Improving Coastal Erosion Assessments for Victoria: Embayments and Living Shorelines

Research Project Summaries - August 2019

1. Geomorphic Setting

1.1 Historic and contemporary erosion and accretion rates

Project team: Kerrylee Rogers (UoW), Neil Saintilan (Macquarie), Nicole Cormier (Macquarie)

Description

The current morphology of the coastal zone is a function of historic sediment deposition from both terrestrial and marine sources and fluctuations in sea level, mediated by coastal vegetation. However, our understanding of sea level fluctuations, both in the recent past (ie. decades) and longer term, as a function of Quaternary sea-level oscillations, in Victoria is limited. Therefore, our understanding of historic erosion and accretion rates is also limited.

Objective

Identify i) contemporary erosion and accretion rates and ii) historic sediment characteristics and change

Methods

Contemporary erosion and accretion rates

Contemporary erosion and accretion rates (ie. from the last 20 years to present) will be determined using the current network of surface elevation tables (SETs) at 5 sites (Rhyll, French Island, Kooweerup, Tooradin, and Hastings). Some SETs have corroded and DELWP will provide advice as to whether to replace these at the same sites, or to install SETs at new sites.

Historic sediment characteristics and change

Cores will be sampled at sites co-located with the longer term SET sites will be characterised for ^{210}Pb, ^{137}Cs and grain size to provide an interpretation of decadal to centennial rates of change. The results will provide a baseline with which to compare current rates of change

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1.2 Coastal Compartments

Project team: Kerrylee Rogers (UoW), PhD student (UoW), Neil Saintilan (Macquarie),

The shorelines of Victorian embayments can be characterised with respect to erosion and inundation risk as a function of the landform shape, position, orientation and lithology ie. the position and shape of the shorelines in relation to important hydrodynamic drivers of sedimentation and erosion. The interaction of waves, tides and river flow in the distribution of sediment in embayments produces characteristic settings of sedimentation and erosion recognisable in morphology, profile and sedimentology.

Objective

Identify and characterise the coastal compartments in Westernport Bay using spatial analysis techniques

Methods

Spatial data (ie. bathymetry, LiDAR, vegetation, geomorphology, geology), including the Smartline database, and data collected from Sub-project 3.1 will be compiled and integrated with the current national sediment compartment framework. These data will be analysed using a range of spatial analysis techniques, such as a boosted regression model, to further interrogate these datasets to provide a classification of coastal compartments

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1.3 Sediment facies evolution of large structural embayments

Project Team: Mitchell Baum (Uni Melbourne), David Kennedy (Uni Melbourne), Sarah McSweeney (Uni Melbourne)

Description

Large structural embayments (LSE) are important coastal features as they are home to some of the world's largest port cities, including Melbourne. Evolutionary models of coastal features are important tools for identification of sediment facies in many coastal features, however, despite their importance, LSEs have not received the same treatment.

Many LSEs are tide-dominated despite residing on wave-dominated coastlines. This can be attributed to the filtering of open coast waves through the confined entrance of these coastal features. However, the effect on evolutionary development of LSEs, and the development of tide dominance over the Holocene is poorly understood.

Objective

Develop an evolutionary model from Holocene sedimentary research and test the model in Westernport Bay.

Methods

LSEs will first be defined morphologically and compared to other coastal features to determine their uniqueness. This will be followed by a synthesis of Holocene sedimentary research to develop an evolutionary model of LSE development. This model will then be tested by collection of sediment cores in Westernport Bay, which will be dated using ^{14}C analysis to provide a temporal context. This will provide an environmental context for the evolution of Westernport Bay during the Holocene.

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2. Coastal Acid Sulfate Soils

2.1 Distribution and formation of coastal acid sulfate soils

Project team: Vanessa Wong (Monash), Meng Wang (Monash)

Description

The current Victorian CASS hazard and risk maps were originally developed from a desktop study with few sites for verification. However, a detailed understanding of the spatial distribution is important, not only because its presence triggers a range of environmental management plans and regulations, but also because erosion and mobilisation of CASS can result in deoxygenation of the water column, acidification and trace metal transport.

Objective

Identify potential coastal acid sulfate soil hazard as a function of sediment geochemistry, erosion and deposition.

Methods

This research component will focus on i) spatial distribution, ii) formation, and iii) oxidation. All analyses will be consistent with the 2018 National Acid Sulfate Soil Guidances

Spatial distribution
Sites will be co-located with SET sites (Rhyll, French Island, Kooweerup, Tooradin, and Hastings) for sampling to identify acidification potential, depth to sulfidic layers, potential for metal mobilisation, and belowground carbon and nitrogen storage

Formation
Controlled laboratory experiments will be used with known vegetation and sampled sediments to quantify rates of reduced inorganic sulfur (RIS) formation which characterises potential acid sulfate soils. Sediments sampled from depositional areas will be combined with organic materials under a range of inundation scenarios to determine RIS formation

Oxidation
Controlled laboratory experiments with sampled cores from the co-located SET sites will be used to quantify oxidation rates and acidification potential by subjecting the intact cores to treatments which simulate erosional processes.

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3. Sediment Dynamics

3.1 Sediment Compartments

Project team: Ruth Reef (Monash), Vanessa Wong (Monash)

Description

The sediments of Westernport Bay can be influenced by the exposed lithology around the Bay, marine sources and inland terrestrial sources. These sources and depositional areas can be characterised using a combination of geochemical analysis and mixing models. The interaction of waves, tides and river flow in the distribution of sediment in embayments produces characteristic settings of sedimentation and erosion recognisable in sediment geochemical characteristics.

Objective

Identify the sediment compartments present in Westernport Bay.

Methods

Sediment will be sampled from known locations around Westernport Bay and subjected to full geochemical characterisation. A mixing model will developed from these results to determine the number and location of the sediment compartments

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3.2 Historical Shoreline Changes

Project team: Ruth Reef (Monash), Research Assistant (Monash), Kerrylee Rogers (UoW), PhD student (UoW)

Description

Quantifying the rates of coastal erosion and accretion across a range of timescales, from short-term events such as storms and tides, to longer term cycles such as changes in sea level, both into the past and projected into the future, is central to an understanding of changes in shoreline dynamics. However, the extensive database of historical aerial photographs in this region has not yet been integrated to understand how the shoreline has changed during the recent past.

Objective

Characterise historical shoreline dynamics using the historical aerial photograph database

Methods

Recent historical changes in shoreline position, morphology and vegetation, in Westernport Bay will be analysed using historical aerial photography and photogrammetry, in conjunction with ITEM (with pixel resolution of 25 m), as a baseline to understand short term shoreline dynamics and extent of changes in the time period which we have these records. Historic shoreline change will be analysed in ArcGIS following georeferencing and shoreline digitisation

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3.3 Cohesive clay cliff erosion of a stranded coastal swamp deposit

Project Team: Mitchell Baum (Uni Melbourne), David Kennedy (Uni Melbourne), Sarah McSweeney (Uni Melbourne)

Description

Relative sea level fall is common for coastal features worldwide and is usually associated with a drop in the base level of rivers connected to the coast. The resulting increase in discharge often leads to the deposition of sediments at the head of embayments. However, this is not the case in Westernport Bay. During the Holocene, sea levels in Westernport Bay reached 1.5 – 2 m higher than present levels around 2 kya. The subsequent sea-level fall lead to the stranding of extensive KooWee Rup coastal swamp deposits along the Lang Lang coastline at the head of Westernport Bay. The coastline in this region is eroding on average by 0.31m/year, and is responsible for a third of the sediment delivered to Westernport Bay annually. This section of coastline is a significant contributor of sediment to Westernport Bay, but the processes driving this erosion are poorly understood.

The Lang Lang coastline lies at the end of the largest fetch available for the development of wind-waves in Western Port Bay. Evaporation has been correlated with erosion along this coastline. Additionally, the orientation of the coastline relative to the prevailing wave climate has also been identified as a potential driver.

Objective

Identify morphological and hydrodynamic drivers of erosion along the Lang-Lang coastline. This will improve our understanding of coastal erosion post-marine regression.

Methods

The morphology of this section of the coastline will be monitored using UAV drone photogrammetry techniques to produce a time series of digital surface models. These will be used to identify regions of erosion along the coastline and determine if there is a morphodynamic component to erosion. In addition to morphological monitoring, hydrodynamic and environmental monitoring will be conducted to link potential drivers to spatial variation of erosion identified with the digital surface model time series.

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4. Hydrodynamic Drivers

4.1 Nearshore wave climate

Project team: Ruth Reef (Monash), Sabrina Sayers (Monash), Celia Martinez Ramos (Monash)

Description

The effect of tides in re-mobilising, transporting and depositing sediment is fundamental to an understanding of erosion and inundation risk in the embayments. Water levels in Westernport Bay are associated with astronomical tides and extreme weather events (ie. storm surges). The presence of Phillip Island and French Island alters the trajectory of waves into Western Port Bay and has led to uncertainty in determining erosion hazard

Objective

Model nearshore embayment wave climate based on offshore wave models, wind data from QuickScat, tidal hydrodynamic energy to identify erosive and depositional capacity across identified geomorphic settings

Methods

Modelling nearshore waves will be done using the Delft 3D Wave model. Boundary conditions for modelling will be determined using QuikSCAT (waves) and available bathymetric data. Custom built high resolution pressure sensors will be installed on the marsh platform to measure inundation patterns and wave parameters in the intertidal zone in representative coastal compartments. Drag coefficients for at each site will be determined by combining data acquired from a UAV-mounted thermal camera with a DEM for parameterising the models.

The movement of nearshore sources of sediment to the intertidal zone, such as from the tidal shoals to the intertidal marsh platforms, is a key process to quantify. Suspended sediment concentrations will be determined using OBS profiling sensors deployed on the marsh platform and nearshore over a period of 10 days each year. A series of erosion pins will quantify erosion from embayed sites.

The erosive and depositional capacity across the coastal compartments will be identified as a function of tidal hydrodynamic energy. Changes in potential erosion hazard as a function of changes in wave energy and the simulation of wave and tidal conditions for different levels of shoreline erosion can be estimated. Following episodic storm events, wind and wave data will be analysed together with remotely-sensed data to identify relationships between wind drivers, wave energy and volume of sediment eroded or deposited.

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