HAZARD NOTE

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NEW TECHNOLOGIES TO BETTER MANAGE COASTAL EROSION

ABOUT THIS PROJECT

This research is part of the *Resilience to clustered disaster events at the coast: storm surge* project, and builds on research from *Hazard Note* 16, May 2016.

AUTHORS

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SUMMARY

Coastal erosion is an ongoing problem for some populated areas of the Australian coast. The fundamental processes that cause erosion during storms are generally well understood and management strategies are available. However, the response of beaches to successive storms (storm clusters), such as those that damaged Australia's east coast in 1974, is not well understood or managed, with the response of any given beach depending on its physical characteristics. Because of this, the likely effectiveness of a given management strategy may not be clear, such as beach nourishment (a remedial process where sand is added to a beach to restore its shape). This project has developed an analytical toolkit for coastal managers to better understand beach response to clustered storms and to place this in the context of the geological and oceanographic setting for a given part of the Australian coast.

▲ **Above:** ERODING SECTION OF OLD BAR IN NEW SOUTH WALES SHOWING EXPOSED ROCK AT THE FOOT OF THE DUNE. THE GROUND-PENETRATING RADAR IMAGE ON PAGE 2 WAS COLLECTED ALONG THE BEACH AT THIS LOCATION.

CONTEXT

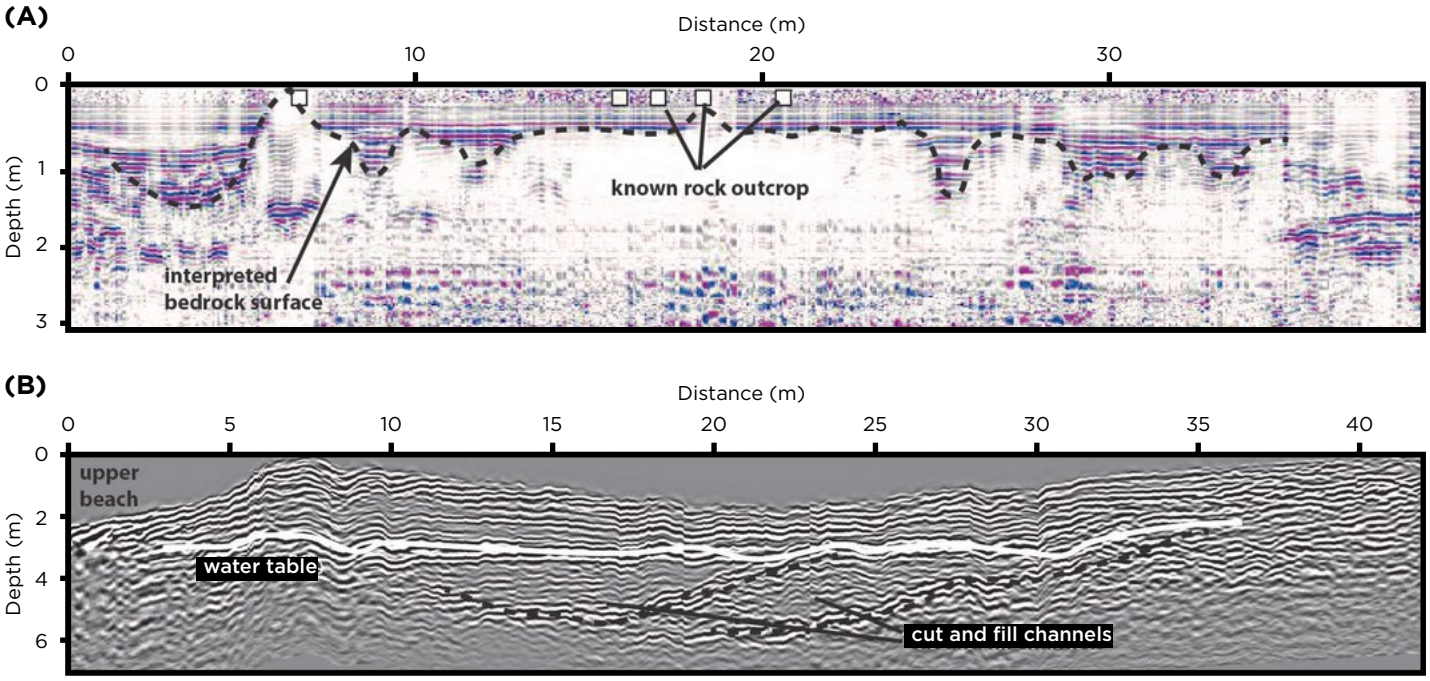
This project aims to investigate how clusters of storms can be modelled and their impact on beach erosion determined.

BACKGROUND

The physical processes that cause coastal erosion are reasonably well understood at the fundamental level and are built into a range of numerical shoreline response models. However, modelling the response of a particular beach under specific conditions, such as clustered storms, remains a challenge. This project sets out to develop a methodology and demonstrate it through two case study sites, which had different oceanographic and geological settings. The methodology combined expertise in statistical modelling, hydrodynamics, coastal geology, hazard mapping and impact analysis. The project aimed to integrate these approaches to develop tools, information and methods that can be used by others nationally.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

In late 2014, in consultation with end-users, two case studies were selected: Old Bar on the New South Wales mid north coast (between Newcastle and



▲ **Above:** IMAGES OF THE SUB-SURFACE STRUCTURE OF OLD BAR FROM GROUND-PENETRATING RADAR (GPR) SURVEY. (A) PROFILE COLLECTED IN AN ALONGSHORE DIRECTION SHOWING LAYERS OF BEACH SAND (HORIZONTAL RED AND BLUE LINES) OVERLYING AN UNEVEN ROCK LAYER (DOTTED BLACK LINE). THE BEACH SAND IS ABOUT ONE METRE THICK AND THE ROCK EXTENDS TO A DEPTH OF MORE THAN THREE METRES, AND EXTENDS ALONG THE BEACH A DISTANCE OF AT LEAST 30 METRES. PRIOR TO THE GPR SURVEY THE LOCATION OF BURIED ROCK AT OLD BAR WAS UNKNOWN, APART FROM SMALL AREAS OF EXPOSED ROCK (SEE PAGE 1 PHOTO). (B) PROFILE COLLECTED ACROSS THE NORTHERN END OF OLD BAR AND DUNES SHOWING SAND IS AT LEAST 4 M THICK. THIS INFORMATION IS INVALUABLE FOR UNDERSTANDING COASTAL EROSION PROCESSES AND IS BEING USED TO RE-ASSESS HAZARD LINES IN THE COASTAL MANAGEMENT PLAN FOR OLD BAR.

Port Macquarie) and the Adelaide metropolitan beaches in South Australia. These beaches were identified as key localities where erosion is an ongoing issue and where field studies and modelling would provide new insights into the problem. Fieldwork completed in early 2015 collected site data that set the context for the subsequent shoreline modelling. This included the innovative use of ground-penetrating radar to estimate the thickness of beach sediment that can be mobilised during storms.

To model beach response to clustered storm events required the development of an artificial set of storm waves to best represent storms through time. This was achieved through advanced statistical modelling based on measured (and hindcast) waves at each study site. The storm event data was in turn used to model shoreline response, incorporating site-specific information on water depth offshore and sediment type. The two case studies revealed that differences in wave data led to modifications in the approach to modelling; this demonstrated the utility of the method.

For Old Bar, a 30-year record of wave data measured by an offshore wave-rider buoy was used to model storm waves from different directions. In contrast, for Adelaide the absence of wave buoy data required use of the wind record to reconstruct wave direction and height.

The final stage in the work involved impact and risk assessments that required geospatial data describing the exposed assets at each site. At both Old Bar and Adelaide, assets include houses, commercial property, roads and access stairways.

All field data is openly available online at the Geoscience Australia website. Computer code for statistical modelling of storm waves will be published as open source in December 2017.

RESEARCH FINDINGS

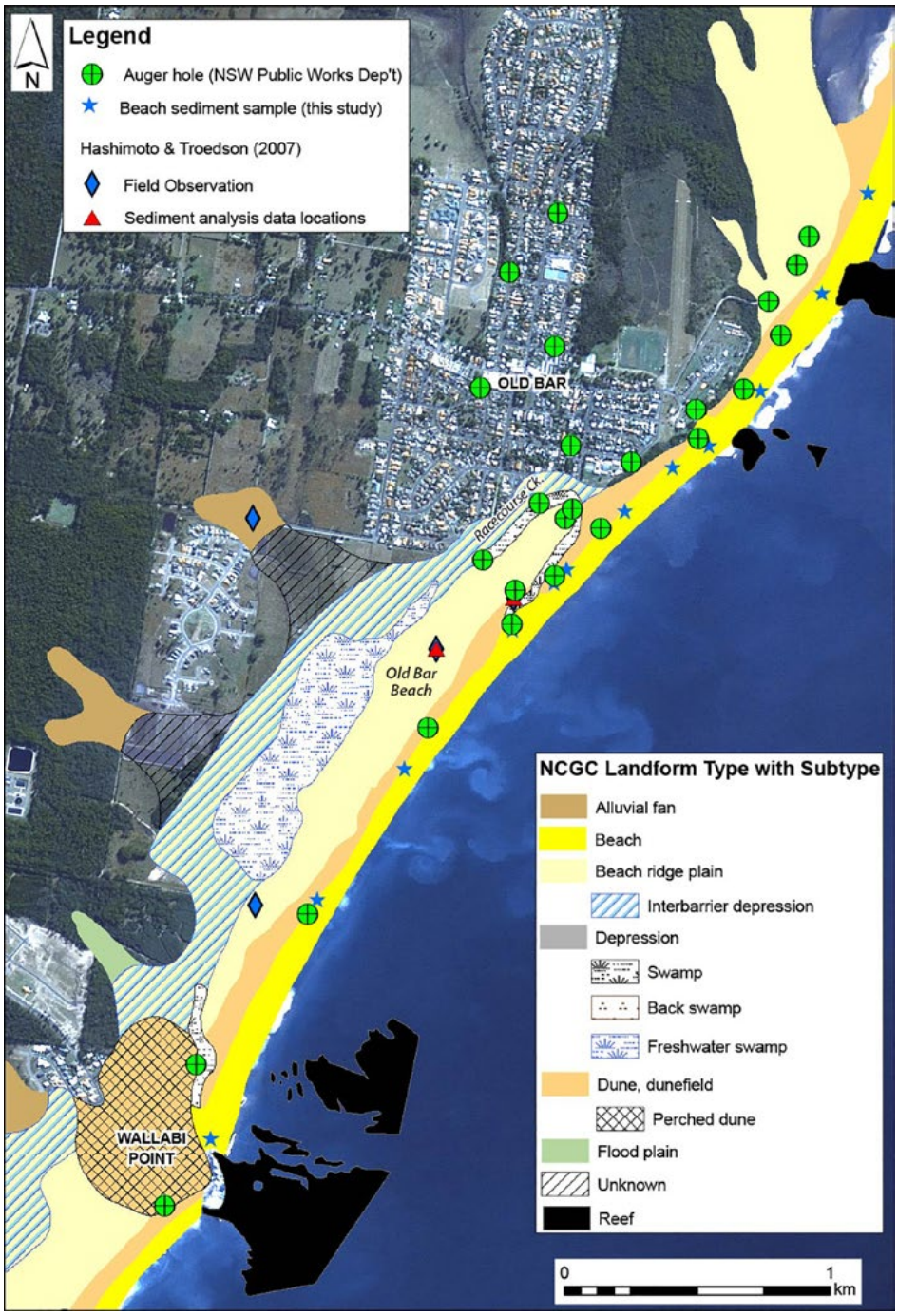
For Old Bar, the research found that erosion and property loss are centred on a section of coast where sand cover is limited by shallow bedrock and offshore reefs. This means that the potential for natural beach recovery is hindered by a finite local sand supply, and modelling indicates that further shoreline retreat is possible. Other parts of the beach are more stable due to larger sand reserves onshore and offshore, as evidenced by sand dunes up to 200 metres wide. These findings support previous observations and are consistent with independent hydrodynamic modelling for Old Bar that shows erosion associated with a near-shore circulation cell under storm conditions.

For the Adelaide metropolitan beaches, erosion is managed effectively through an established beach-nourishment program. This project demonstrated that nourishment strategies could be fine-tuned and made more cost-effective by

END-USER STATEMENT

This project has played an important role in building the body of knowledge around shoreline response to clustered storms. The new data, modelling tools and summary information for case study sites are essential reference materials for coastal managers. This allows agencies like my own to take a more informed approach to future coastal management strategies. For example, as the agency responsible for implementing the South Australian Government's Adelaide's Living Beaches Strategy, DEWNR will use the outcomes of this research to refine our annual beach replenishment program, which is used to maintain adequate storm buffers for the protection of infrastructure along the Adelaide coast.

– James Guy, Team Leader Coastal Programs, Department of Environment, Water and Natural Resources, South Australia.



▲ **Above:** A MAP OF OLD BAR AND HINTERLAND SHOWING COASTAL LANDFORMS AS MAPPED USING THE NATIONAL COASTAL GEOMORPHOLOGY CLASSIFICATION SCHEME (HAZELWOOD *ET AL.*, 2013). THIS INFORMATION PROVIDES COASTAL MANAGERS WITH AN OVERVIEW OF THE LOCATION AND EXTENT OF LANDFORMS THAT MAY BE EXPOSED TO COASTAL EROSION (FOR EXAMPLE, BEACH OR DUNE).

mapping beach thickness using ground-penetrating radar. At the time of fieldwork (February 2015) the narrow southern beaches of Adelaide were less than two metres thick in places, whereas northern beaches were greater than four metres thick and tens of metres wider. This rapid assessment method provides land managers with reliable data to quantify sand volumes on individual beaches and, in turn, gauge the scale of ongoing beach-replenishment work.

HOW IS THIS RESEARCH BEING USED?

As part of the project's utilisation plan, a workshop was held with end-users in April 2017. The workshop focused on two aspects: the software that enables statistical modelling of storm events and the preliminary results from shoreline modelling at Old Bar. Feedback from end-users was centred on the value of improving on-the-ground knowledge regarding the processes driving coastal erosion at case study sites and the potential for end-users to make use of data and software modelling tools. It was noted that coastal managers would likely engage consultants to undertake future modelling, as was typically the practice in state agencies.

While the modelling to date has focused on Old Bar in New South Wales, the South Australian end-users wish to compare the current beach management strategies with the modelling results and make changes

GPR INSIGHTS

Ground-penetrating radar (GPR) surveys were conducted at both study sites in early 2015 to define the thickness of sediment that could be potentially eroded during a storm. Figure 1 (page 2) shows an example of a GPR image of the beach thickness at Old Bar Beach. This data can be used in conjunction with the National Coastal Geomorphic Classification (Hazelwood *et al,* 2013) and the Australian Coastal Sediment Compartments (McPherson *et al,* 2015) to characterise landforms in the coastal zone and to provide site-specific information for detailed shoreline response modelling.

FURTHER READING

Hazelwood M, Nicholas WA and Woolf M, (2013), National Coastal Geomorphology Information Framework: Discovery and Distribution. Record 2013/35. Geoscience Australia: Canberra. https://d28rz98at9flks.cloudfront.net/74294/Rec2013_035.pdf

McPherson A, Hazelwood M, Moore D, Owen K, Nichol S and Howard F (2015), The Australian Coastal Sediment Compartments Project: methodology and product development. Record 2015/25. Geoscience Australia: Canberra. http://dx.doi.org/10.11636/Record.2015.025

Nichol S, McPherson A, Davies G, Jiang W, Howard F, Gravois U, Callaghan D, and Baldock T (2016), A framework for modelling shoreline response to clustered storm events: A case study from south east Australia, *Journal of Coastal Research Special Issue*, **75**, pp. 1197-1201. http://www.jcronline.org/doi/pdf/10.2112/SI75-240.1

▲ **Above:** ASSESSING OLD BAR AFTER THE APRIL 2015 EAST COAST LOW. PHOITO: UNIVERSITY OF QUEENSLAND.

if required. South Australian coastal managers are also planning similar studies for other beaches using the methodology showcased in this project.

In New South Wales, the project results will be part of a broader conversation about how to manage the coastal erosion hotspot of Old Bar. For instance, the sub-surface investigations using ground-penetrating radar are being used by the New South Wales Office of Environment and Heritage to re-assess hazard lines as it develops a coastal management plan for the area.

For all end-users, seeing the data, methods and tools being published and made open source is a positive step towards enabling others to apply this method at other locations.

FUTURE DIRECTIONS

From a research perspective, understanding the processes that drive coastal erosion requires the integration of modelling across multiple time scales. These range from wave and tide processes operating over hours to days, to sedimentation processes operating over years to decades, and longer. This project has focused on the short term in order to better understand the impact of clustered storms that may occur over periods of weeks to months. Uncertainties in this modelling relate to assumptions made on longer term processes that influence sediment supply to coastal compartments. Future work should therefore be aimed at model refinement to better integrate across short to long time scales, so that coastal managers have a more holistic understanding of the natural behaviour of the coast.

The Bushfire and Natural Hazards CRC is a national research centre funded by the Australian Government Cooperative Research Centre Program. It was formed in 2013 for an eight-year program to undertake end-user focused research for Australia and New Zealand.

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