part of the planning process.

Coastal morphology

Key to appreciating both regional and local changes in coastal behaviour is knowledge of the types and characteristics of shoreline.

Both the position and shape of the shoreline are ephemeral. They change in response to variations in sea level, sediment supply and transport, and wave and swell patterns.

Changes in sea level are related to changes in climate on a geological timescale (hundreds of thousands to millions of years), on historical timescales (hundreds of years), and to short-term storm events (days). These changes are interrelated and their effects can be seen in the landforms that develop in the coastal environment.

Shorelines in southwest Western Australia are wave-dominated and can be broadly characterised into two types—rocky coasts and sandy coasts. Rocky coasts occur where coastal erosion has exposed the underlying rock. Cliffs occur along the whole coastline and are either in hard gneissic rocks or softer calcarenite (limestone composed of calcareous grains). Gneissic rocks of the coast between Cape Naturaliste and Dunsborough generally form smooth slopes with boulders at the base of the cliffs. In contrast, calcarenite is eroded into vertical cliff faces that can, depending on the force of waves, be undercut and become liable to collapse. Intertidal rock platforms occur predominantly in limestone. Platforms are only exposed at low water, and are commonly undercut and can collapse. Some platforms occur as nearshore reefs, as they do at Yanchep Lagoon, where they help protect the shore.

Sandy coasts are more dynamic and display a wide range of landforms. Large-scale landforms, such as cuspate forelands, parabolic and transgressive dunes, have formed gradually during periods of higher and lower sea levels. The lower sea levels coincided with glaciations when polar ice caps expanded. Higher sea levels occurred when the polar ice caps shrank during interglacial periods. Sediment was pushed ashore and deposited as a foreshore wedge as the sea level rose. Sometimes this sediment enclosed embayments and formed coastal lakes like Lakes Preston and Clifton south of Mandurah.

Three types of beaches are found along the coast: wave-dominated sandy beaches on high-energy coasts like those between Fremantle and Trigg undergo rapid erosion and accretion in response to storm events; low-wave, sheltered coasts like those north of Sorrento and south of Fremantle, which usually do not recover fully after erosion; and perched beaches like those at Cottesloe and North Beach, which are characterized by a thin layer of sand over a rock platform. Perched beaches are very variable in comparison to simple sandy or rocky coasts and can change rapidly in width and height as a result of changes in water level either depositing or removing sand from the beach.

Approach

There have been many studies undertaken along the coast of Western Australia with the objectives of identifying and mapping the geomorphological components of the coast and assessing the response of the coast to potential future sea-level rises (see, for example, Green, 2008; Sanderson *et al*., 2000; Stul, 2005; Travers, 2007; Trenhaile, 2004). These studies provide valuable information for the area under study. The morphological classifications that were used and the approaches to modelling that were taken in these studies can be transferred to other areas. However, as good as these studies are, one of the main shortcomings of them is that it can be difficult to compare the results from an area of one shoreline type to another area of similar shoreline type. For example, the results from one section of rocky calcarenite coastline cannot always be directly compared with those from another similar section of rocky calcarenite coastline because both the classification of landform types and the modelling approach and software used are usually different in both studies.

Therefore, for this study, which covers 400 km of coastline, and which will be extended a further 400 km north from Lancelin to Kalbarri in the near future, it was essential to use a standardised coastal geomorphological classification that could be used for a variety of shoreline types. Such as classification should be simple and yet comprehensive enough to encompass geomorphological forms that are found at a range of scales in the landscape as well as those forms that are more scale-specific.

The coast can be divided into a number of tidally-defined zones—nearshore, foreshore, and backshore. The backshore can be further divided into proximal and distal zones. The nearshore is permanently inundated by the sea and for the purposes of this study is defined as being immediately seawards of the foreshore zone but may extend to an arbitrary distance of approximately 500 m offshore; the foreshore is the intertidal zone or beach; the proximal backshore is immediately landward of the foreshore; the distal backshore is the hinterland landward of the proximal backshore and for the purposes of this study is defined to extend an arbitrary distance of approximately 500 m inland.

For each tidally-defined zone a standardised list of morphologies was drawn from established published classifications. For example, for sandy shorelines the classification of Short (1999) is used to describe foreshore (beach) morphologies, that of Hesp (1999) to describe proximal backshore landforms, and that of Roy *et al*., (1994) to describe distal backshore barrier systems. These classifications were developed in eastern Australia and consequently have a New South Wales and Queensland bias. For this study these classifications were supplemented by the addition of coastal morphologies more prevalent in Western Australia such as perched beaches.

For rocky shorelines the principal classifications used are those of Green (2008) and Semeniuk and Johnson (1985).

In addition, coastal exposure (Sharples, 2008) and geological substrate of the coastline were also classified.

Once the different elements that make up the coastline were identified and catalogued capture of these elements took place:

- Identify and capture the 198 individual beaches in the study area and intervening rocky coastline as an ArcMap GIS polyline layer initially based on collating information in Short (2006);
- Identify access to the beaches using high resolution orthophotography;
- Characterise each beach, at one or more locations in the field. Data collected in the field characterise the nearshore, proximal foreshore, distal foreshore, proximal backshore, distal backshore, coastal exposure, and geological substrate at the field location. At each location four context photographs were taken, two at the backshore looking left and right along the beach and two at the proximal foreshore looking left and right along the beach. These data were entered into and validated in a purpose-designed MSAccess database before being exported to ArcMap GIS as a point layer;
- Charter a fixed-wing light aeroplane to take oblique aerial photographs of the whole coastline of the study area and georeference each photograph;
- Use the 'Smartline' concept of Sharples (2008) to create a fully attributed ArcMap GIS polyline layer identifying the coastal landforms in each tidally-defined zone. Attribution of this layer is based on interpreting the data collected in the field, from oblique aerial photographs, and from high-resolution orthophotographs;
- Map the landforms within three kilometres of the coast as an ArcMap GIS polygon layer based on the field data collection, high-resolution orthophotographs, a high-resolution digital elevation model, and Landsat TM multispectral data.

Outputs from the study

The main outputs of this study are:

- An ArcMap GIS project containing the following layers:
  - Polyline layer representing the Mean High Water Mark;
  - Attributed polyline layer showing the individual beaches and intervening rocky coastline;
  - Attributed polyline 'Smartline' layer identifying the geomorphological components of each tidally-defined zone of the coastline;
  - Attributed point layer showing the field characterisation locations with hotlinks to the four context photographs taken at each field characterisation location;
  - Attributed point layer showing the location of the centroids of the georeferenced oblique aerial photographs;

— Attributed polygon layer showing the landforms within three kilometres of the coast.

- Google Earth kml and kmz files of the ArcMap GIS project layers;
- An atlas of the four context photographs taken at each field characterisation location;
- An interactive map-based viewing system of all georeferenced oblique aerial photographs allowing the user to access the photographs by either overview or detailed mapping, to zoom in and out on each photograph, and to activate an animated sequence of photographs.

Use of WACoast outputs

The results of the study are aimed specifically at coastal engineers, planners, managers and organizations that are involved in developing and implementing coastal management plans or coastal defence strategy options. The study outputs provide a sound scientific basis for decision making and should be applied to underpin strategic coastal planning and management decisions.

Any systematic approach to coastal management should be based on the concept of behavioural systems (Halcrow, 2002). Such a system is an identified set of geological or geomorphological units that are spatially contiguous as a single entity. This is a valid approach because it recognises that there are more influences that drive coastal processes than those confined to the shoreline, such as littoral cells that only highlight offshore sediment erosion, transport, and deposition. The geological structure and geomorphological elements that make up the coastline have responses and behaviours that must be understood and taken into account. For rocky coasts the main factor governing rates of recession is the geological nature of coastal cliffs. Along sandy coasts geomorphological parameters are more important. Here the morphology of the beach, the presence or absence of a foredune, the type and morphology of dune barrier landforms, the movement of sediment in the littoral zone, and the level of coastal exposure are more important.

At a regional level, Coastal Behavioural Systems are defined as segments of coastline that are bounded by major geological structures or having similar geomorphological attributes. They are therefore likely to behave and evolve in a similar way.

At more local scales are Shoreline Behaviour Units. At this scale it is the interaction of the component geomorphological units that produces a particular response.

The outputs of WACoast are integral to understanding coastal behaviour at all scales and enable coastal managers to identify particular geological and geomorphological attributes to precisely target different sections of coastline while still working within the larger framework of Coastal Behavioural Systems. In particular, the assessment of the vulnerability of the coast and key coastal infrastructure to rises in sea level as a result of climate change can only be undertaken with a detailed knowledge and understanding of the geological and geomorphological structure of the coast. It is the interaction of the geological and geomorphological makeup of the coast that governs how the shoreline will respond to climate change.

Conclusion

In planning and managing strategies, policies, and projects for and in the coastal zone it is essential that coastal engineers, planners and managers have an appreciation of coastal geology and geomorphology. WACoast provides that knowledge base. The physical structure and natural features of the coast provide a framework of coastal and nearshore management units.

By raising an awareness of the importance of geology and geomorphology in coastal management and planning it is hoped that better informed strategic decisions will be made in a wider-scale context than has previously been the case.

Acknowledgments

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