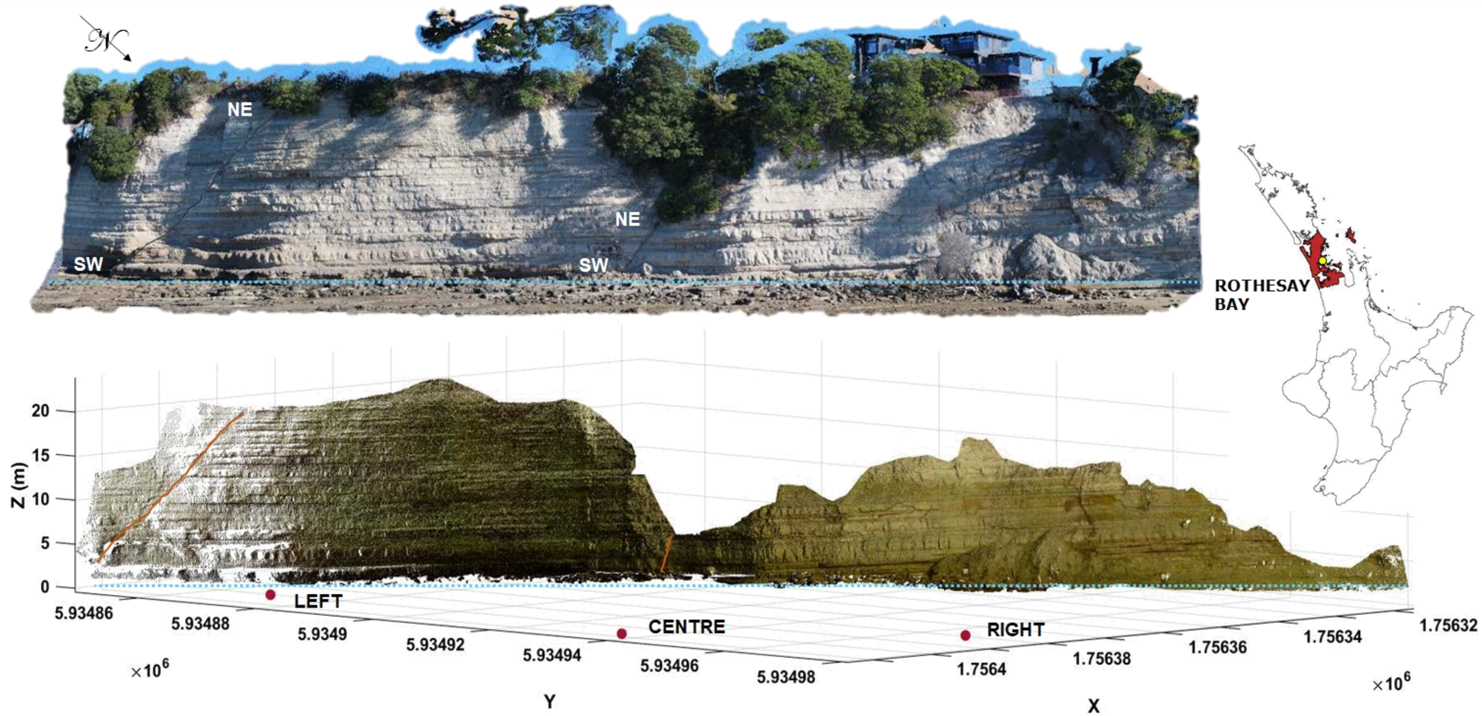
REGIONAL ROUND-UP

AUCKLAND

DO SHORT-TERM CLIFF-EROSION MEASUREMENTS RELIABLY REPRESENT LONG- TERM EROSION RATES?

Presented by Lovleen Acharya Chowdhury

Study Area



Location of the study site. A) Frontal view of the scanned cliff face with cliff-top dwellings at the cliff edge and collapsing vegetation captured during a drone survey on 1st July 2021. Two NE-SW running fault lines have been highlighted. The mean sea level interacts with the cliff base at 1.3 m demarcated by a blue dotted line. B) Dimensions of the surveyed cliff face along with the location of the ten transects at an interval of 15.26 m and bolt locations on the shore platform used as stations for the laser scan surveys have been shown.

- **The 120m-long scan area includes cliffs of 10-30 m height with an average slope of 3-5^{o}.**
- **Formed of horizontally bedded soft sedimentary flysch rock.**
- **Two distinct NE-SW fault lines can be traced across the cliff face**
- **Fronted by an ~140m wide near-horizontal shore platform that terminates in an abrupt seaward edge.**
- **Believed to have been formed several millennia of stable Holocene Sea level (around 6,000 years).**

Motivation:

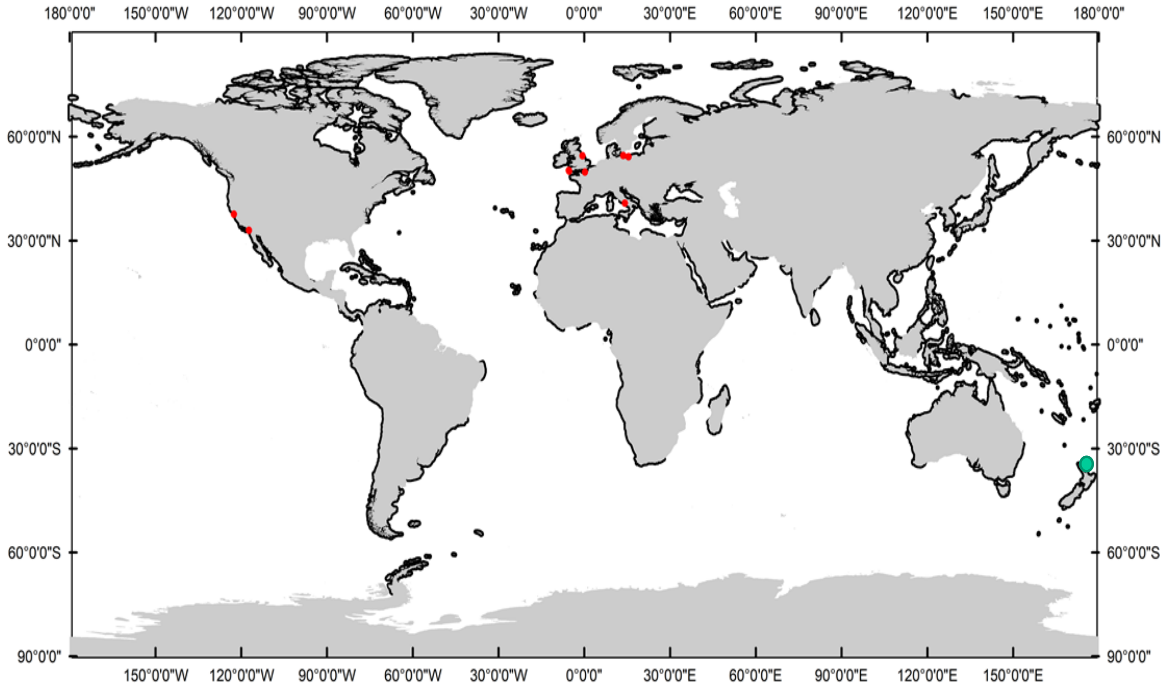
Implications of growing population pressure and anthropogenic modifications to the coastlines

A) Location of the wedge failure with its associated vertical jointed surface/failure plane (black dashed lines). B) Failure of sandstone bedding plane C) Talus formed due to the accumulation of the debris supplied by the two failures above. D)Collapse of weathered soil at the cliff top has exposed the Pōhutukawa tree root system and foundations of the properties. A properties' deck can be seen hanging mid-air.

- **The cumulative effects of growing population pressure and anthropogenic modifications to the coastlines have had serious implications for cliff recession along North Shore, Auckland.**

Motivation:

Contribution to global coastal TLS cliff monitoring program



Distribution of sea cliffs worldwide (indicated in black): modified after Emery and Kuhn, 1982. The locations at which TLS was used for cliff monitoring has been indicated in red.

Here we report new TLS point cloud datasets from 13 years of monitoring (2009-2022) at Rothesay Bay, Hauraki Gulf, New Zealand.

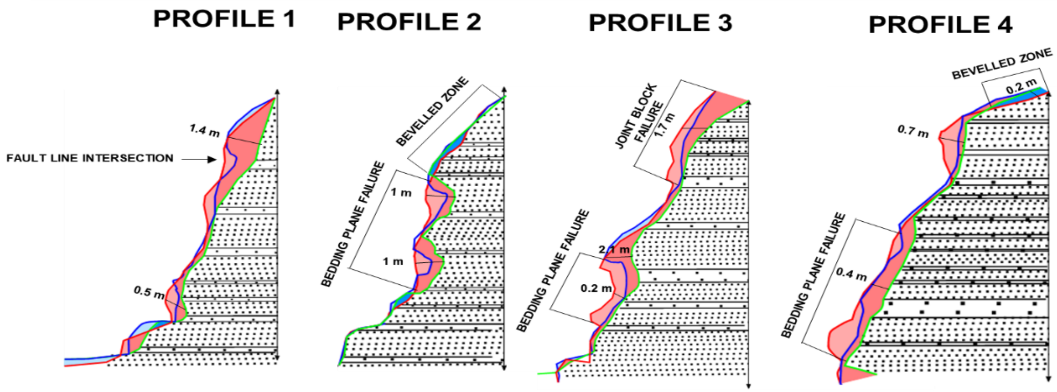
For a detailed assessment of cliff erosion was achieved by:

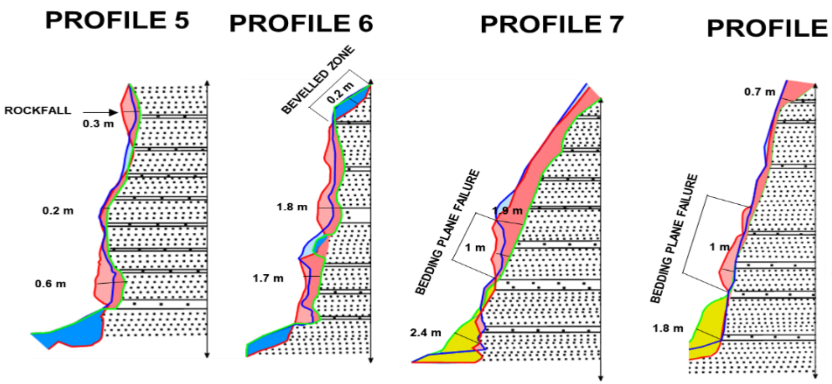
(1) Examine and contextualize cliff failure patterns using a spatio-temporal profiling analysis.

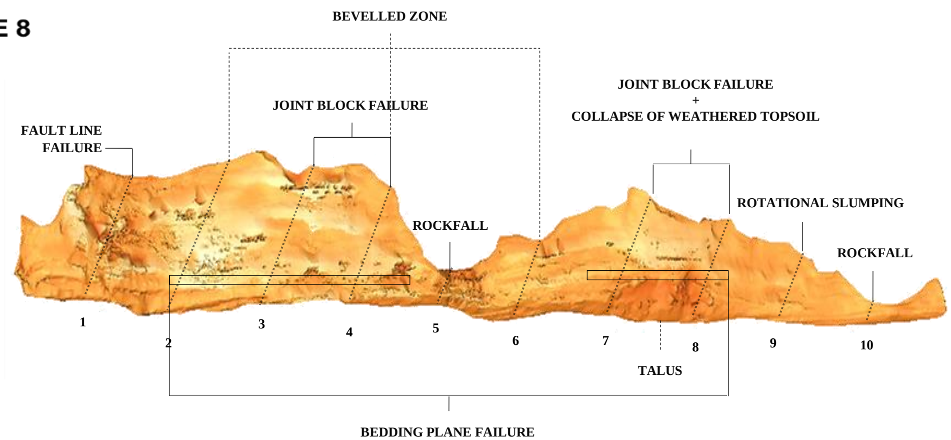
(2) Apply change detection and volumetric analysis to map and quantify temporal geomorphic changes

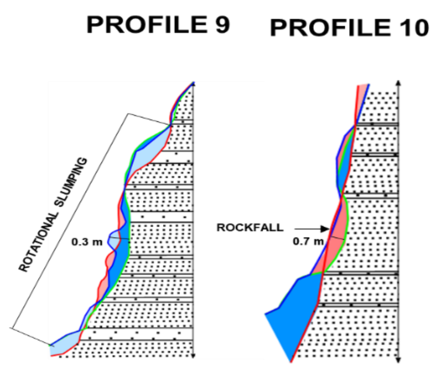
(3) Estimate and compare annual retreat rates to those of previous studies.

Spatio-temporal Profiling



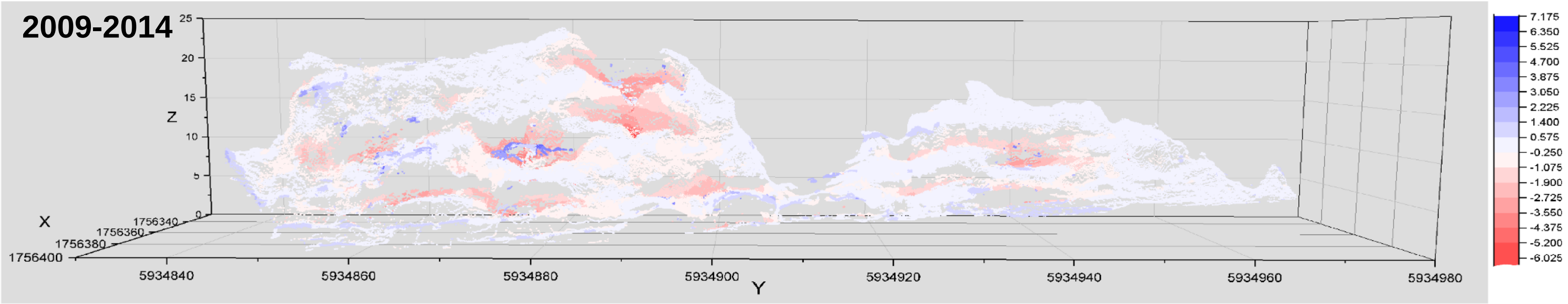


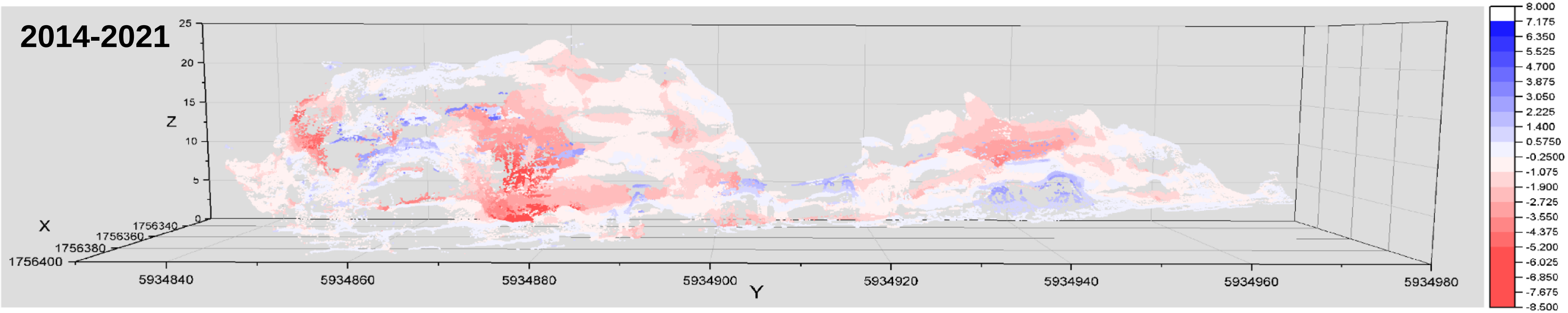


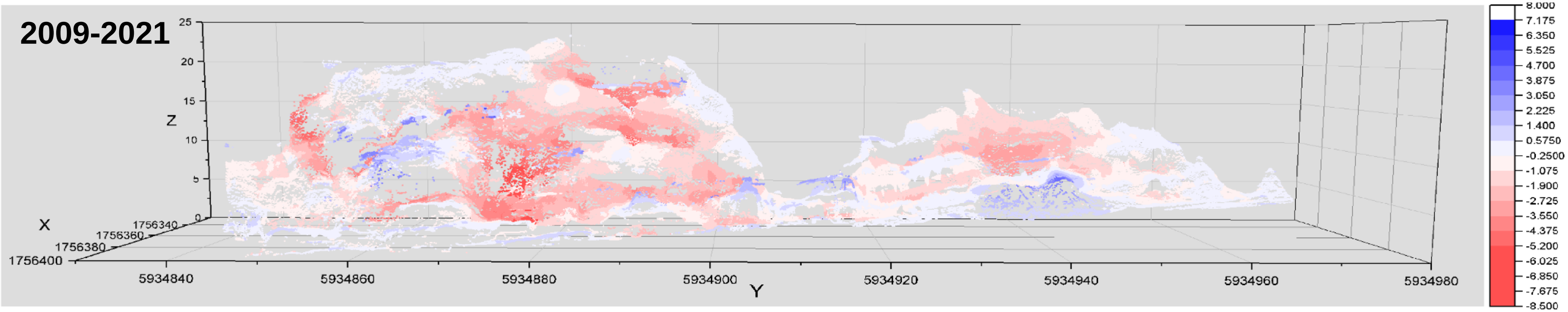


Stratigraphic cross sections (1-10) displaying failure depth and mechanisms. Shades of pink and shades of blue are the sequential erosion and deposition occurring between 2009 (red),2014 (blue) and 2021(green).

Change Detection Analysis



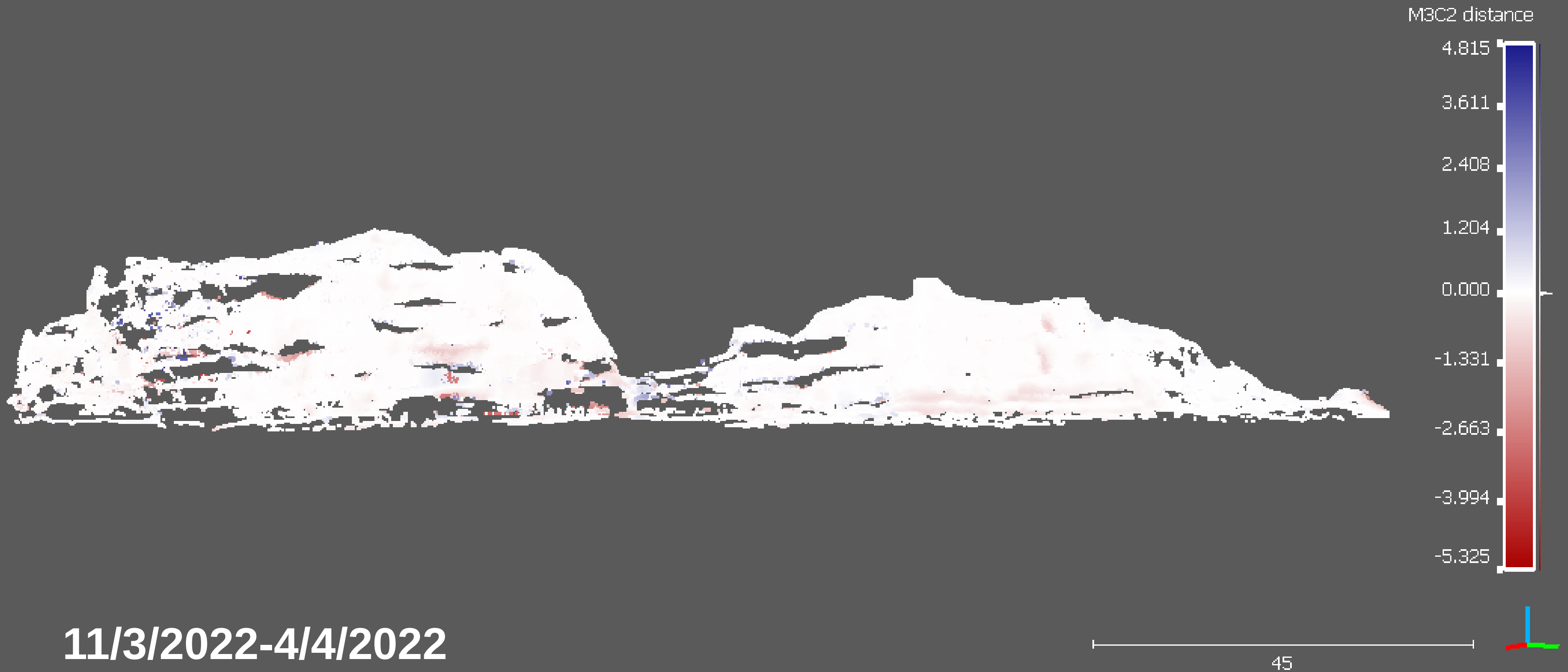




Cliff deformation over 12 years

July 2021-August 2021

Change Detection Analysis



11/3/2022-4/4/2022

Volume change and erosion rate estimation

Reference Scan	Compared Scan	Time interval	Volume added/ Total area deposited (m^3)	Volume removed/ Total area eroded (m^3)	Total surface area (m^2)	Annual retreat rate ($m\ yr^{-1}$)
2009	2014	5 years	241.868	294.419	1,414.500	0.04
2014	2021	7 years	151.668	619.189	1,417.120	0.06
2009	2021	12 years	267.582	752.948	1,370.050	0.04

Comparison of estimated annual retreat rate

Source	*Method*	*Time Period (Years)*	*Range (mm/ yr–1)*	*Average (mm/ yr–1)*
Brodnax (1991)	Aerial photographs	40	30-350	180
Gordon (1993)	Dated structures	60-70	3.5	Dated structures
Moon and Healy (1994)	Dated structures	60-70	20-60	n/a
Glassey et al. (2003)	Aerial photographs	40	5.3-50.7	16.8
	Cadastral surveys	70-75	50-100	75
	Dated structures	60-70	0-81.8	33.4
	Geological markers	~6500	6-31	19
	Laser surveys	5-10	n/a	15.6
	Average of all methods	n/a	11-75	30.7
Paterson and Prebble (2004)	Dated structures	70-80	26-127	62.7
	Geological markers	~6500	n/a	111
	Shore platform width	~6500	n/a	31
Gulyaev and Buckeridge (2004)	Laser surveys	2	10-33	24 ± 7
De Lange and Moon (2005) North Shore Site	Shore platform widths	7120 +- 70	1.4-14.3 +-0.1	8.0±0.3
De Lange and Moon (2005) Tawharanui Peninsula Site	Shore platform widths	7120 +- 70	1.8-13.8 +- 0.1	5.3±0.1
Current study	Laser surveys	12	40-60	45

Key Takeaways

1. **Over a span of 12 years, the cliffs at Rothesay Bay have exhibited large scale horizontal retreat with average rockfall volumes of 1.1 m3.**
2. **The retreat rate appears to have escalated in the latter half of the monitoring period with rates increasing from 4 cm/y-1 between 2009-2014 to 6 cm/y-1 from 2014-2021. However, when viewed holistically the rate calculated is around 4 cm/y-1.**
3. **A mean value of -0.664 m and a high standard deviation value of 1.175 m for this period indicates that Rothesay Bay can be characterized a low frequency high magnitude rock failure site.**
4. **The average medium retreat rate has been estimated to be 4.5 m/century which is consistent with rates presented in previous literature for the Waitemata rock cliffs (2-6 m/century by Moon and Healy (1994)).**
5. **Presence of earlier signs of cliff toe erosion suggests that marine processes in the form of Infragravity waves play a role in undercutting the base sandstone layer which then propagates upwards along the cliff face.**
6. **High resolution TLS data sets have played a vital role in estimating the short-term and medium-term cliff retreat rates at Rothesay Bay efficiently.**