Earth Systems and Climate Change Hub

National Environmental Science Programme

NCCC
National Centre for Coasts and Climate

Coastal erosion under a changing climate

Dunes in East Gippsland (Image: David Kennedy)

> Six percent of the open coast of Victoria has experienced some level of coastal erosion over the past 30 years.

> Sandy beaches adjacent to infrastructure and at estuary mouths experienced the greatest change in shoreline position.

> Erosion alters sand dune vegetation, resulting in potential adverse implications for coastline resilience to future erosion.

Coastal erosion refers to the movement of sediment within a coastal bay. Landward shore retreat (the loss of coastal lands) is caused by waves, currents, sea-level rise and human activities.

Rising sea levels due to climate change are likely to cause accelerated erosion of many Australian coastlines, with consequences for coastal infrastructure, communities, ecosystems and coastal leisure activities.

While Australia maintains a strong science capability to assess the risks associated with sea-level rise, waves, and storm surge, knowledge gaps remain around the amount of long-term shoreline retreat that may occur under climate change. Greater understanding is therefore required of historical shoreline dynamics over decadal timeframes and the influence of sediment supply, vegetation and human infrastructure on this process. In addition, improved linkages are required between ocean-climate models and erosion hotspots under climate change.

Researchers at the National Centre for Coasts and Climate (NCCC) in the Earth Systems and Climate Change Hub are working on improving our understanding of the variability and underlying drivers of coastal erosion. Our research targeted the open-coast of Victoria and focussed on three themes; 1) quantifying historic change on the Victorian coast; 2) changes in beach and dune morphology when eroded; and 3) examination of the role of vegetated systems (coastal dunes) in mitigating erosion.

This research was conducted through a partnership between NCCC and CSIRO researchers under the Earth Systems and Climate Change Hub, and was developed through field surveys and models based on atmospheric and hydrodynamic forcing. Our research will lead to improved predictions of future erosion – specifically in relation to climate change impacts – and will provide important information and data to inform coastal management activities.

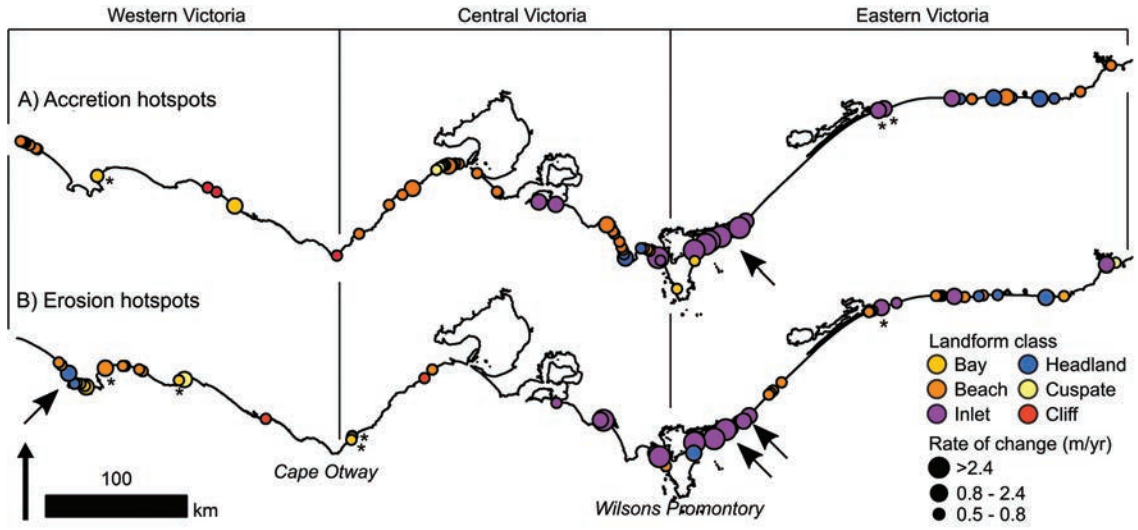
Historic shoreline changes in Victoria

Significant change in shoreline position was experienced by 13% of the Victorian coast between 1986 – 2017. Hotspots are coastal regions characterised by persistent landward shifts (erosion) or seaward advance (progradation) in shoreline position. They were defined in this study as shores at least 250 metres in length, that showed a change in shoreline position at rates greater than 0.5 m per year.

We found that erosion hotspots extend over 76.6 km of the coastline, equivalent to approximately 6.2% of the Victorian coast. Progradation hotspots extend over 72.7 km of coast, equivalent to approximately 5.9% of the coast.

The greatest rates of change were located near the entrances of tidal-inlets, indicating a strong landform and sediment supply component to hotspot development; however, hotspots were not strongly correlated to changes in wave height. This suggests that changes to wave height in isolation cannot predict shoreline change for the Victorian coastline.

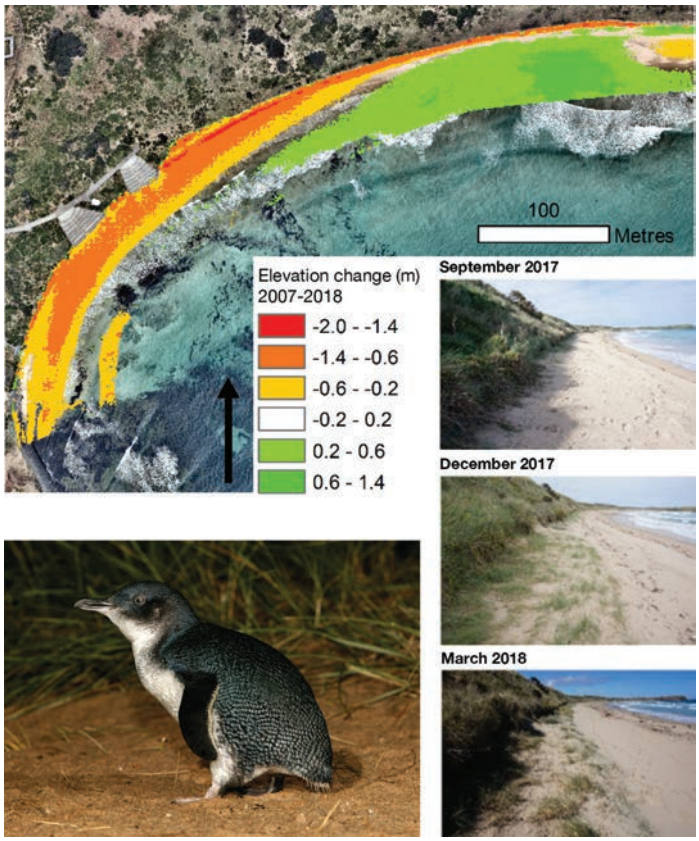
Future studies into shoreline change must therefore look beyond just projected changes to wave height and should include changes in wave direction and sediment transport.



Location of erosion and accretion hotspots on the Victorian Coast. Hotspots were derived from a 30-year shoreline dataset obtained from Landsat satellite imagery. Arrows indicate the location of the longest hotspots. (Data: T. Konlechner et al. The University of Melbourne/The Victorian Coastal Monitoring Program/DEWLP/DELTARES).

CASE STUDY: Shoreline erosion at the Penguin Parade on Phillip Island

Little penguins are the premier tourist attraction in Victoria. Over 1,000 little penguins come ashore each night on Summerland Beach, Phillip Island at the world-famous 'Penguin Parade'. However, coastal erosion limits penguin access to breeding sites, particularly when steep faced and high dune cliffs (scarps) are formed. In partnership with Phillip Island Nature Parks we quantified changes to the beach adjacent to the penguin viewing stands and evaluated the potential for dune recovery following erosion. Our research found that there has been a loss of 3,000 cubic metres of sand since 2007, resulting in a drop in beach elevation of about 1m adjacent to the viewing stands. Lower beaches increase the likelihood of dune erosion. Scarps are now formed during even moderate storm events at the parade site, and the ability for the beach and dunes to recover is limited, with dunes rebuilding slowly. This makes it harder for the penguins to come and go between their nesting sites and the ocean. We are now working with Phillip Island Nature Parks to prepare an erosion mitigation plan for the Penguin Parade.



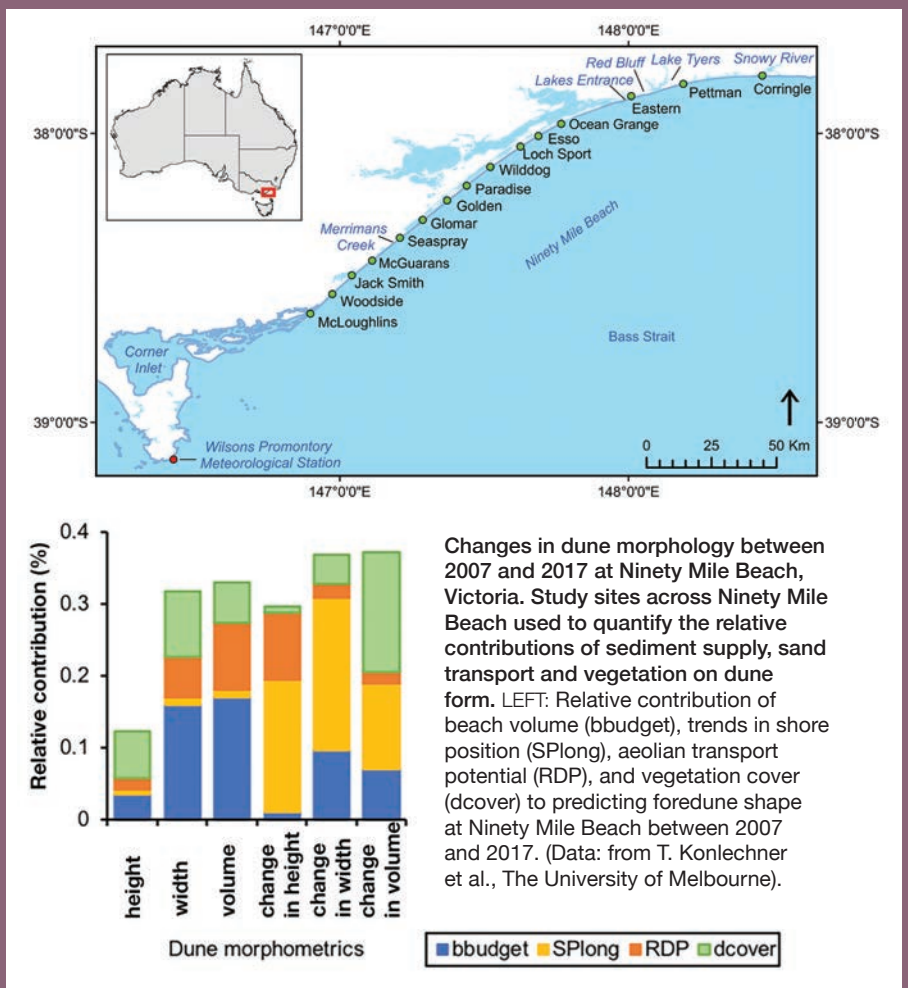
Loss of sand from the Penguin Parade viewing stands at Phillip Island. Storm-surge eroding dunes adjacent to the stands; limited dune recovery derived from UAV surveys following foredune erosion. (Data: from T. Konlechner et al. the University of Melbourne/Phillip Island Nature Parks).

CASE STUDY: Determining what shapes foredunes on Ninety Mile Beach

The protective role of coastal dunes depends on their morphology (their form, shape and structure); larger and higher dunes are more resilient to waves and provide better protection.

Results from 15 sites across Ninety Mile Beach in East Gippsland show that foredune shape depends on vegetation cover, beach volume, and the potential for wind transport of sand. However, we found that the main cause of change in foredune morphology on Ninety Mile Beach since 2007, was long-term rates of change in shoreline position.

For example, we found that dunes on erosional shores were more likely to have narrowed in width and decreased in volume. This indicates that on eroding coasts, the protective capacity of coastal dunes is likely to be reduced as the amount of sand stored in the dune declines.



Changes in dune morphology between 2007 and 2017 at Ninety Mile Beach, Victoria. Study sites across Ninety Mile Beach used to quantify the relative contributions of sediment supply, sand transport and vegetation on dune form. LEFT: Relative contribution of beach volume (bbudget), trends in shore position (SPlong), aeolian transport potential (RDP), and vegetation cover (dcover) to predicting foredune shape at Ninety Mile Beach between 2007 and 2017. (Data: from T. Konlechner et al., The University of Melbourne).

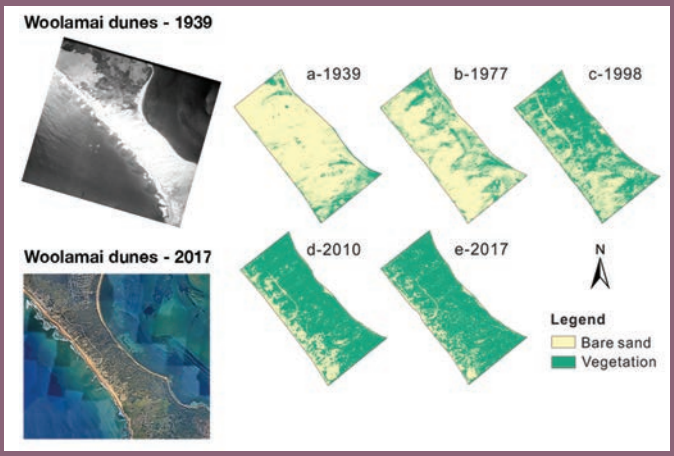
Effects of erosion on foredune plant communities

To predict the response of foredune plant communities to increased erosion, we examined the abundance of six dune plants across 71 beaches in Victoria. The beaches were able to be categorised into 6 groups based on species abundance and recent changes in shoreline position. We found that species that grow closer to the water-line, that have a persistent rather than opportunistic growth-history, or that are limited in their ability to recolonise following erosion are more likely to be negatively impacted by increased rates of coastal erosion. We also found that shifts in plant communities under conditions of prolonged erosion may reduce foredune building capacity or result in changes in dune form. Unfortunately, non-native plant species were more likely to be found on eroding coasts than native species. These findings have important implications for the management of sandy coasts and could provide coastal managers with important information about appropriate vegetation species to use for dune rehabilitation.

Six classes of foredune communities present on the Victorian coast. (Data: from T. Konlechner et al. The University of Melbourne).

Changes in dune mobility in Victoria

Dunes can range from completely mobile to fully fixed by vegetation depending on climate and human activities. Our research quantified the primary drivers of dune dynamics in Victoria and looked at the influence and balance between wind, precipitation, and management in determining vegetation growth and landscape mobility. As a case study, the Woolamai dunes show a typical pattern of change for Victoria. Vegetation cover has increased by 500% since 1939. Dune stability has also increased and was found to be related to an increase in precipitation and temperature, as well as the introduction of marram grass for dune stabilisation in the 1960s. These results suggest that dune mobility in Victoria is likely to respond to future changes in climate.



Mobile dunes provide important habitat for coastal plants and animals. They are also often environments of high cultural value. While sand movement is a natural process, poor coastal management can destabilise dunes. Sand transport inland can remove sand from the beach, potentially increasing the vulnerability of the coast to erosion. By better understanding dune mobility change over time we can better determine how to manage sand dunes to protect conservation values and predict erosion.

Changes in relative proportion of unvegetated sand and vegetation at Woolamai Beach, Phillip Island since 1939. Cover was calculated from a time series of aerial photos (Data: J. Gao et al. The University of Melbourne).

Further information

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Developing an ecological and geomorphological index of dune resilience to coastal erosion

NCCC are working with CSIRO researchers within the Earth Systems and Climate Change Hub to improve understanding of the drivers of coastal change. This research will be combined with data on vegetation and geomorphic drivers of change to develop an index of Victorian dune resilience to coastal erosion to inform coastal management activities.

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