COASTAL CHANGE

Guidance for using for using Aotearoa's Coastal Change Dataset

1.0 Background and purpose

The University of Auckland (UoA) has released a nationally consistent, open-source data set of coastal change for open coast beaches at a national scale, called '**New Zealand's Coastal Change Dataset (NZCCD)'**, funded by the Resilience to Nature's Challenges (RNC) National Science Challenge. This document provides guidance on using the data. Additional guidance for tangata whenua, including case studies of how other whānau have used the data, is available on the Coastal Change website[1]. A detailed methodology, including description of uncertainty calculation, has been published and made available by Ford et al[2], and Tuck et al[3] has described the dataset itself.

2.0 How was the dataset generated?

We have mapped historic coastal change around Aotearoa New Zealand using both historic vertical aerial photographs (from late 1930's to present) and high-resolution satellite imagery (from early 2000s). The historic photos were sourced from New Zealand's national archive (Retrolens, https://retrolens.co.nz/), while the satellite images were obtained from commercial providers. Images were all georeferenced (aligning all images to a common reference) to ensure accurate positioning and comparability between years. New Zealand was divided into over 400 Areas of Interest (AOIs), each ranging from 5 to 10 km in length and covering most open coast beaches and soft cliffed coasts. This detailed mapping effort produced a high-quality dataset of coastal change across most of the open coast of New Zealand. We did not map hard-rock cliffs, many of which have changed imperceptibly over many decades, and we have not mapped inner harbour coasts, which were beyond the scope of this work. In general, we have not mapped urbanised coasts that have been protected for many decades with engineering structures that have held the coastline in the same position.

3.0 Generating coastal positions

The position of the coast was manually digitised within a Geographical Information System (GIS). New Zealand's open coastline is highly diverse, featuring sandy and gravel beaches, various cliff formations, and active coastal dunes. To account for this variability, we defined the coastal position according to different coastline indicators that were easily identifiable in both aerial and satellite images. For sandy beaches, we usually mapped the edge of coastal vegetation, which often corresponds to the bottom of sand dunes, or steep scarps in the face of eroding dunes. For gravel beaches we mapped the storm ridge and for cliffed coasts we mapped either the cliff top or the cliff toe (base) depending on the location and what could clearly be seen in the imagery. In some rare instances we mapped the waterline, and where there were sea walls or rock revetments along part of a beach, we mapped the edge of these structures. Importantly, we mapped the same coastal position at each location through time, so that coastal change rates could be derived. The coastal positions are available for download at data.coastalchange.nz ('NZCCD Coastlines'). The uncertainty (in metres) of the coastal position is provided in the attribute table of the file (Total_UNCY).

4.0 What does the rate of coastal change represent?

Once all the coastlines had been mapped, rates of coastal change were then determined at 10-metre intervals along the coast, using the Digital Shoreline Analysis System (DSAS) v6 provided by the United States Geological Survey (USGS)[4]. All data and the range of coastal change metrics can be downloaded from data.coastalchange.nz. The USGS provides detailed guidance on the use of DSAS and we provide explanations on the various coastal change metrics published with the coastal change dataset (Table 1).

Table 1: An explanation of the coastal change metrics used to describe changes in the position of the coastline at 10 m intervals around New Zealand. These metrics are found in the attribute table of the 'NZCCD Coastal Change Rates' file available to download from data.coastalchange.nz.

Attribute	Example	Description	What does this mean?
Start_Date	21/03/1943	The date of the earliest coastline used in analysis in DD/MM/YYYY format	The earlier the start date generally indicates a longer coastline record at the point of interest. The start date varies depending on the availability of aerial imagery around the country.
End_Date	05/11/2022	The date of the most recent coastline used in analysis in DD/MM/YYYY format	The end date indicates the date of the most recent coastline mapped and used to calculate coastal change metrics. This will be updated as more coastlines are mapped and added to NZCCD.
Duration	77	The duration (rounded to nearest year) of the coastline record at this point.	It is important to note the duration of the coastline record mapped and used to calculate coastal change metrics. The duration of the coastline record varies around the country and this must be considered if comparing rates of coastal change. It is best practice to compare rates of coastal change over the same time period.
ShrCount	7	The number of coastlines used in analysis	The greater the number of coastlines that are mapped and used to calculate coastal change metrics, the more confident we can be in the results.
Net Shoreline Movement	NSM	The distance (m) between the earliest and the most recent coastline for each transect.	The NSM indicates the net change in coastal position. A small NSM indicates little net movement of the coastline. This does not necessarily mean that the coastline is not dynamic, any landward or seaward movement of the coastline may have been cancelled out.
Shoreline Change Envelope	SCE	The distance (m) between the most landward and most seaward coastline.	The SCE indicates how dynamic a coastline is. If the SCE is small, the position of the coastline has shown minimal variation over the observed period suggesting relatively stable conditions.
End Point Rate	EPR	The rate of change (m/year) between the earliest and most recent coastal positions is calculated by dividing the distance by the time between the two coastlines.	The EPR provides a rate of change based solely on the oldest and most recent positions of the coastline. It does not account for variations in the position of the coastline between these two points. A large (small) EPR suggests a faster (slower) rate of change.
End Point Rate Uncertainty	EPRunc	Uncertainty of the end point rate (m). This uncertainty is calculated based on the uncertainty in the position of the two coastlines used.	The EPRunc indicates how confident you can be in the EPR rate. If the EPRunc is high the EPR should be interpreted with caution as the true rate of coastal change may differ considerably from the EPR.

Linear Regression Rate	LRR	The linear regression rate of change (m/year) is determined by fitting a least-square regression line to all coastlines at a point location.	The LRR provides a rate of coastal change that utilises all mapped coastlines, giving a more comprehensive picture of coastal change than the EPR, which only uses two points. A large (small) LRR suggests a faster (slower) rate of change.
Linear Confidence Interval	LCI	The 90% confidence interval of the linear regression	The LCI represents the uncertainty in the LRR values. If the LCI is high the LRR should be interpreted with caution as the true rate of coastal change may differ considerably from the LRR.
Linear Standard Error	LSE	Standard error of the linear regression	The LSE describes the variability in the coastline positions around the linear regression line used to calculate the LRR. If the LSE is high, it is likely due to a dynamic coastline or non-linear coastal change.
Linear R-Squared	LR2	The LRR R-squared statistic is a dimensionless index (ranging from 1.0 to 0.0) that describes the scatter (variance in the data).	The LR2 indicates how much variance of the coastline positions is described by the linear regression model. A high LR2 indicates that coastal change is relatively linear at this location.
Weighted Linear Regression Rate	WLR	The WLR (m/year) is determined by fitting a regression line to all coastline points for a transect. The more reliable data (lower uncertainty) are given a greater weighting in a WLR.	The WLR provides a rate of coastal change that utilises all mapped coastlines and provides a higher weighting to coastlines of higher quality e.g. smaller positional uncertainty. The WLR provides a robust measure of coastal change through time.
Weighted Confidence Interval	WCI	The 90% confidence interval of weighted linear regression	The WCI represents the uncertainty for the WLR rate. If the WCI is high, the WLR should be interpreted with caution as the true rate of coastal change may differ considerably from the WLR.
Weighted Standard Error	WSE	Standard error of weighted linear regression	The WSE describes the variability in the coastline positions around the weighted regression line used to calculate the WLR. If the WSE is high, it is likely due to a dynamic coastline or non-linear coastal change.
Weighted R-Squared	WR2	The WLR R-squared statistic is a dimensionless index (ranging from 1.0 to 0.0) that describes the scatter (variance in the data).	The WR2 indicates how the weighted regression model explains the variance in the coastline positions. A high WR2 indicates that coastal change is relatively linear at this location.

The rate of coastal change presented on the web-map accessed through the Coastal Change website (coastalchange.nz) is the Weighted Linear Regression Rate (WLR) (in m/year). The WLR is calculated by fitting a regression line to all the coastline position points (at each 10 m interval), where the trend line is fitted by placing more weight on the coastline positions that have smaller positional uncertainties. The WCI for each WLR rate is given as (+/-) indicating the range of uncertainty around the estimated rate of coastal change. The accuracy of the WLR rate increases with more data points, therefore coastal change metrics were only calculated where more than 3 coastlines were mapped.

Positive WLR indicates accretion (seaward movement of the coast, also known as progradation) and negative WLR indicates erosion (landward wearing back of the coast). While the WLR provides a useful measure of coastal change rates through time, it omits a complete understanding of coastal change. For example, a highly dynamic coast that has accreted (moved seaward) and eroded (moved landward) periodically through the study period of analysis but has a similar position in 2023 as in 1940, will show a relatively 'stable' WLR rate (i.e. close to zero). The WLR rate does not capture the variability of coastal positions through time for coastlines that have been through variable periods of coastal erosion and accretion.

None of the coastal change metrics should be interpreted in isolation. A comprehensive analysis using multiple metrics is required to robustly understand the changes in New Zealand's coastline. For example, using the Shoreline Change Envelope (SCE) or Net Shoreline Movement (NSM) in conjunction with WRL can provide a more detailed picture of coastal dynamics through time. The WLR provides the rate of coastal change while the SCE and NSM give a description of the spatial extent of change, and the Weighted R-squared value (WR2) indicates how linear the change is (Table 1). Examples describing the use of multiple coastal change metrics to interpret changes in the position of the coastline have been provided in Table 2.

Table 2: Examples of synonymous use of multiple coastal change statistics to better interpret changes in the position of the coastline through time.

Coastline	WLR	WR2	NSM	SCE	Interpretation
A	Stable	Small	≈ 0	Large	The coastline is dynamic and has experienced episodes of erosion and accretion through the study period. However, the position of the coastline has ended up in a similar position to which it started.
B	Large	Large	≈ SCE	≈ NSM	The position of the coastline has moved considerably throughout the study period and has moved consistently in one direction.
C	Stable	Small	≈ 0	Small	The position of the coastline has remained relatively stable with small periods of erosion and accretion. The position of the coastline has ended up in a similar position to which it started.

5.0 How can community use these data?

Coastal Change data can be used in a variety of applications, and can be used to:

- Understand the historical pattern of change at the coast you are interested in.
- To estimate where potential future erosion is likely to occur.
- Consider potential impacts of coastal change on a variety of values and assets, including, but not limited to: property, infrastructure, ecology, conservation land, recreation, coastal access.

- Feed into coastal hazard assessments and climate adaptation planning. While not all coastal areas are currently covered in the dataset, the UoA Coastal Change team is open to generating data for new coastal sites or adding to the resolution of data for existing sites. You can find information about this on the website.
- Compare coastal change data with local knowledge and experience.

6.0 Contributing authors and acknowledgements

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7.0 References

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