Modelling Group
WATER NEW ZEALAND

Modelling Symposium

Understanding the effects of sea level rise on the runup and erosion occurring at Waimangō Point using GIS and numerical modelling

Waimangō Point, Auckland. Source: Lalita Garg

Presented by
Lalita Garg

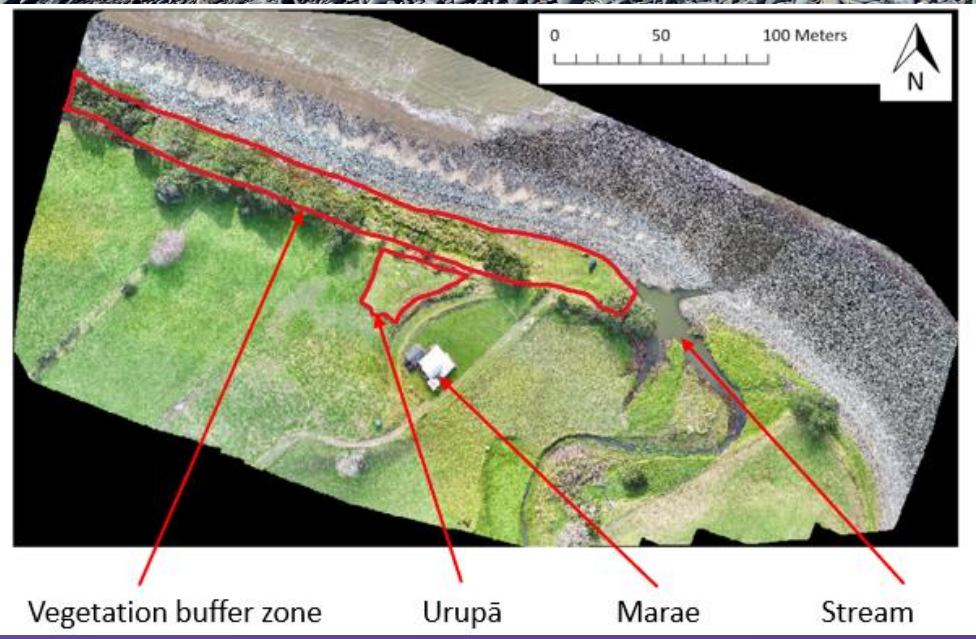
ARUP

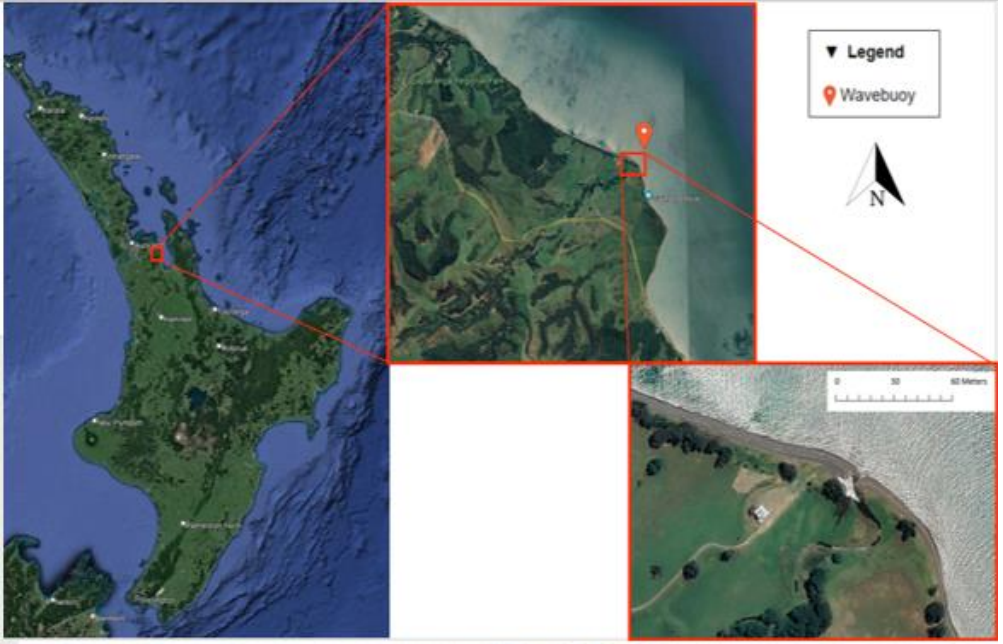
water NEW ZEALAND
The New Zealand Water & Wastes Association Waiora Aotearoa

Research Significance

- Helps understand:
  - Offshore wave conditions affecting runup
  - The impacts of sea level rise and climate change on runup
  - The cliff erosion trends occurring in the presence of a vegetation buffer zone at the cliff toe
  - The impact that mixed sediment can have on runup calculations

- Help the Local Iwi, the Royal Family, understand the type of events that lead to coastal and cliff erosion, threatening the presence of their marae and urupā.





Field Setting

- A coastal point located on the north-western shore of the Firth of Thames.
- The beach is sheltered by the Hauraki Gulf and the Firth of Thames but exposed to swell from the north.
- It is located near Ōrere Point, approximately 48km from Auckland City.
- The Tapapakanga regional park is located to the north, a mussel farm to the south.
- It is a mixed sediment beach.
- According to the NIWA Tide Forecaster, the beach has a tidal range of about 2.6 m. Therefore, Waimangō Point is a micro-tidal beach.

This Research is divided into three parts

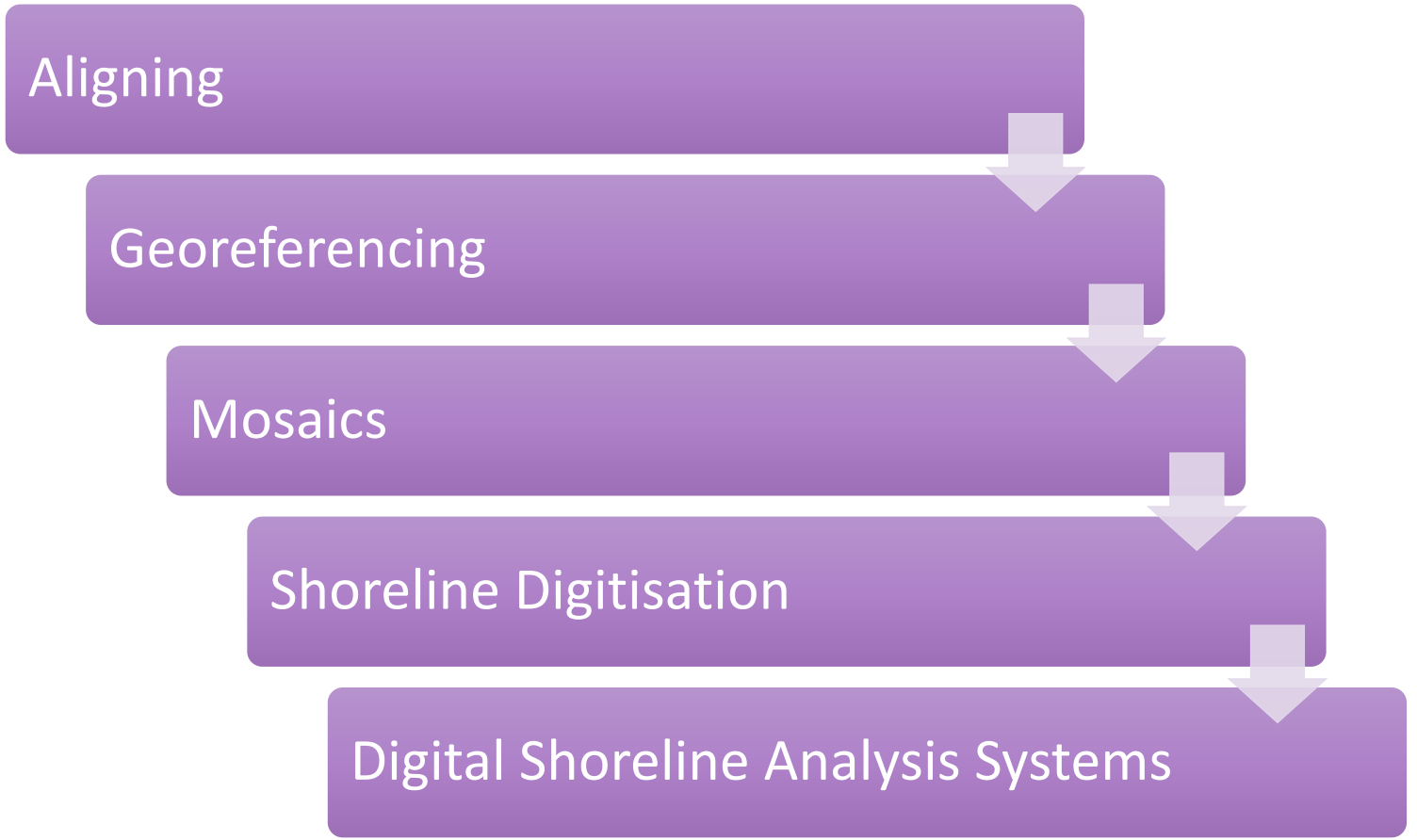
Past cliff erosion trends modelling coastline change using GIS

Modelling present wave runup conditions contributing to cliff erosion

Projecting future wave runup elevations influencing cliff erosion

Methodology

Using ArcGIS to understand cliff erosion trends

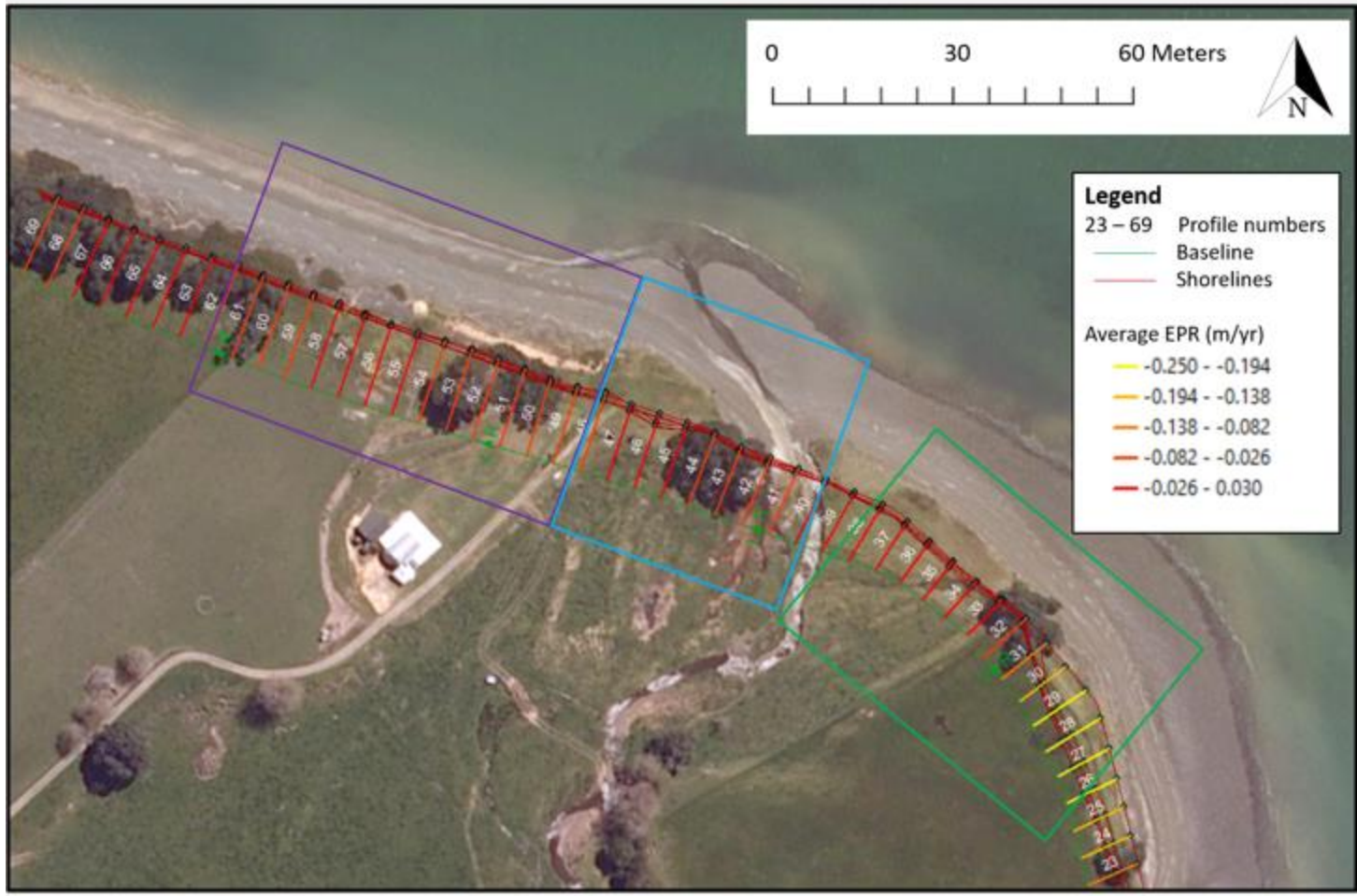


Results

Historical Erosion using ArcGIS

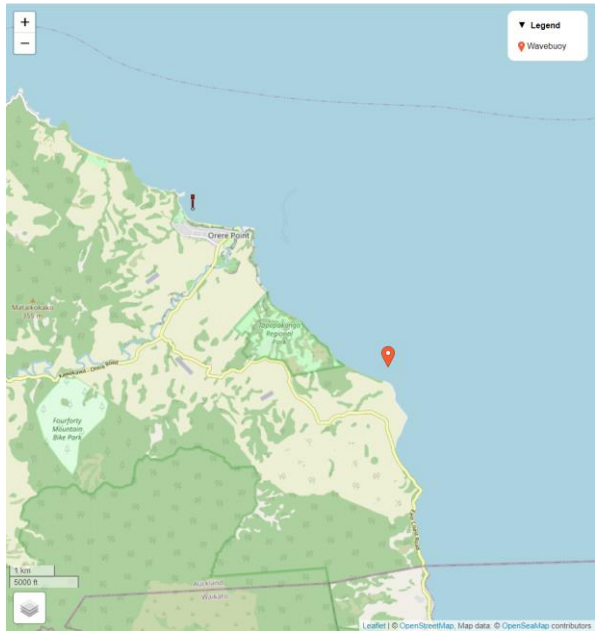
- DSAS uncertainty = +/- 0.03m/yr
- Northern Cliffs showed no detectable change with erosion rates ranging between 0.03 – 0.08m/yr.
- Near the stream and estuary, initially accreting but now eroding between a rate less than 0.026m/yr.
- Southern section erodes at a rate ranging between 0.2 – 0.3m/yr.

DSAS results of Waimangō Point. Source: Lalita Garg

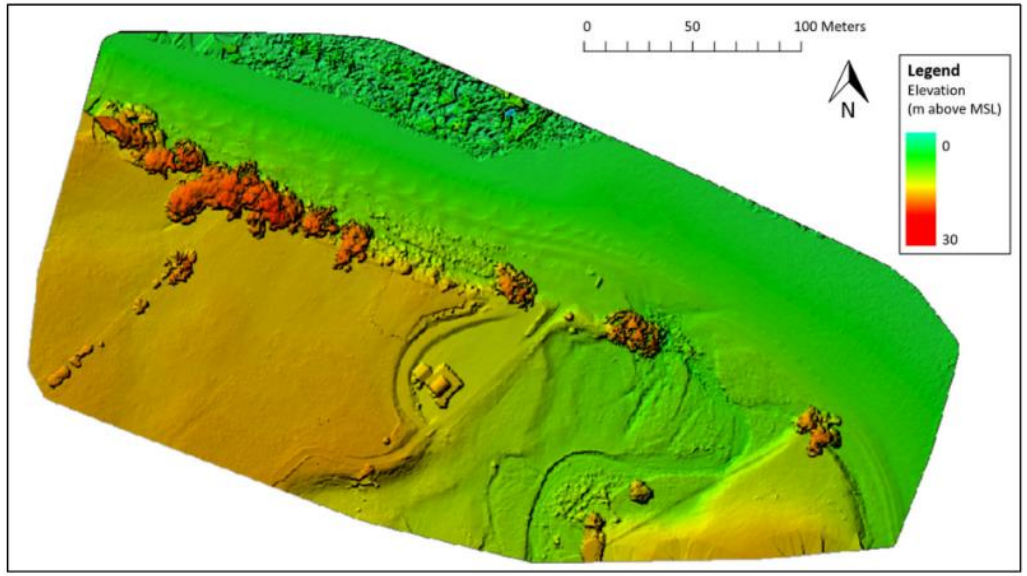


Methodology

Calculating present wave runup elevations



Obscape Wave Buoy



Digital Elevation Model

$$R_{2\%} = 1.1\left(0.35\beta_f(H_0L_0)^{1/2} + \frac{[H_0L_0(0.563\beta_f^2+0.004)]^{1/2}}{2}\right)$$

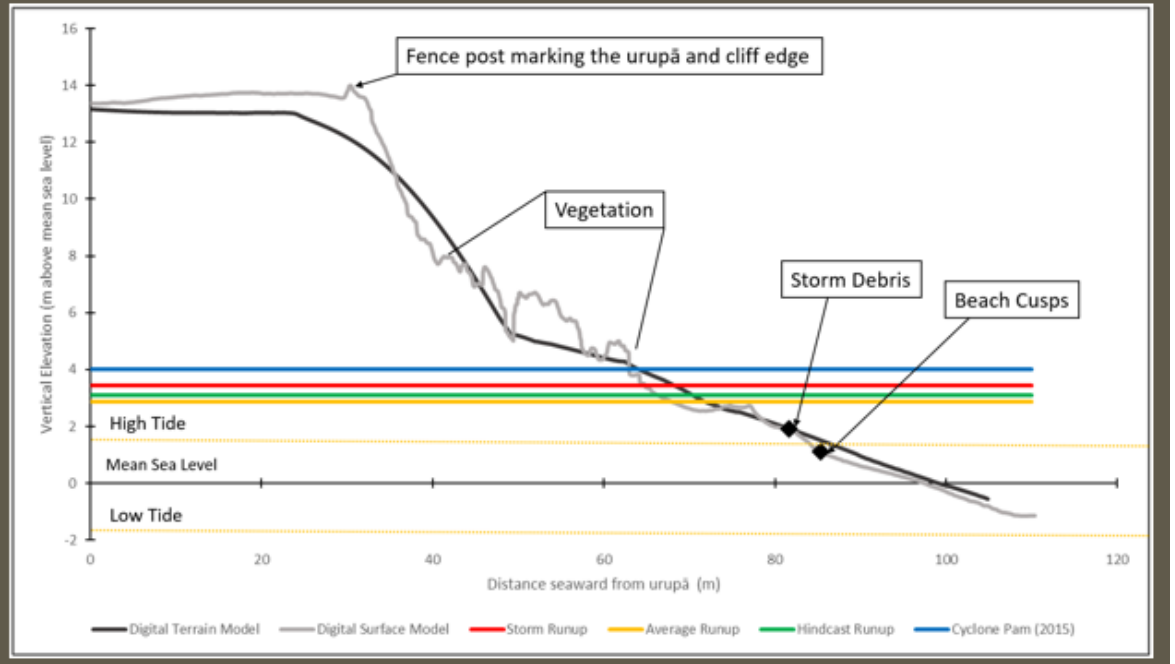
Where *H* = wave height

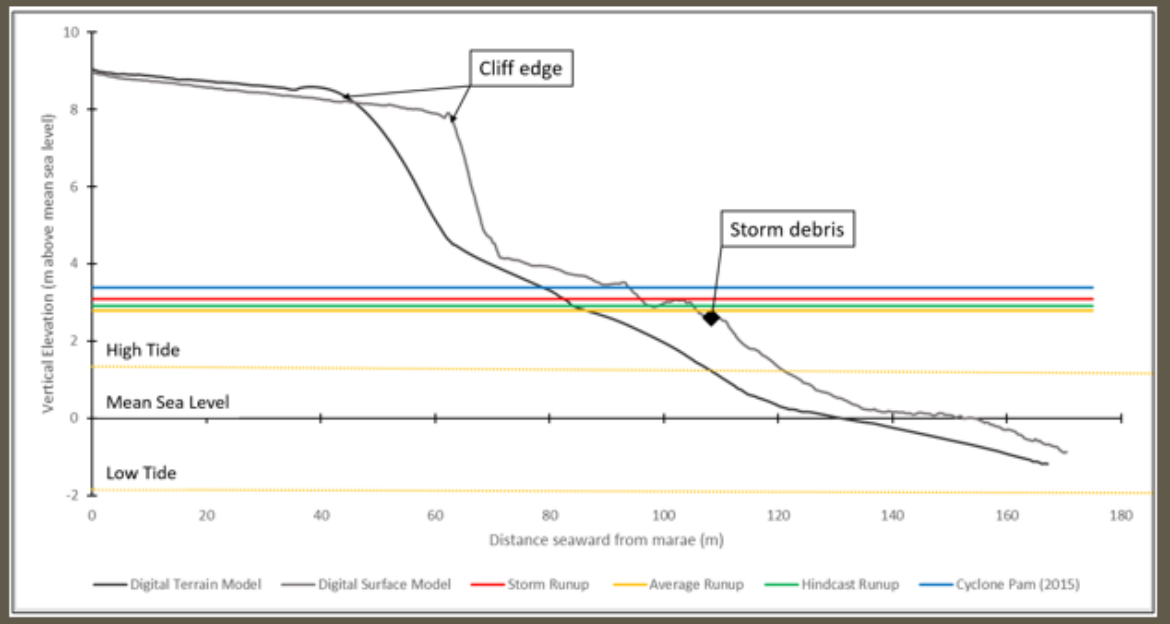
L = wavelength

Bf = foreshore beach slope

R2% = wave runup elevations exceeded 2% of the time

Stockdon Equation





Results

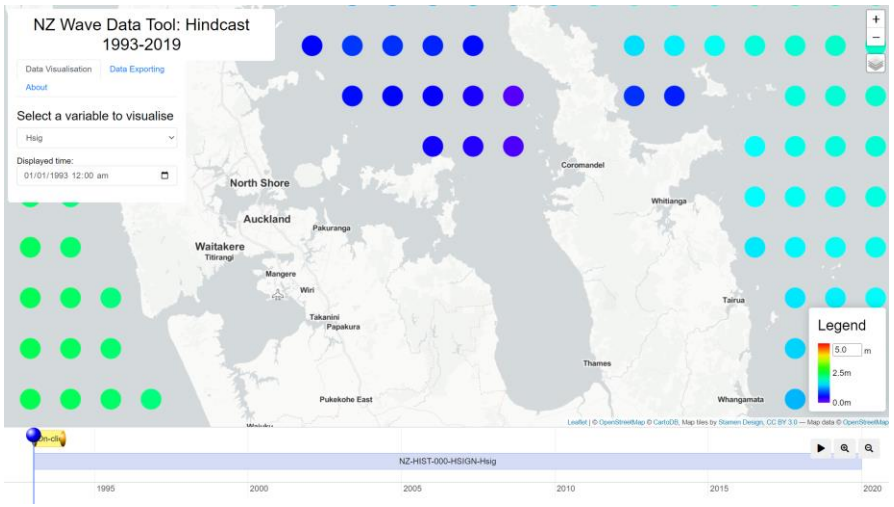
Current runup elevations using Stockdon equation

- Runup elevations
  - Urupā:
    - Ranged between 2.9m – 4m during normal or median wave conditions to the presence of Cyclone Pam in 2015.
  - Marae:
    - Ranged between 2.8m – 3.4m during normal or median wave conditions to the presence of Cyclone Pam in 2015.
- Elevations are approximately 1 - 2m below cliff toe and so are underestimations

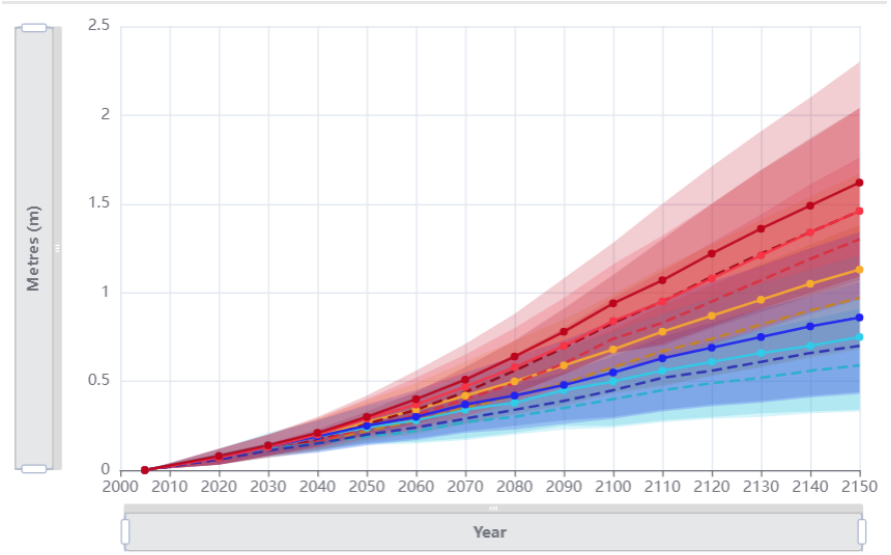
Methodology

Projecting future erosion trends

NZ Wave Hindcast Data Tool



NZ SeaRise Data



Stockdon Equation

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Where *H* = wave height

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Results

Future wave conditions for cliff erosion using NZ SeaRise data and the Stockdon equation

- Wave period decreases as wave height increases.
- Normal wave conditions will cause erosion as sea level rises rather than extreme events.
- An increase in the probability of cliff erosion events occurring is observed as the sea level rises.

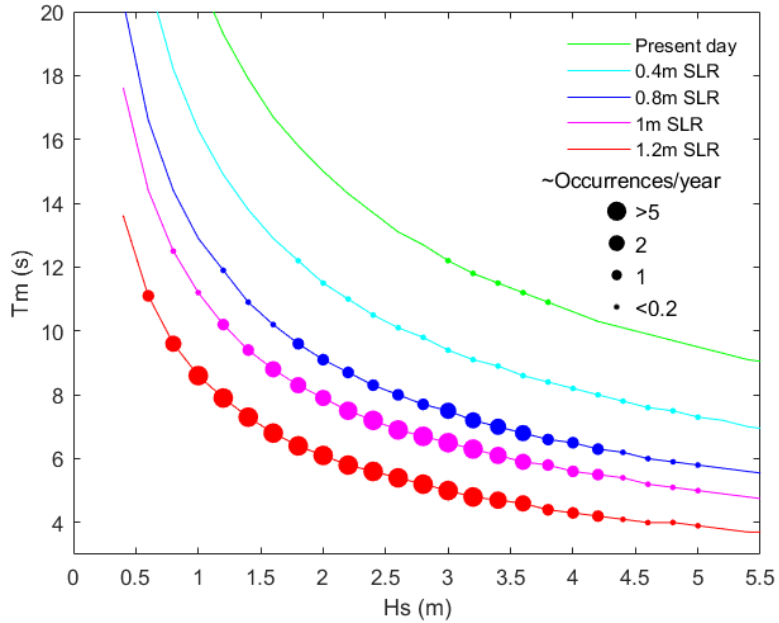

Figure 1: Distribution of wave height and wave period combinations resulting in coastal erosion.

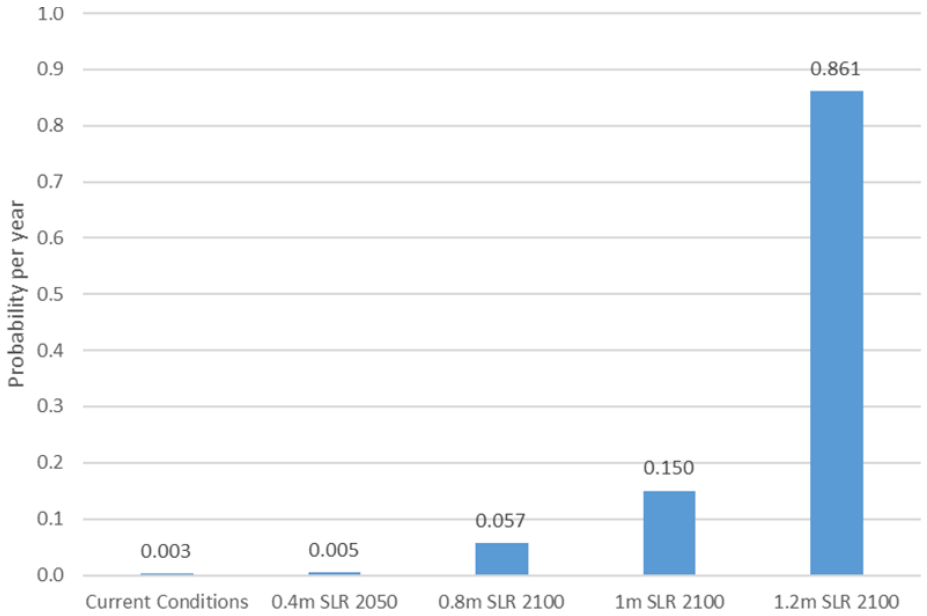

Figure 2: The probability of coastal erosion events occurring as the sea level rises.

Conclusions

- GIS suggests the cliffs at Waimangō Point are stable.
- The Stockdon equation produced runups which were underestimations when compared to the observations by the Royal Family.
- Under sea level rise scenarios, coastal and cliff erosion at Waimangō Point will accelerate due to the increase in the number of events being able to erode the coast.

Storm in early Jan 2018. Source: Miria Royal

Assumptions, Limitations and further research

- The Stockdon equation is a numerical model that has been used, calibrated and validated extensively. BUT for sandy beaches.
- Different models should be tested
  - A different wave runup model that is applied to gravel beaches such as Poate et al. (2016).
  - SWAN model that simulates nearshore waves
- Clifftop cameras to help with more accurate water elevation observations

Poate, T. G., McCall, R. T., & Masselink, G. (2016). A new parameterisation for runup on gravel beaches. *Coastal Engineering*, *117*, 176–190. https://doi.org/10.1016/j.coastaleng.2016.08.003

The next steps for Waimangō Point

- Results and conclusions relayed back to the Local Iwi.
- Surprised with the stable conclusion of the northern cliffs.
- In the process of cliff top camera installation.
- Seismic analysis and monitoring has been planned for this site.

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Thank you!
Questions? Patai?

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