Beach Change in the Auckland Region: Current State and Trends

State of the Environment Reporting

Megan E. Tuck

September 2025 Technical Report 2025/13

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Alongshore view of Pākiri Beach, Pākiri. Photograph by Jonathan De Villiers

Page 2 image credit
Alongshore view of Stanmore Bay, Whangaparāoa Peninsula. Photograph by Megan Tuck

Acknowledgement
I would like to thank Aidan McLean and all his predecessors for collecting the high-quality beach profile data used throughout this report to describe in detail the state and trends of Auckland's beaches.

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Executive summary

Te Kaunihera o Tāmaki Makaurau / Auckland Council's Coastal Processes Monitoring Programme provides essential long-term information on coastal change across the region. The programme has been monitoring coastal change at key beaches across Tāmaki Makaurau since the 1960s. Through the regular and long-term collection of beach profile surveys, the programme provides valuable data on erosion and accretion rates, which supports our understanding of natural coastal dynamics, informs adaptation planning, and enables effective management responses to coastal hazards and climate change. This report provides detailed beach profile analyses of 12 beaches, with beaches categorised into four groups (west coast, open east coast, inner Hauraki Gulf, and Tāmaki Strait) representing distinct wave climates around Tāmaki Makaurau. The analysis evaluates long- and short-term beach state and trends by assessing variations in beach envelope, beach volume, beach width, and for certain beaches, dune dynamics and beach rotation. Several important patterns emerge providing valuable insights into our region's dynamic coastlines.

1. Site-specific beach dynamics

The beaches of Tāmaki Makaurau exhibit considerable diversity in their long- and short-term trends, despite similarities in geographic setting and wave climate within each coastal group. Notably, Piha and Muriwai, both exposed to the high-energy west coast wave climate, demonstrate opposing long-term trends (1980s - 2025): Piha has experienced substantial accretion and widening across all profiles, whereas Muriwai has undergone significant sand volume loss and foredune retreat. These contrasting behaviours highlight the site-specific nature of sand transport, deposition and accommodation space along Auckland's west coast.

Inter-beach variability is observed across all groups, where adjacent beaches often exhibit contrasting trends. For example, the open east coast beaches Pākiri and Omaha exhibit opposing patterns of beach change, with Pākiri undergoing long-term erosion (1970s -2025) while the majority of Omaha Beach has accreted during the same period. As well as differences in sediment dynamics and accommodation space, these variations are largely influenced by differing beach management practices at these sites. As illustrated with these examples, variability in natural and human-influenced drivers of coastal change throughout the region underscores the necessity for continued site-specific monitoring to inform targeted coastal management at key locations.

2. Changes to long-term trends

Since the last State and Trends Assessment, published in 2016, the long-term trend at many beaches has altered considerably. The previous assessment reported relative long-term stability at both Pākiri Beach and Maraetai Beach. However, this report reveals the emergence of long-term erosion trends at both sites, with Pākiri, in particular, exhibiting accelerated erosion over the past decade. These changes highlight the dynamic nature of Auckland's beaches and emphasises the necessity to continue monitoring these beaches to detect and respond to any significant changes to the long-term trend.

3. Human interventions

Human activities such as sand mining, beach renourishment, dune planting, and the construction of coastal structures can strongly influence beach states in Tāmaki Makaurau, having the potential to mask or exacerbate natural trends. At Omaha Beach, human activities such as groyne construction and dune planting programmes have contributed to the long-term accretive trend at the beach by helping to trap sand within the beach and dune system. Similar impacts are observed at Muriwai and Piha beaches, where restoration initiatives – including dune reshaping and replanting – have supported dune stabilisation and accretion. Continued monitoring of these beaches is essential to better understand the long-term effects of human activities and restoration efforts.

4. Vulnerability of urban beaches

The inner Hauraki Gulf beaches are characterised by high intra-annual variability, with all monitored sites exhibiting substantial event and seasonal-scale fluctuations in beach profile position, volume, and width. Most inner Gulf beaches are 'urban beaches' that are predominantly backed by seawalls or rock revetments. They are also considered closed systems, with limited sediment typically present on the beaches and little inputs of sediment into the nearshore system. As such, these beaches are particularly vulnerable to erosion during high-energy events.

Notably, recent years have seen many sites exceed historic lower limits of beach elevation, suggesting a potential emerging trend of sediment loss. Ongoing monitoring will determine whether these changes represent short-term responses to recent storm activity or indicate a long-term trend of sediment loss at these beaches. The contrasting response of Ōrewa Beach and Takapuna Beach to Cyclone Lola that impacted Auckland in October 2023, is investigated in this report as a case study in Section 6.

5. Cyclical patterns of beach change

Several beaches in Tāmaki Makaurau exhibit cyclical patterns in beach volume, beach width or beach rotation that may correspond to major climatic oscillations such as the El Niño Southern Oscillation, Interdecadal Pacific Oscillation or Southern Annual Mode. Beaches such as Pākiri Beach, Omaha Beach, and Long Bay exhibit cyclical patterns of beach change occurring on five- to ten-year cycles, coinciding with sustained periods of sand accumulation or loss. Understanding the drivers of these cycles at different beaches is critical for anticipating future beach change and appropriate coastal management.

These patterns collectively highlight the necessity of maintaining long-term, site-specific monitoring to track beach evolution, detect emerging issues, and inform proactive coastal management. Monitoring results also help prioritise resource allocation by identifying beaches that may require more frequent monitoring and those where reduced effort may be appropriate. Given resource constraints, strategic prioritisation of key sites is essential.

The high variability of beach change across Tāmaki Makaurau reflects a complex interplay of local drivers – including wave climate, sediment supply, bathymetry, geographic setting, and human interventions. Improving understanding of these drivers at the site level will be key to managing future coastal change.

The Coastal Processes Monitoring Programme continues to evolve, integrating long-term datasets with new technologies. New initiatives outlined in this report, including nearshore bathymetry surveys, a pilot drone monitoring programme, wave buoys, coastal monitoring cameras, and efforts to improve public access to coastal data, will strengthen Auckland's ability to protect and adapt its coastline in response to future environmental challenges.

Supporting information

This report is one of a series of technical publications prepared in support of *Te oranga o te taiao o Tāmaki Makaurau – The health of Tāmaki Makaurau Auckland's Natural Environment in 2025: a synthesis of Auckland Council State of the Environment reporting*.

All related reports (past and present) are published on the Knowledge Auckland website.

All data supporting this report can be requested through our Environment Auckland Data Portal. Here you can also view live rainfall data and use several data explorer tools.

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Glossary

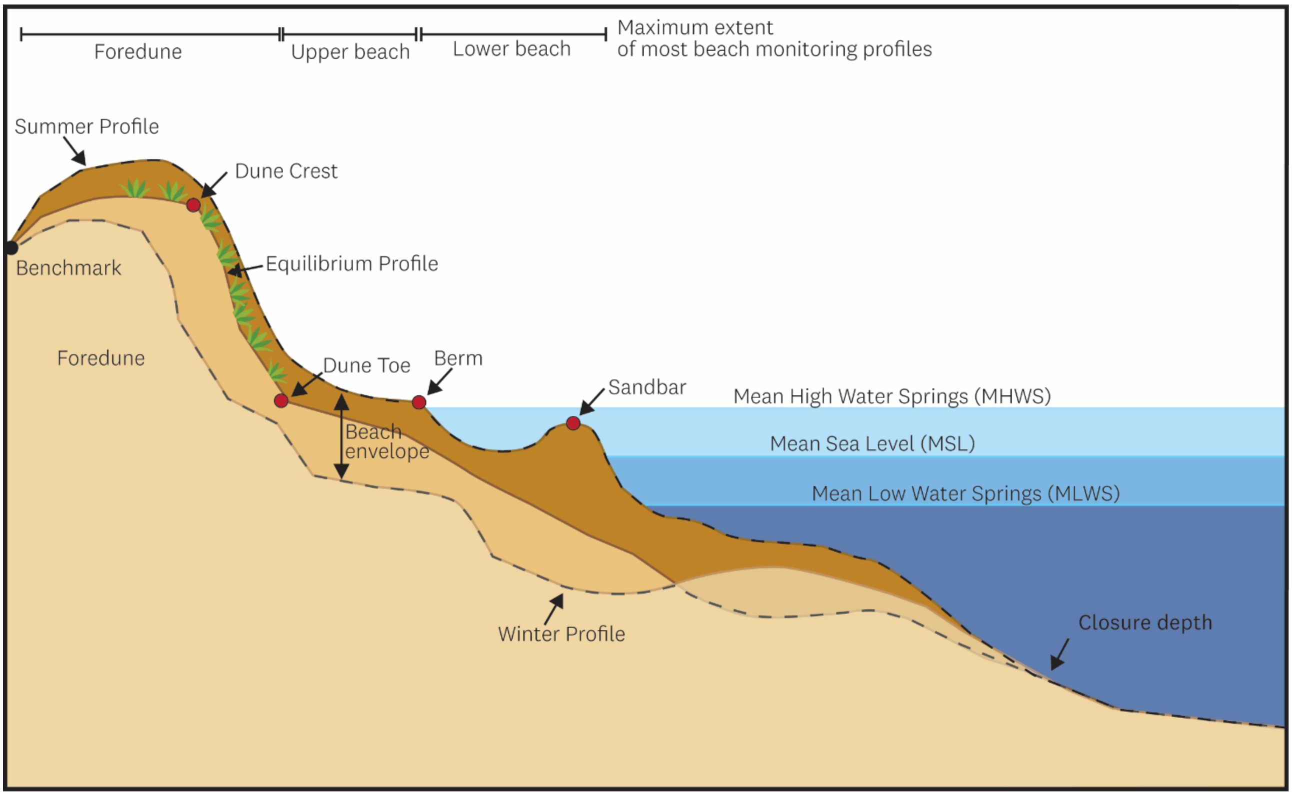

Figure 0. 1: Beach profile sketch with common morphological features noted and explained in glossary below.

Table 0. 1: Glossary of useful words to aid reading this report.

Accommodation space	The area available for the deposition of sediment on the coast. It forms the boundaries within which a beach forms and fluctuates.
Accretion	Gains of sediment to the beach when compared with previous beach measurements.
Beach envelope	The maximum and minimum limits of the beach profile recorded across the entire monitoring period (Figure 0. 1).
Beach profile	Horizontal cross-section of a beach starting from a fixed landward position, usually a benchmark, and extending seaward past mean sea level (Figure 0. 1).
Beach state	Indicates whether the beach profile is undergoing accretion or erosion, and/or flattening or steepening throughout the monitoring record.

Beach width	A horizontal measurement usually taken from a benchmark starting point out seaward to a specific contour usually Mean Sea Level (representing the lower beach width) or Mean High Water Springs representing the upper beach. In this report, beach width refers to the full-profile beach width, which extends beyond the intertidal zone to incorporate the active beach system, including the dune toe and backshore where applicable.
Berm	A nearly horizontal feature that forms in the backshore (landward of the beach face). It is an accretionary feature formed by the deposition of the coarsest beach sediment. The shape of the berm is a key predictor of dune growth.
BOI	Beach Oscillation Index describes the rotational behaviour (clockwise or anti-clockwise) of the beach through time.
Closure depth	Closure depth describes the depth at which no significant changes in the profile occur, e.g. the limits of significant sand exchange within the beach system that drive profile change (Figure 0. 1). Ideally beach profiles would extend to closure depth but it is not practical.
Dune crest	The highest elevation peak of the dune (Figure 0. 1).
Dune toe	The boundary of the beach-dune interface and the most seaward extension of the aeoline (wind) processes and deposits (Figure 0. 1).
ENSO	El Niño Southern Oscillation, periodic shifts in sea surface temperature that results in changes to wave climates in the southern Pacific. Two phases occur, El Niño (warm phase) where dominant wave direction is from the west, and La Niña (cold phase) where dominant wave direction is from the north-east in northern New Zealand.
Erosion	Losses of sand from the beach when compared to previous beach measurements.
Flattening	Loss of sediment to the upper part of the beach, and gains of sediment in the lower part of the beach when compared with previous beach measurements. The lower beach advances while the upper beach retreats. This usually occurs when the dune erodes, and the sediment is deposited in the lower part of the beach.
Foredune	The dune immediately landward of the active beach, which is built up by sand deposited by wind and trapped in vegetation (Figure 0. 1).

Interdecadal Pacific Oscillation (IPO)	A long-term (10-30 year) climate oscillation that impacts weather patterns and sea levels in the Pacific and can affect the strength and frequency of the El Niño Southern Oscillation. The IPO fluctuates between positive phases that are linked to stronger westerly winds and rain in the west, and negative phases in which the trend is reversed.
Littoral drift	Transport of sand along the beach system, also known as 'longshore drift'.
Long-term	Defined in this report as the entire monitoring record. The monitoring period varies between beaches but typically spans between 27 to 60 years.
Lower beach	Section of the beach that is uncovered during low/very low tides but covered during mid-high tides. The lower beach parameter is beach specific and detailed for each beach in Table 2.1.
Mean Sea Level (MSL)	The average sea level usually taken over a rolling 19-year block, measuring the average of all high and low tides. Also serves as a vertical datum from which heights such as elevations are measured.
Mean High Water Springs (MHWS)	The MHWS elevation was defined as MHWS-10, which is the level equalled or exceeded by the largest 10% of all high tides (Stephens, 2012; Figure 0. 1).
Significant wave height (Hs)	The average height of the highest 1/3 of the waves in a wave record.
Southern Annular mode (SAM)	A ring of climate variability that encircles the south pole and extends over New Zealand. The negative phase of SAM generally leads to high air pressure over New Zealand and light winds whereas the positive phase brings lower air pressure over New Zealand and stronger westerlies and stormy weather.
Sand bar	A submerged or partially exposed ridge of sand built up by waves and currents (Figure 0. 1).
Short-term	Usually a five-year period. In this report we use a 10-year period to capture trends in beach change since the last assessment in 2014 (Boyle, 2016).
Standard deviation	A value that describes the spread of the data points around the mean. A higher standard deviation indicates higher variation.
Steepening	Loss of sediment to the lower part of the beach, and gains of sediment in the upper part of the beach when compared with previous beach measurements. The lower beach retreats while the upper beach advances.

Upper beach	Section of the beach near the bottom of the dune, usually where there is constantly dry sand above high tide. The upper beach parameter is beach specific and detailed for each beach in Table 2.1.
Wave height (hs)	The height of a wave measured between the elevation of the crest and the neighbouring trough.

1 Report purpose

The purpose of this report is to describe the current state and long-term trends of twelve Auckland beaches based on detailed beach profiling records. Each beach is monitored using multiple cross-shore beach profiles which capture beach changes across different sections of the beach. Monitoring records vary between beach surveys but typically span between 27-60 years, providing a robust dataset for identifying both short- and long-term coastal trends. The information reported here is critical for State of the Environment monitoring and reporting, enhancing public awareness of beach conditions, informing coastal management and planning, and supporting the implementation of several New Zealand Coastal Policy Statement (NZCPS) policies (Section 1.3).

In addition to long-term monitoring of Auckland's beaches utilising beach profile surveys, Auckland Council's Coastal Processes Monitoring (CPM) programme has initiated use of a range of complementary technologies such as wave buoys, tidal gauges, coastal monitoring cameras, and numerical models to monitor beach change and its drivers. The programme also conducts targeted pre- and post-storm monitoring at key beaches to assess the impact of high-energy events and improve understanding of how future events may affect Auckland's coastline.

Data collected through Auckland Council's CPM Programme plays a crucial role supporting and informing decision-making regarding the planning, maintenance and management of coastal infrastructure in Auckland. For example, this data has informed strategic decisions such as the location of the new Muriwai surf club (Dahm, 2000), the construction of multiple coastal protection structures and the implementation of beach renourishment programmes and sand transfer around Auckland. More recently, the programme has played a central role in informing and advancing Shoreline Adaptation Plans (SAPs), which guide the strategic management of Auckland's coastal assets and land in response to coastal hazards and climate change. Furthermore, the programme's coastal data is increasingly utilised by academic and research institutions to advance scientific understanding of coastal change.

This report focuses on the current beach condition and long-term change derived from beach profile records. It does not explore in detail the impacts of storm events and beach recovery processes, the impact of coastal protection works such as seawalls or beach renourishment programmes, or the influence of decadal-scale climate oscillations on coastal change. These topics will be investigated in upcoming reports as part of the revised reporting schedule, which includes a combination of five-yearly state and trends assessments and more frequent reporting on shorter-term dynamics. An exception to this can be found in the case study (see section 6) which uses hindcast, real-time wave buoy, and coastal monitoring camera data to explore the disparate response of Ōrewa Beach and Takapuna Beach to Cyclone Lola, that impacted Auckland in 2023.

New Reporting Schedule:

State and Trends (5-yearly): Comprehensive reporting on the current state and long-term trends of 12 Auckland beaches. This report is based on the beach profile monitoring record.

Annual beach group reports (Years 1-4): Investigative reports focusing on beach dynamics and drivers of beach change within each beach group. These reports will integrate data from beach profiles, drone surveys, coastal monitoring cameras, bathymetry, wave buoy records, and the Auckland hindcast dataset.

Annual beach summary report: Concise, high-level summaries of beach changes observed over the previous year, published annually.

1.1 Report scope

The beaches reported in the monitoring programme are grouped within four distinct wave energy and tidal settings, which help to define the magnitude of beach change in the Auckland region. This report describes the findings of beach profile analysis up to the year 2025 for all 12 beaches within the four beach groups (Figure 1. 1).

Group 1: West coast beaches – Piha Beach and Muriwai Beach.

Group 2: Open east coast beaches – Pākiri Beach and Omaha Beach.

Group 3: Inner east coast beaches – Long Bay, Takapuna Beach, Browns Bay, Campbells Bay, Milford Beach and Cheltenham Beach.

Group 4: Tāmaki Strait beaches – Maraetai Beach and Kawakawa Bay.

This report has built on previous beach profile analysis prepared by Kench (2008) and Boyle (2016), who established the original database of beach envelopes and trends. This report has expanded the analyses to report on lower and upper trends in beach width and beach volume, as well as foredune dynamics and beach rotation at relevant beaches, see Data analysis (Section 2.2).

Figure 1. 1: Site map showing location of the 12 beaches within the four beach groups included in the report.

1.2 Report objectives

The specific objectives of this report are detailed below:

- **Quantify and report long and short-term trends** in beach change, including changes in beach width and beach volume at Auckland beaches.
- **Assess the short to long-term state of Auckland's beaches** by analysing beach width at both the lower and upper beach, identifying spatial and temporal variability.
- **Examine beach profile movements within the historical beach envelope**, identifying instances where recent surveys exceed previous thresholds, indicating new recorded highs or lows in shoreline position.
- **Analyse foredune position changes at key Auckland beaches**, assessing trends in dune retreat, accretion, or stability.
- **Analyse patterns in beach rotation at key Auckland beaches,** by analysing changes in the Beach Oscillation Index (BOI) throughout the monitoring period.
- **Compare beach change within and between distinct beach groups**, exploring spatial patterns and potential drivers such as sediment supply, wave exposure, and human interventions.

1.3 Policy context

The New Zealand Coastal Policy Statement (NZCPS) 2010 is a national policy document that sets out objectives and policies for the management of New Zealand's coastal environment. Please note, the NZCPS is currently under review and is likely to be updated in the next few years.

Auckland Council's CPM Programme directly supports the implementation of several NZCPS policies, including:

Policy 4: Integration

Integrated management of natural and physical resources in the coastal environment.

Auckland's CPM programme contributes to regional reporting, and planning efforts with multiple groups within Auckland Council. Our data is used alongside water quality, biodiversity, and climate projections to inform coordinated and evidence-based coastal management.

Policy 24: Identification of coastal hazards

Auckland's beach monitoring data supports the identification of erosion hotspots and assessing long-term trends that may signal increased vulnerability to coastal hazards. This data supports the development of hazard zone mapping, coastal asset construction and relocation, as well as decision-making around the management of high-risk coastal areas.

Policy 26: Natural defences against coastal hazards

Auckland's CPM programme helps track the condition and extent of natural defences such as dune systems and beach nourishment programmes over time. The long-term data can show whether dune-building efforts (e.g. fencing, dune planting) are successful in rebuilding natural defences.

Policy 28: Monitoring and reviewing the effectiveness of the NZCPS

Policy 28 focuses on assessing the effectiveness of regional policies, plans, and resource consents in giving effect to the NZCPS. Auckland Council's long-term beach monitoring dataset is essential to support this evaluation. Continuous records of shoreline change, erosion and accretion patterns, and beach volume trends provide the evidence needed to determine whether coastal planning measures are achieving their intended outcomes.

2 Beach data collection and analysis

The 12 beaches reported on in the Coastal Processes Monitoring Programme are grouped within four distinct wave energy and tidal settings. The number of beach profiles used to monitor each beach varies between the 12 beaches, and both the duration of the monitoring record and the number of surveys at each beach profile varies considerably between the beach groups (Figure 2. 1).

The west coast beaches (Piha Beach and Muriwai Beach) are characterised by high average wave conditions, above 1.5 m, and water levels with the highest MHWS levels in the region. Piha and Muriwai also hold a relatively long monitoring record with profiles extending back to the 1980s (Figure 2. 1). Regular monitoring on the west coast has resulted in a relatively high number of surveys at each west coast profile with slightly higher profile numbers at the most southern profiles of each beach (Figure 2. 1).

The open east coast beaches (Pākiri Beach and Omaha Beach) experience relatively high wave conditions with an average wave height close to 1 m. In contrast, Pākiri and Omaha experience some of the lowest MHWS levels (Figure 2. 1). Pākiri and Omaha hold some of the longest monitoring records where Omaha Beach profile records extend back to the early 1960s. Both Omaha and Pakiri also have a large number of beach profiles monitoring change at each beach compared to the other beach groups. Regular monitoring on the open east coast and an extensive monitoring record has resulted in a high number of surveys at both Pākiri and Omaha Beach (Figure 2. 1).

The inner Hauraki Gulf beaches (Long Bay, Takapuna Beach, Browns Bay, Campbells Bay, Milford Beach and Cheltenham Beach) experience some of the lowest wave conditions in the region with average wave conditions at just 0.36 m, as well as relatively low MHWS levels. The monitoring record is relatively short at the inner Gulf beaches starting at most sites in the late 1990s. However, each beach has a high number of surveys due to a generally high monitoring frequency (Figure 2. 1).

Tāmaki Strait beaches (Maraetai Beach and Kawakawa Bay) experience the lowest wave conditions in the region with an average wave height of just 0.2 m (Figure 2. 1). However, Maraetai Beach and Kawakawa Bay experience relatively high MHWS levels. The monitoring record at these beaches is short, starting in the late 1990s at both beaches but sustained regular monitoring has provided a good number of surveys for beach change analysis (Figure 2. 1).

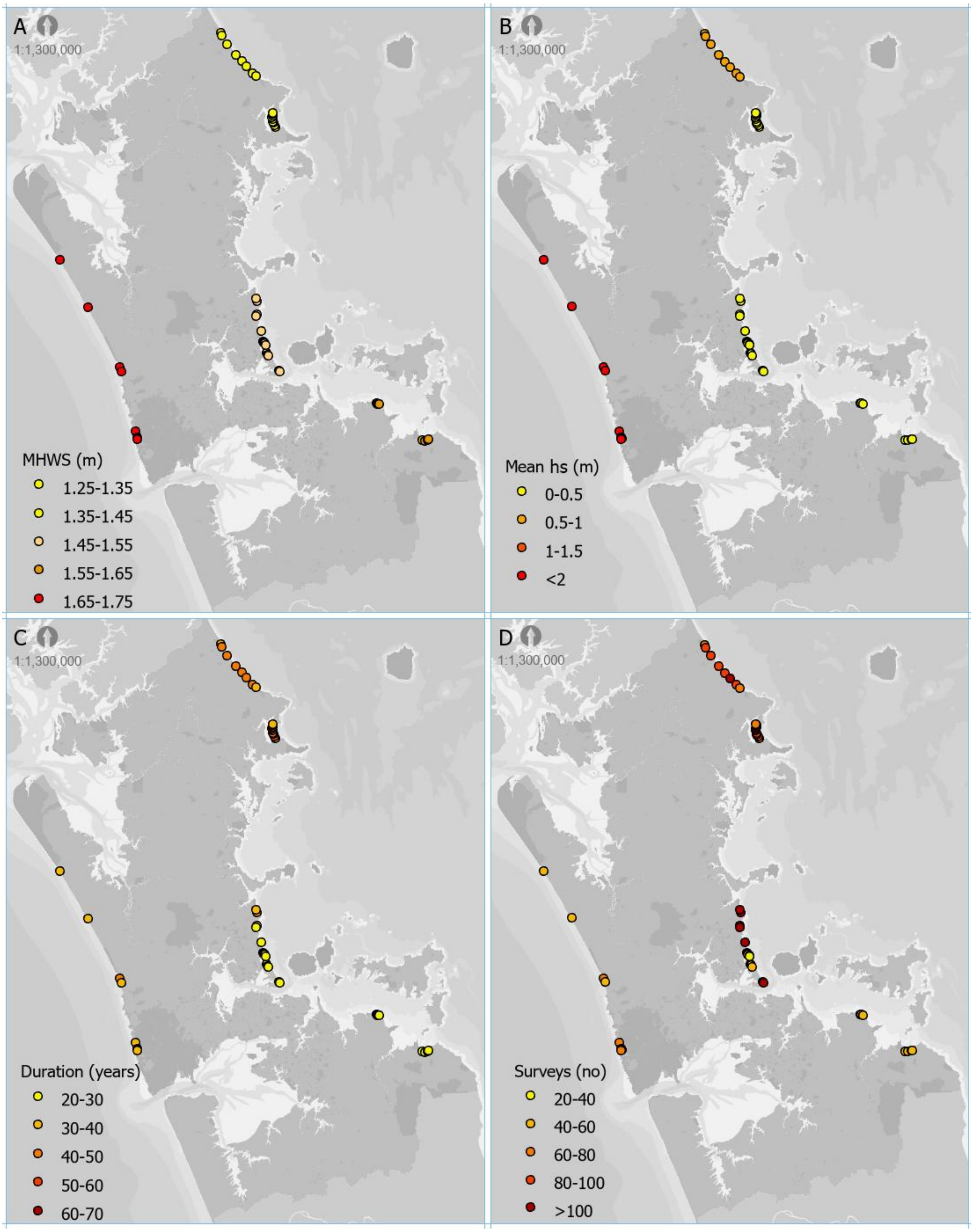

Figure 2. 1: Beach group settings illustrating A) Mean High Water Springs (MHWS) (Stephens, 2012) (m), B) mean wave height (hs) (m), C) beach monitoring record duration (years), and D) the number of surveys undertaken at each beach profile for the 12 beaches reported on in the Coastal Processes Monitoring Programme.

2.1 Data collection

Beach profile data is collected by surveying the surface of the sand along a cross-section profile of the beach (Figure 2. 2). The oldest historical profiles were surveyed using the 'Emery' method, using a tape and pole (Emery, 1961). This method was replaced by the automatic level 'dumpy' survey technique that uses a level and a staff to create topographic profiles of the beach. Since 2012 RTK-GPS (real-time kinematic global positioning) has replaced these surveying methods. The RTK-GPS increases efficiency as it only requires one operator and provides higher resolution mapping.

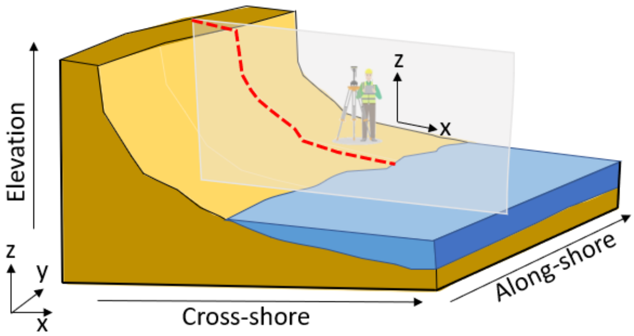

Figure 2. 2: Schematic of a beach profile survey measuring the elevation changes along a beach cross-section.

Monitoring frequency varies between all 12 beaches and throughout the monitoring record. Most beaches have been surveyed bi-annually, although some were surveyed monthly, capturing seasonal beach conditions for approximately a decade (Table 2. 1). Monitoring of some inner Gulf beaches was suspended following the last assessment (Boyle, 2016) but monitoring was reinstated in 2022. Periodic pre- and post-storm beach surveying has also been undertaken but these surveys will be analysed in future reporting.

Beach-specific lower and upper beach contours (Table 2. 1) have been defined for each site where beach width and volume analyses are conducted (see section 2.2). In most cases these reflect the MSL for the lower beach and MHWS for the upper beach. On wider beaches, however, the upper beach contour has been set at a higher elevation to capture changes occurring further up the beach face. Please note that the MHWS water levels have been updated since the last assessment (Boyle, 2016), this report uses the NIWA's updated values derived using tide-gauge records and hydrodynamic numerical models (Stephens, 2012).

Table 2. 1: Beach surveying details for Auckland beaches. Lower and upper elevations used for beach width and volume calculations are uniform across all profiles at each beach.

Beach	Initial Survey Year	Length of Record (Years)	MHWS contour location	Number of profiles	Lower beach elevation (m)	Upper beach elevation (m)
Piha	1981	44	1.72	5	1.72	4.00
Muriwai	1981	44	1.72	4	1.72	5.00
Pākiri	1978	47	1.27	8	1.27	4.00
Omaha	1962	63	1.33	9	1.33	4.50
Long Bay	1982	43	1.46	2	1.46	3.00
Takapuna	1998	27	1.49	3	0.00	1.49
Browns Bay	1998	27	1.49	2	0.00	1.49
Campbells Bay	1998	27	1.49	2	0.00	1.49
Milford	1998	27	1.49	5	0.00	1.49
Cheltenham	1998	27	1.53	3	0.00	1.53
Maraetai	1998	27	1.61	4	0.00	1.61
Kawakawa	1998	27	1.63	4	0.50	1.63

2.1.1 Limitations

It is important to acknowledge the limitations of the beach profile dataset used to assess the state and trends of Auckland's beaches. The Auckland Coastal Processes Monitoring Programme has been in operation since the 1960s and, over this time, has undergone numerous changes in leadership, policy directives, monitoring recommendations, and technological capabilities. These developments have influenced the resolution, frequency, record length, and spatial coverage of the dataset.

The frequency of beach profile surveys has varied both temporally and spatially throughout the monitoring record, with periods of intensified monitoring as well as data gaps at specific beaches or beach profiles. For instance, some inner Gulf beaches were monitored monthly between 2000 and 2010, but then had monitoring entirely suspended between 2015 and 2022. These inconsistencies affect how rates of coastal change are calculated, as higher-frequency data disproportionately influence trend calculations. Accordingly, the method employed in this report has been adapted to account for these imbalances, see Data analysis (Section 2.2.1).

The duration of the monitoring record also varies significantly between beaches. While some beaches have continuous data extending back to the 1960s, others were not incorporated in the programme until the 1990s. It is therefore essential to consider these differences in record length when comparing rates of coastal change between beaches or individual profiles. The monitoring duration for each beach is summarised in Table 2.1.

Technological advancements have resulted in a substantial increase in the spatial and temporal resolution of beach profile data over time. The earliest historical surveys employed more laborious manual techniques such as the Emery method and dumpy level surveys to record changes in elevation across a beach profile, while recent surveys use the more accurate and efficient RTK-GPS. As a result, the average distance between recorded points has improved from approximately 9 m in the 1990s to around 1 m in 2024, enhancing the precision and accuracy of the profiles.

Lastly, spatial coverage within individual beach profiles has also varied. In many cases, particularly in older records, surveys captured only the beach face up to the dune toe, omitting the foredune and lower beach. This inconsistency complicates volumetric calculations and limits the ability to assess foredune dynamics, as many historical profiles do not extend across the full beach width. Consequently, the number of profiles suitable for volumetric analysis is substantially reduced.

2.2 Data analysis

Methods of analysis have been adapted from those outlined in Boyle (2016) in order to interpret beach change results from the beach profile monitoring record and provide an up to date understanding of the state and trends of Auckland's beaches. A number of parameters for each beach profile have been calculated and analysed within and across all beaches.

2.2.1 Calculating rates

Calculating rates of coastal change in systems regularly characterised by non-linear behaviour is not always straightforward and work continues to refine statistically robust approaches that can accurately delineate trends of coastal change (Genz et al., 2007). Despite the non-linearity of coastal systems, often driven by climate oscillations and episodic events, it remains essential to quantify long-term changes to assess any net sediment gains or losses within a beach system to inform sound coastal management decision-making.

A commonly employed method to estimate rates of coastal change is the linear regression rate, derived by fitting a least-squares regression line to all data points (Luijendijk et al., 2018; Himmelstross et al., 2021; Tuck et al., 2024). This approach is widely adopted in coastal science due to its simplicity and capacity to provide a first-order assessment of directional trends. In this study, linear regression is used to calculate rates of change in both beach width and beach volume across Auckland's beaches. A p-value is reported for trends of beach-wide average width and beach-wide averaged volume to indicate whether the trend is statistically significant (p-value < 0.05). A p-value represents the probability of obtaining the observed trend if no trend exists. In this study, a threshold of 0.05 is used to assess significance, meaning trends with p-values below 0.05 are considered statistically significant and unlikely to result from random variation alone.

As noted in Section 2.1.1, temporal inconsistencies in the beach profile dataset - particularly variable monitoring frequency - can limit long-term trend analyses (Aris et al., 2005). To address this issue, beach profile data were resampled to a uniform temporal resolution, with annual averages calculated for each beach profile. This approach ensures each year is equally weighted in the regression, thereby minimising bias associated with high-frequency periods and improving the robustness and comparability of calculated rates of change.

2.2.2 Beach envelope

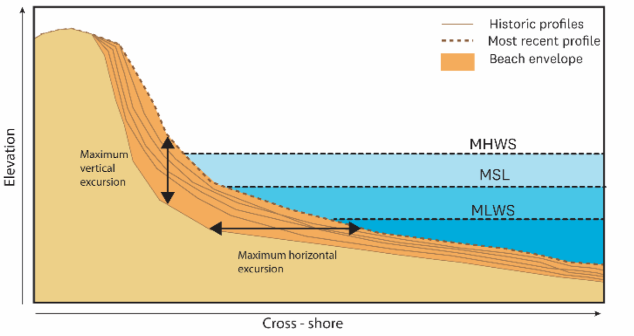

Figure 2. 3: Beach envelope derived from full beach profile dataset and description of vertical and horizontal excursions of the beach.

The beach envelope for each beach profile is derived from the full beach profile dataset and is defined by the maximum and minimum elevations recorded across the entire monitoring period (Figure 2. 3). This envelope represents the historical range of beach variability and serves as an important metric for assessing beach dynamism.

The size of the beach envelope, quantified by its maximum horizontal and vertical excursions, indicates how dynamic the beach profile position is over time. These metrics enable comparative analysis between beaches and highlight spatial variability in beach response to environmental forcing. In this report, the horizontal and vertical excursions of the beach are calculated across the entire beach profile, offering a comprehensive representation of beach variability (Figure 2. 3). This approach differs from previous assessments (Boyle, 2016), which focused on the upper beach.

In addition to inter-beach comparisons, comparing the position of recent beach profiles to the historical beach envelope provides valuable insights into the current state of each beach. Profiles that fall near or outside the historical limits may indicate notable changes in sediment supply, beach recovery, or recent erosive events.

2.2.3 Beach volume

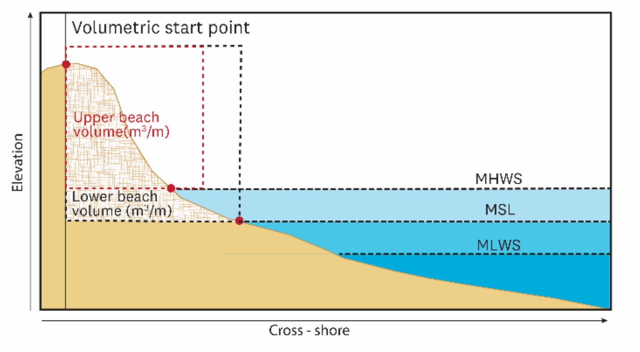

Figure 2. 4: Beach volume is calculated above the 'Lower' and 'Upper' beach thresholds. These are beach specific but usually reflect MSL and MHWS, respectively.

Beach volume is calculated between site-specific start and end points along each beach profile (Figure 2. 4). Ideally, these would correspond to the full extent of each beach profile; however, as described in Section 2.1.1, the spatial coverage of beach profiles is inconsistent across the monitoring period. Many historical surveys do not extend far enough landward or seaward to capture the full profile, limiting the availability of data for volumetric calculations.

To maximise the usable dataset, bespoke start points were selected for each beach profile. These points are chosen to include the greatest number of surveys possible, while maintaining consistency through time and ensuring comparability within the beach. Volume is calculated between and above the fixed start point and the specified lower and upper elevation thresholds, which are specific to each beach (Table 2. 1). Volume is expressed in cubic meters per unit metre length of beach (m^3/m).

In addition to individual profile calculations, beach-wide average volume was determined to assess overall changes at the scale of the entire beach. For each profile, all available surveys for each year were averaged to create an annual volume value. These values were then averaged across all profiles within a beach to produce a beach-wide annual average. A five-year smoothing filter was subsequently applied to highlight medium- to long-term trends in volumetric change.

As noted in Section 2.1.1, variations in monitoring frequency across profiles – even within the same beach – can introduce artificial variability when averaging. To minimise bias, only years that met a minimum threshold of valid profile measurements were included in beach-wide calculations. It is important to note that beach volume calculations in this report differ from earlier assessments (e.g., Boyle, 2016), which measured volume from the 1 m elevation contour rather than applying beach-specific lower and upper beach thresholds.

2.2.4 Beach width

Beach width is calculated by measuring the distance between a fixed benchmark and where the position of the profile interests the lower and upper beach thresholds specified in Table 2.1 (Figure 2. 5). Beach width is expressed in meters (m).

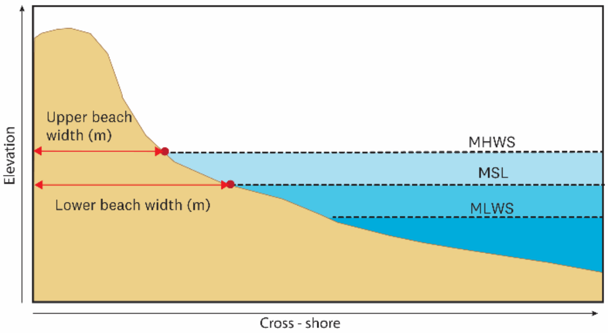

Figure 2. 5: Beach width is calculated at the 'Lower' and 'Upper' beach threshold. These are beach specific but usually reflect the MSL and MHWS, respectively.

Like beach volume, beach-wide average width was determined to assess overall changes at the scale of the entire beach. For each profile, all available surveys for each year were averaged to create an annual beach width value. These values were then averaged across all profiles within a beach to produce a beach-wide annual average. A five-year smoothing filter was subsequently applied to highlight medium- to long-term trends in beach width change.

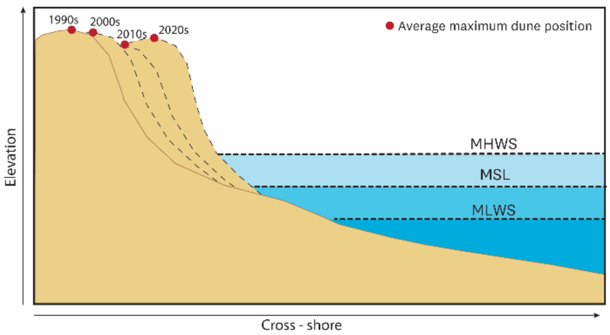

Figure 2. 6: Foredune dynamics assessed through tracking the decadal average maximum dune position through time.

2.2.5 Foredune dynamics

The foredune represents a critical sediment reservoir within the beach system and plays a key role in providing natural protection to coastal assets, residential properties, and important habitats that lie behind the dune system. Understanding long-term changes in the foredune is therefore essential for assessing coastal resilience and sediment dynamics.

Changes in the position of the foredune are assessed only at beach profiles where a distinct foredune exists and where sufficient historical data is available. As such, this analysis is restricted to selected profiles along the west coast and open east coast beaches, where regular monitoring of the foredune has occurred.

Both vertical and horizontal changes in the foredune position are calculated to characterise foredune evolution over time. The position and trajectory of the dune throughout the monitoring period are plotted for each profile individually and presented in Appendix B. To facilitate comparison between profiles and visualise temporal changes, the average highest dune position is calculated for each decade. These values are then normalised relative to the 1990s, a period for which data is available across all analysed profiles. This approach reduces the influence of differing record lengths and enables a consistent, comparative assessment of foredune change. The normalised decadal dune positions are then plotted for all relevant profiles across each beach.

2.2.6 Beach Oscillation Index

The Beach Oscillation Index (BOI) calculates the relative rotational behaviour of a beach (clockwise or anticlockwise) through time by comparing beach width changes across multiple beach profiles at a single beach. To isolate short- to medium-term rotation patterns from long-term progradation or recession trends, the lower beach shoreline position time series for each profile was first normalised by subtracting the mean shoreline position over the study period. This normalisation enhances the comparability of inter-profile variability and ensures the BOI reflects relative, rather than absolute, changes in shoreline position.

The BOI is calculated by averaging the differences in the shoreline position between neighbouring profiles along the beach, providing a measure of the beach's overall rotation state at each point in time. A positive BOI indicates clockwise direction of the beach e.g. northward accretion and/or southern erosion of the beach, while a negative BOI indicates anti-clockwise rotation e.g. southward accretion and/or northward erosion of the beach. The code used to calculate the BOI for each inner Gulf beach was initially developed by Yafar and Miyamoto (2024) and was subsequently adapted to support analysis across multiple beaches.

The BOI could not be calculated for all beaches due to inconsistencies in the spatial extent and frequency of historical profile surveys, particularly at open coast beaches. Many historical profiles at these sites did not extend to mean sea level, and profile surveys were often not conducted simultaneously across the same beach (Section 2.1.1). As a result, the BOI was calculated only for six inner Gulf beaches where data coverage was sufficient.

2.2.7 Beach state

Beach state is determined using the rate of beach width change at the lower and upper beach profile determining four possible beach states:

Retreat: Beach erosion at both the lower and upper profile (Figure 2. 7A)

Advance: Beach accretion at both the lower and upper profile (Figure 2. 7B)

Flattening: Accretion of the lower beach and erosion of the upper beach (Figure 2. 7C)

Steepening: Erosion of the lower beach and accretion of the upper beach (Figure 2. 7D)

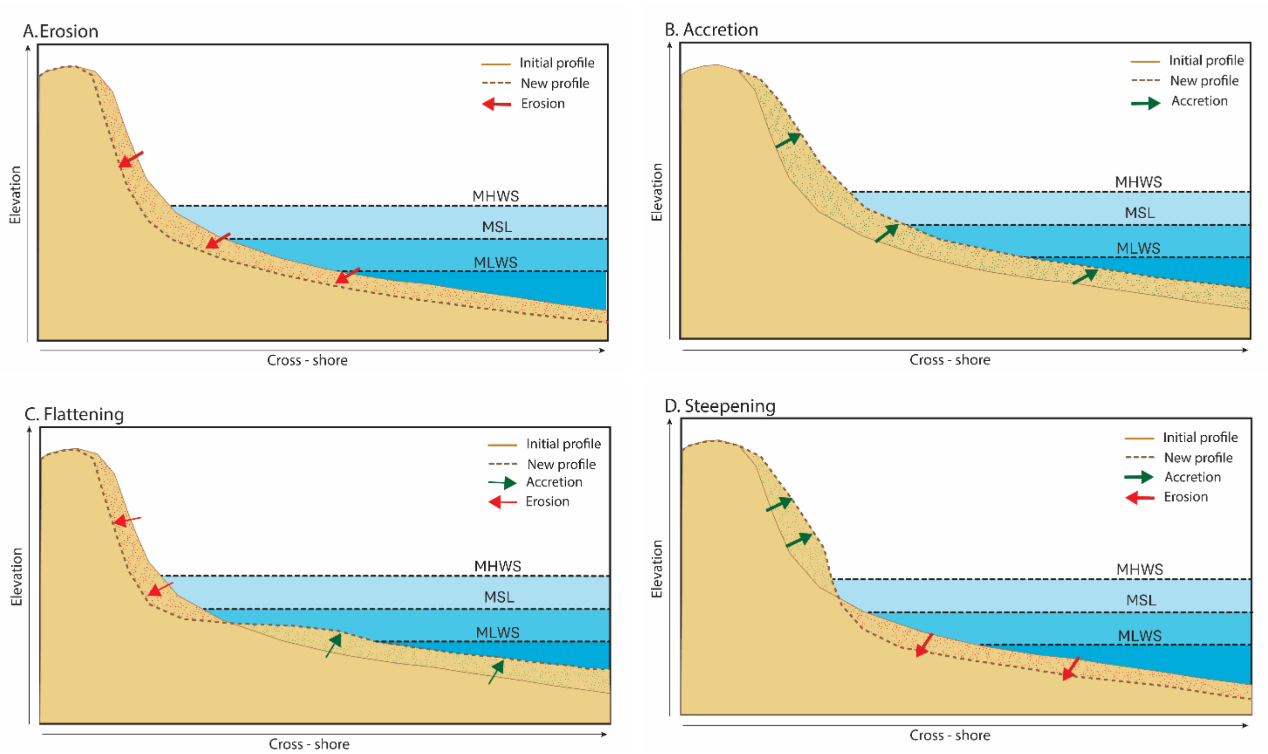

Figure 2. 7: Beach profile schematic depicting A) erosion, B) accretion, C) flattening, and D) steepening. Note the seaward limit of most profiles is close to Mean Low Water Springs (MLWS).

Further to the four beach states outlined above the rate of erosion and accretion at the lower and upper beach is also considered providing further insights into the state of the beach with additional descriptions of beach state including:

Retreat and steepening: Beach erosion at both the lower and upper profile with a faster rate of erosion at the lower beach (Figure 2. 8A).

Retreat and flattening: Beach erosion at both the lower and upper profile with a faster rate of erosion at the upper beach (Figure 2. 8B).

Advance and Steepening: Beach accretion at both the lower and upper profile with a faster rate of accretion at the upper beach (Figure 2. 8C).

Advance and flattening: Beach accretion at both the lower and upper profile with a faster rate of accretion at the lower beach (Figure 2. 8D).

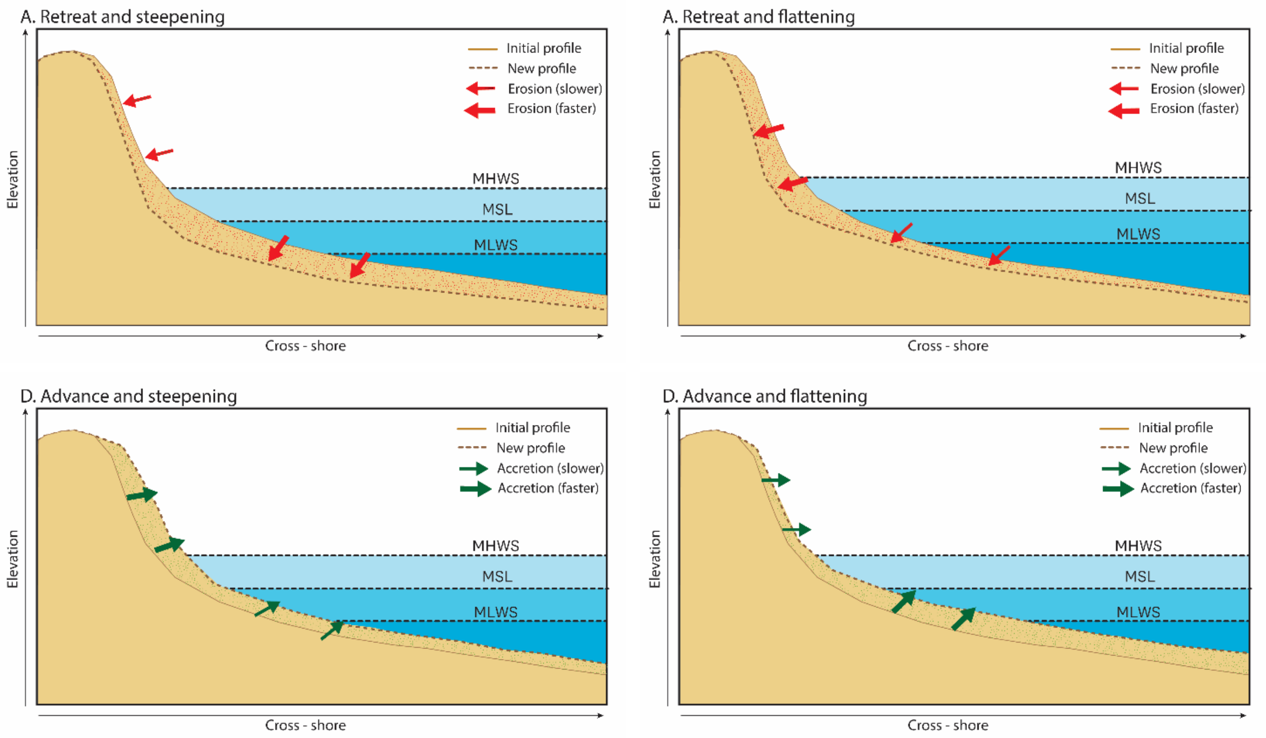

Figure 2. 8: Beach profile schematic depicting A) Retreat and steepening, B) Retreat and flattening, C) Advance and steepening, and D) Advance and flattening. Note the seaward limit of most profiles is close to Mean Low Water Springs (MLWS).

3 Overview: Beach change in Auckland

Long-term trends in beach change across Auckland indicate that many beaches are experiencing long-term erosion, with some beach profiles eroding at rates of -1.5 m/yr (Figure 3. 1). The primary exceptions are Piha Beach, located on Auckland's west coast, which exhibits the highest long-term accretion rates, exceeding 1.5 m/yr, and Omaha Beach, located on the open east coast, which has experienced high rates of accretion (0.5 – 1 m/yr). In contrast, the highest rates of long-term beach width erosion (> -0.1 m/yr) are observed at Muriwai Beach on the northern west coast and Pākiri Beach on the northern east coast. Correspondingly, these sites also exhibit the greatest long-term volume losses, with rates exceeding -2.0 m^3/m/yr at the northern Muriwai profiles and across Pākiri Beach.

Beaches within the inner Hauraki Gulf generally experience low (-0.5 – 0 m/yr) long-term erosion rates, while those in the Tāmaki Strait display more variable trends, with both erosion and accretion occurring across different sites (Figure 3. 1). The inner Gulf and Tāmaki Strait beaches also exhibit the smallest long-term volumetric changes.

Short-term trends (2014-2025) highlight an acceleration of erosion at Muriwai and Pākiri, with more rapid beach width and volume loss recorded since the last assessment (Boyle, 2016). In contrast, short-term changes at the inner Gulf beaches are highly variable. Despite a long-term erosional trend, some inner Gulf beaches have exhibited short-term accretion, while others continue to erode, underscoring the significant short-term and seasonal fluctuations characteristic of these environments (Figure 3. 1).

At Piha Beach, high rates of accretion persist, with an acceleration of sediment accumulation particularly evident post 2014 (Figure 3. 1). Similarly, Maraetai Beach in the Tāmaki Strait has recently experienced increased accretion, with short-term trends indicating beach widening and volume growth since the last assessment (Boyle, 2016). In contrast, Kawakawa Bay, also located in the Tāmaki Strait, exhibits little deviation from its long-term trends (Figure 3. 1).

Identifying clear spatial patterns in coastal change across Auckland remains challenging, except for Muriwai and Pākiri, which consistently exhibit high rates of erosion throughout the monitoring record. However, a range of anthropogenic factors – including sand mining, seawall construction, and beach renourishment – can obscure or modify natural coastal processes, complicating assessments of underlying trends in beach evolution.

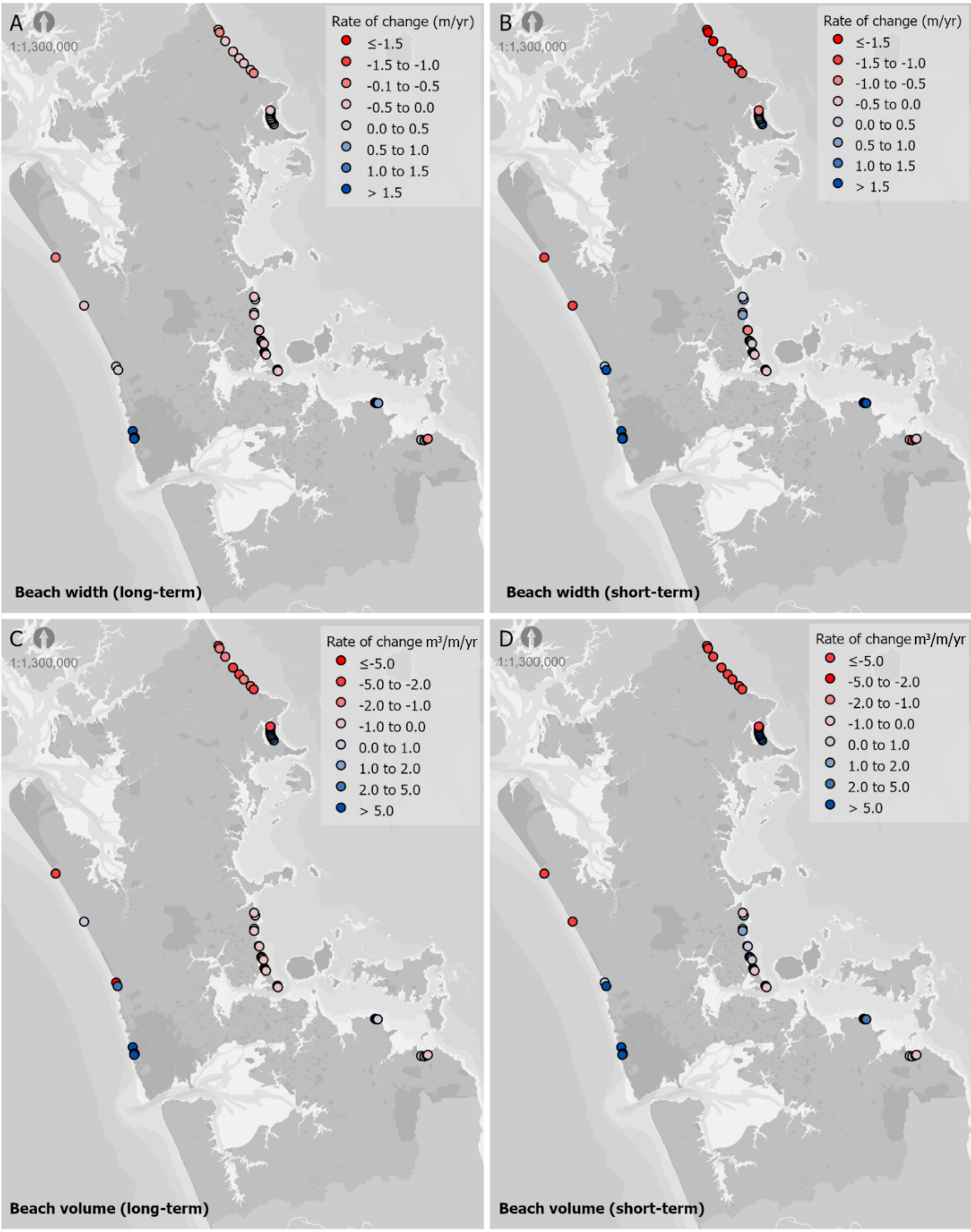

Figure 3. 1: Trends maps showing A) long-term rates (entire monitoring record), and B) short-term rates (2014 - 2025) of change in lower beach width, C) long-term rates (entire monitoring record) and D) short-term rates (2014 - 2025) of change in lower beach volume at 12 Auckland beaches. Data provided in Table 3.1.

Many of Auckland's beaches (as monitored) are experiencing long-term retreat. However, the mode of retreat at Auckland's beaches – whether through beach profile steepening or flattening – varies spatially (Figure 3. 2). Both northern beaches, Muriwai and Pākiri, are retreating, yet their responses differ: Pākiri Beach is predominantly retreating and steepening, whereas Muriwai's northernmost profile is steepening while the remainder of the beach is flattening.

Omaha Beach exhibits long-term shoreline advance and steepening across most of its extent, with the exception of the northern end, where retreat and flattening are occurring as the upper beach erodes at a faster rate than the lower beach. Inner Gulf beaches, by contrast, exhibit a long-term trend of retreat and steepening, driven primarily by more rapid erosion of the lower beach.

Since the last assessment (Boyle, 2016), subtle shifts in the beach state have emerged, particularly at the northern beaches, where the mode of retreat has fluctuated between steepening and flattening. These changes suggest that erosion rates and the zone of concentrated erosion along the beach profile are dynamic, leading to periodic switches in beach profile response.

Short-term assessments of inner Gulf beaches further highlight their dynamic nature. While some beaches maintain their long-term state, others show a recent shift from retreat to short-term advance, underscoring the complex and variable nature of coastal change within the inner Gulf (Figure 3. 2).

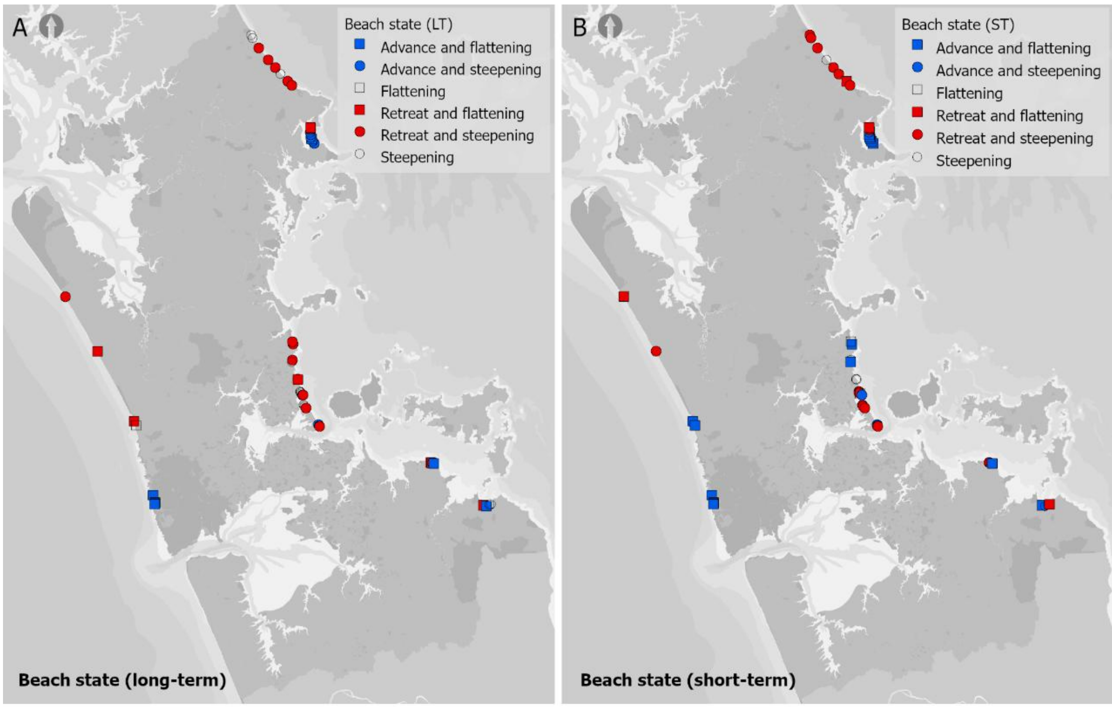

Figure 3. 2: Trends maps showing A) long-term state of the beach (entire monitoring record), and B) short-term state of the beach (2014 - 2025). Data provided in Table 3.1.

4 Beach change results and discussion

Beach change results and maps are presented in this section, discussing both the long and short-term trends for all 12 beaches within the four beach groups (Figure 1. 1). In order to produce a concise report only one or two beach profiles are presented for beach envelope analysis at each beach, the rest are presented in Appendix A. Furthermore, for beach volume and beach width, only data from one profile is presented to illustrate variability across the monitoring record, alongside beach-wide averaged results. Foredune movements are also averaged and presented together to aid interpretation of the data, individual plots of foredune movements are presented in Appendix B.

Table 4.1 provides the beach change statistics, including the long and short-term trends of coastal change, for all 12 beaches, providing an overview of changes in sediment volume and beach width across all profile records.

Table 4.1: Beach change statistics at Auckland beaches. Beach state A = Accretion, R = Retreat, F = Flattening, and S = Steepening. Asterix* indicates beaches where monitoring was suspended between 2015 and 2022, therefore short-term rates only reflect changes between 2022 and 2025 and should be considered with caution.

Beach	Profile	Rate of change – beach volume (m^3/m/yr) – initial survey to 2025		Rate of change – beach volume (m^3/m/yr) - 2014 - 2025		Average beach volume (m^3/m/yr)		Standard deviation beach volume (m)		Rate of change – beach width (m/yr) – initial survey to 2025		Rate of change – beach width (m/yr) – 2014 - 2025		Average beach width (m)		Standard deviation beach width (m)		Beach state	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	L-term	S-term
Piha	P1	9.8	7.4	30.2	19.8	435.5	331.1	101.9	69.6	2.1	1.0	6.0	2.6	95.0	49.2	29.5	12.8	A+F	A+F
	P2	20.4	14.4	38.7	24.5	754.6	565.6	241.3	166.3	3.6	1.8	7.3	2.6	131.6	69.7	40.3	17.6	A+F	A+F
	P3	16.9	10.4	33.3	20.7	460.1	220.8	168.9	104.6	3.4	1.5	6.2	2.6	109.2	33.6	37.0	16.8	A+F	A+F
	P4	10.3	5.4	19.3	12.5	326.3	148.8	163.4	83.6	2.6	1.0	4.9	2.5	92.1	29.6	38.8	14.1	A+F	A+F
	P5	10.9	4.1	20.9	9.5	309.1	154.3	111.3	47.0	3.3	0.9	5.3	1.9	93.4	32.1	35.6	10.6	A+F	A+F
Muriwai	P1	-3.5	-2.2	-26.3	-23.1	470.0	390.2	78.9	67.8	-0.8	-0.4	-1.4	-2.0	72.3	42.6	12.5	6.8	R + S	R + F
	P2	0.9	0.8	-7.1	-4.9	695.0	596.7	52.0	36.7	0.0	-0.1	-1.1	-0.4	89.8	56.2	10.9	3.6	R + F	R + S
	P3	-9.4	-10.6	0.2	-0.7	259.4	153.4	121.9	124.9	-0.3	-0.8	0.4	0.0	61.1	27.5	12.6	9.4	R+ F	A + F
	P4	2.6	0.9	12.5	11.3	376.3	273.7	70.5	54.8	0.3	-0.2	2.3	1.4	70.0	36.8	10.4	6.3	F	A + F
Pākiri	P2A	-2.1	-0.9	-6.1	-4.4	179.9	88.9	53.9	43.9	-0.3	0.0	-1.8	-0.8	53.7	14.8	14.8	6.3	S	R + S
	P3	-1.4	0.4	-11.3	-8.4	195.4	102.6	45.7	34.1	-0.6	0.0	-2.3	-1.2	79.1	40.5	14.0	5.8	S	R + S
	P4	-1.4	0.0	-9.7	-8.2	675.1	580.6	64.8	51.3	-0.4	-0.1	-2.0	-0.7	167.2	128.5	13.2	5.3	R + S	R + S
	P5	-3.8	-3.1	-8.2	-2.8	422.2	324.5	76.1	63.9	-0.4	-0.2	-1.4	0.1	90.6	54.7	11.3	7.2	R + S	S
	P6	-2.7	-2.1	-8.9	-6.2	376.0	291.5	70.4	48.4	-0.3	-0.2	-1.4	-0.7	68.1	33.4	11.3	5.9	R + S	R + S
	P7	-1.1	-0.2	-12.5	-9.7	542.9	452.8	53.5	36.4	-0.2	0.1	-1.8	-0.7	84.2	52.4	10.3	4.9	S	R + S
	P8	-1.2	-0.2	-7.1	-6.4	363.5	274.4	44.4	34.9	-0.3	0.0	-0.6	-0.6	73.8	37.6	12.0	5.1	R + S	R + F

Beach	Profile	Rate of change – beach volume (m^3/m/yr) – initial survey to 2025		Rate of change – beach volume (m^3/m/yr) - 2014 - 2025		Average beach volume (m^3/m/yr)		Standard deviation beach volume (m)		Rate of change – beach width (m/yr) – initial survey to 2025		Rate of change – beach width (m/yr) – 2014 - 2025		Average beach width (m)		Standard deviation beach width (m)		Beach state	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	L-term	S-term
	P9	-3.4	-2.7	-6.5	-4.3	180.7	101.4	41.0	31.4	-0.5	-0.4	-1.3	-0.6	64.4	30.8	10.8	5.3	R + S	R + S
Omaha	P1	2.5	3.0	10.1	4.5	323.2	127.5	49.0	29.3	0.5	0.7	2.1	1.0	108.1	25.5	15.3	7.0	A + S	A + F
	P2	3.2	3.3	4.2	2.8	306.8	120.8	63.3	59.7	0.5	0.6	0.7	0.6	99.2	20.8	15.0	10.2	A + S	A + F
	P3	3.7	3.6	5.1	3.3	296.9	129.0	81.8	75.0	0.6	0.6	0.7	0.5	91.8	21.5	17.1	11.9	A + F	A + F
	P4	4.5	4.6	8.1	3.7	344.6	143.2	84.0	75.0	0.5	0.6	1.1	0.5	106.6	28.0	15.5	10.0	A + S	A + F
	P5	3.3	3.7	6.8	3.4	305.0	111.3	63.4	64.4	0.4	0.6	0.7	0.5	97.8	20.7	13.1	10.3	A + S	A + F
	P6	5.8	7.0	7.1	5.0	449.0	243.4	106.7	121.6	0.6	1.1	0.0	0.7	124.6	47.8	16.9	21.4	A + S	A + S
	P7	7.4	9.2	27.6	19.9	475.6	277.7	171.9	173.7	0.4	1.3	-0.4	-0.2	126.1	56.3	28.3	31.4	A + S	R + S
	P8	-1.4	-1.6	1.0	1.2	290.1	131.7	25.6	27.9	-0.5	-0.6	-0.3	-0.1	109.9	46.5	10.2	15.5	R + F	R + S
	P9	-2.7	-1.0	-8.4	-15.0	256.1	115.6	42.5	61.2	-0.4	-0.6	-0.9	-3.0	71.3	25.3	7.0	11.3	R + F	R + F
Long Bay	P1	-0.3	0.0	1.6	0.7	59.4	16.8	8.0	5.5	-0.2	0.0	0.7	0.2	26.9	8.7	3.8	1.6	R + S	A + F
	P2	-0.6	-0.1	-0.7	-1.0	69.0	27.8	15.5	4.2	-0.3	0.0	0.3	-0.3	31.4	11.0	7.3	1.0	R + S	F
Takapuna	P1	0.0	0.4	-0.8	-0.1	52.4	27.1	7.2	9.5	-0.6	0.2	-1.2	-0.1	52.9	15.3	6.8	4.8	S	R + S
	P2	0.0	0.3	-0.5	-0.2	53.6	31.6	6.7	8.7	-0.4	0.1	-0.9	-0.2	49.5	17.1	6.5	4.3	S	R + S
	P3	-0.2	-0.3	-0.4	-0.7	79.8	41.4	7.7	11.1	-0.1	-0.1	-0.4	-0.3	56.4	29.5	5.0	4.2	R + S	R + S
Browns Bay	P1	-0.2	0.1	0.4*	0.8*	32.4	5.9	6.3	5.9	-0.3	0.0	-0.5*	0.4*	55.8	13.6	4.9	3.8	R + S	S
	P2	-0.1	0.1	1.2*	0.7*	55.1	22.3	14.7	14.1	-0.2	0.0	0.8*	0.4*	106.9	54.0	10.0	9.5	S	A + F
Campbells Bay	P1	-0.4	-0.4	0.3*	0.4*	58.7	44.7	5.9	7.5	-0.2	-0.1	-0.5*	0.4*	43.1	22.9	4.0	3.3	R + S	S
	P2	-0.3	-0.4	0.4*	0.2*	48.6	33.2	7.1	10.0	0.0	-0.2	-0.6*	0.3*	39.5	16.5	4.1	4.5	R + F	S

Beach	Profile	Rate of change – beach volume (m³/m/yr) – initial survey to 2025		Rate of change – beach volume (m³/m/yr) - 2014 - 2025		Average beach volume (m³/m/yr)		Standard deviation beach volume (m)		Rate of change – beach width (m/yr) – initial survey to 2025		Rate of change – beach width (m/yr) – 2014 - 2025		Average beach width (m)		Standard deviation beach width (m)		Beach state	
		Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	L-term	S-term
Milford	P1	-0.2	0.0	-1.2*	-1.0*	49.5	26.6	5.4	7.0	-0.4	0.0	-0.9*	-0.3*	49.9	14.5	6.5	3.5	S	R + S
	P2	0.1	0.3	-0.5*	-0.5*	35.4	1.0	7.4	9.0	-0.3	0.2	-0.3*	-0.2*	44.3	9.5	4.5	4.7	S	R + S
	P3	-0.3	0.0	-0.2*	-0.4*	29.2	11.2	7.0	7.3	-0.5	0.0	0.1*	-0.1*	35.9	6.5	5.4	3.6	S	F
	P4	-0.5	-0.3	0.0*	0.4*	20.0	8.6	5.5	4.2	-0.4	-0.1	-0.1*	0.2*	22.0	4.8	5.1	2.2	R + S	S
	P5	-0.5	-0.4	0.2*	0.3*	22.0	10.7	5.9	4.4	-0.4	-0.2	0.1*	0.1*	22.2	5.7	5.1	2.2	R + S	A + S
Cheltenham	P1	1.2	1.3	0.5*	0.7*	33.6	19.8	7.9	8.9	0.5	0.6	0.1*	0.3*	28.7	11.9	4.3	5.3	A + S	A + S
	P2	-0.1	0.0	0.9*	1.0*	56.5	44.2	3.3	4.4	-0.1	0.0	0.3*	0.4*	35.9	20.0	2.2	1.8	S	A + S
	P3	-0.2	-0.1	-0.5*	-0.5*	33.9	21.8	2.5	3.6	-0.1	-0.1	-0.2*	-0.2*	26.6	11.5	1.5	1.9	R + S	R + S
Maraetai	P1	-0.6	-0.7	-0.7	-0.8	41.5	20.3	7.7	8.8	-0.2	-0.3	-0.3	-0.3	56.4	31.3	2.8	4.0	R + F	R + S
	P2	-1.0	1.0	-0.6	-0.3	31.6	16.2	8.8	9.7	-0.4	-0.5	-0.4	-0.1	26.7	8.4	3.5	4.5	R + F	R + S
	P3	-0.8	-0.7	-0.2	0.0	36.3	23.6	7.1	6.8	-0.4	-0.3	-0.1	0.0	26.0	10.2	3.6	3.1	R + S	S
	P4	0.9	0.9	3.5	2.9	19.5	7.5	9.2	8.8	0.6	0.5	2.2	1.9	47.1	30.7	6.9	5.9	A + F	A + F
Kawakawa	P1	0.0	0.0	0.0	-0.2	25.3	15.8	2.6	2.0	0.0	0.0	0.1	0.0	16.3	7.1	2.1	0.8	R + F	A + F
	P2	1.1	0.4	-0.7	0.4	42.4	17.9	14.6	4.5	1.0	0.2	-1.5	0.2	38.7	8.5	17.9	2.0	A + F	S
	P3	-0.4	0.2	0.0	0.5	60.8	21.2	13.3	4.2	-0.4	0.1	-0.7	0.3	50.3	10.0	18.6	2.0	S	S
	P4	-0.4	1.8	-0.8	-0.7	90.6	36.9	16.2	15.1	-1.0	0.8	-0.2	-0.5	72.3	17.0	22.3	6.5	S	R + F

Table 4.2: Beach-wide averaged volume and width at Auckland beaches. Statistically significant values (p-value < 0.05) are in bold.

Beach	Beach-averaged rate of change – beach volume (m^3/m/yr)				Beach-averaged rate of change – beach width (m/yr)			
	Lower	p-value	Upper	p-value	Lower	p-value	Upper	p-value
Piha	**13.7**	**0.000**	**7.7**	**0.000**	**2.9**	**0.000**	**1.3**	**0.000**
Muriwai	**-3.8**	**0.016**	**-4.2**	**0.006**	-0.1	0.371	**-0.3**	**0.000**
Pākiri	**-2.8**	**0.028**	-1.5	0.155	**-0.7**	**0.000**	**-0.3**	**0.000**
Omaha	-0.1	0.950	1.2	0.094	0.0	0.805	**0.5**	**0.000**
Long Bay	**-0.6**	**0.000**	**-0.2**	**0.005**	**-0.3**	**0.000**	**-0.1**	**0.001**
Takapuna	-0.1	0.503	0.2	0.187	**-0.4**	**0.000**	0.1	0.123
Browns Bay	-0.2	0.449	0.2	0.605	**-0.3**	**0.009**	-0.0	0.875
Campbells Bay	-0.3	0.090	-0.4	0.131	-0.1	0.359	-0.2	0.087
Milford Beach	**-0.2**	**0.020**	-0.0	0.876	**-0.4**	**0.000**	-0.0	0.806
Cheltenham Beach	**0.3**	**0.000**	**0.3**	**0.001**	**0.1**	**0.010**	**0.1**	**0.005**
Maraetai Beach	**-0.2**	**0.008**	**-0.3**	**0.007**	-0.1	0.319	-0.0	0.667
Kawakawa Bay	**1.1**	**0.002**	**0.6**	**0.000**	**0.8**	**0.044**	**0.3**	**0.000**

4.1 Group 1 – West Coast beaches

Piha and Muriwai beaches, located on the west coast of Tāmaki Makaurau (Figure 1. 1), are completely exposed to southerly and south-westerly winds, making them subject to the highest wave heights of all Auckland beaches. These beaches are exposed to both localised, short period waves and significant long period waves. The average wave height at these beaches is 2.1 m, increasing during winter to an average of 2.4 m, with the 99th percentile wave height reaching 5.3 m (Figure 4.1). Both Piha and Muriwai are part of the northward littoral drift system, which extends from Taranaki to Cape Reinga, as such, the majority of sand on Auckland's west coast is believed to originate from Taranaki and the Waikato River (Blue & Kench, 2017; Hart & Bryan, 2008).

Piha beach is an embayed pocket beach bounded by headlands, Te Waha Point and Kaiwhare Point, that help trap and constrain sediment that would otherwise have moved further along the west coast (King et al., 2006). The width of the dune system at Piha varies from 20 m at the south, to over 200 m closer to the northern end of the beach (Dahm, 2013). Muriwai Beach, in contrast, is only partially constrained by a rocky headland to the south, Otakamiro Point, allowing sediment to move more freely out of the beach system. Muriwai features an extensive transgressive dune system, that widens as you move north while the southern end of the beach is restricted by two car parks. Much of the coastline is backed by Muriwai Regional Park, transitioning into Woodhill Forest further north.

Both Piha and Muriwai remain relatively unmodified with no major shoreline protection structures in place. However, Piha's backdune was developed for housing in the 1940s, and at Muriwai, the southern carpark was realigned in 2009 in response to a period of accelerated erosion between 2005 and 2007, which resulted in approximately 8 metres of shoreline retreat (Carpenter and Klinac, 2015). Dune replanting and reshaping programmes have also been implemented at both beaches (Dahm, 2013; Auckland Council, 2016).

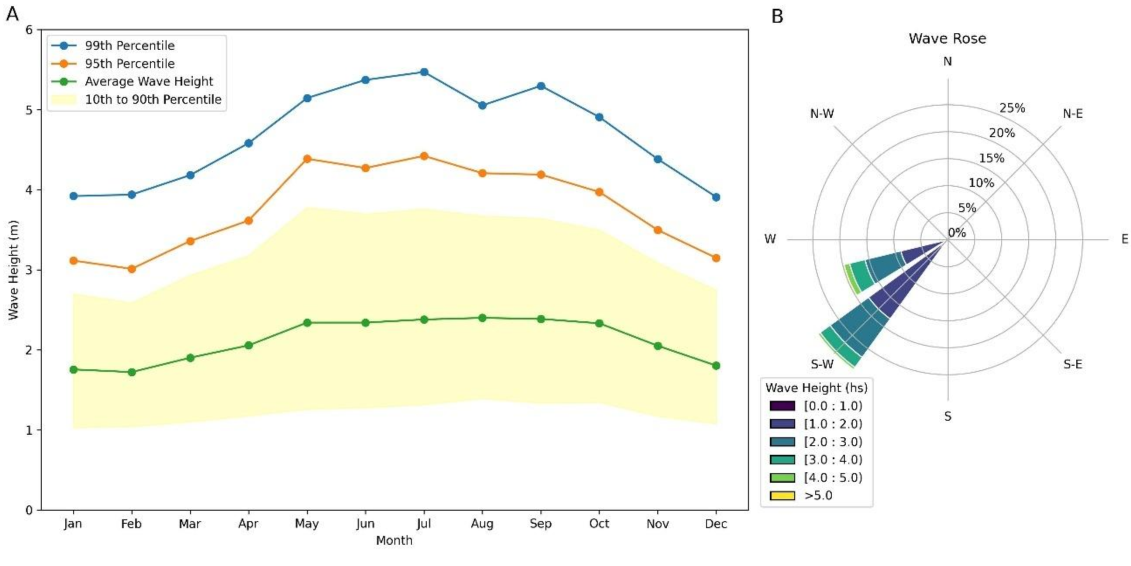

Figure 4.1: Wave summary statistics for the west coast region of Auckland (Oceanum, 2025). A) wave height and B) wave rose.

4.1.1 Piha Beach

Five beach profiles are monitored at Piha Beach (Figure 4.2). Profile 1 is located in North Piha in front of a wide section of coastal dune. Profiles 2-5 are located at South Piha in front of the residential area and two carparks. The monitoring record varies at Piha; Profile 4 holds the longest record starting in 1981 while Profile 1 started in 1990, and Profiles 2 and 5 began in 1993.

Figure 4.2: The position of the beach profiles 1-5 at Piha beach.

4.1.1.1 Beach envelope

Since records began in 1981, the shape of beach at Piha has remained relatively consistent across all five profiles surveyed, presenting a low sloping beachface typical for high-energy west coast beaches (King *et al.*, 2006). Profile 1 and 4 have been selected to represent Piha Beach: Profile 1 is the only profile located in North Piha, while Profile 4 is used to represent all other profiles located in South Piha as it has the longest record (44 years) and exhibits common morphological features found across the other south Piha profiles (Appendix A).

Piha beach has a large beach envelope highlighting the dynamic nature of sand movement within the beach system (Figure 4.3; Figure 4.4). Profile 1 exhibits vertical fluctuations of up to 6.8 m and horizontal excursions of up to 170 m while Profile 4 exhibits vertical fluctuations of up to 4 m and horizontal excursions of up to 156 m, over the monitoring period. These oscillations are second only to Muriwai (Section 4.1.2) in beach envelope variability within Auckland.

The most recent survey of Profile 1 (31/03/2025) exhibits an elevation above the average profile, reaching 94% of the extent of the beach envelope, indicating that the current beach surface is reaching its highest level on record (Figure 4.3). In contrast, the most recent surveys of South Piha, Profiles 2-5, remain above the average profile but only reach between 70 - 80% of the beach envelope (Figure 4.4). This is predominantly due to a large deposition of sediment in 2024 that expanded the higher limits of the lower beach envelope at South Piha before the sediment was gradually transported up the beach. It is notable that this sediment deposit is not evident in Profile 1, suggesting the pulse of sediment did not reach North Piha.

Throughout the monitoring period, Piha Beach has steadily accreted, with a large supply of sediment being stored on the beach. Since the last assessment (Boyle, 2016) the beach profile has continued to accrete vertically, and the maximum vertical extent of the beach envelope has been regularly exceeded, indicating recent beach levels have increased above previously recorded highs (Figure 4.3; Figure 4.4).

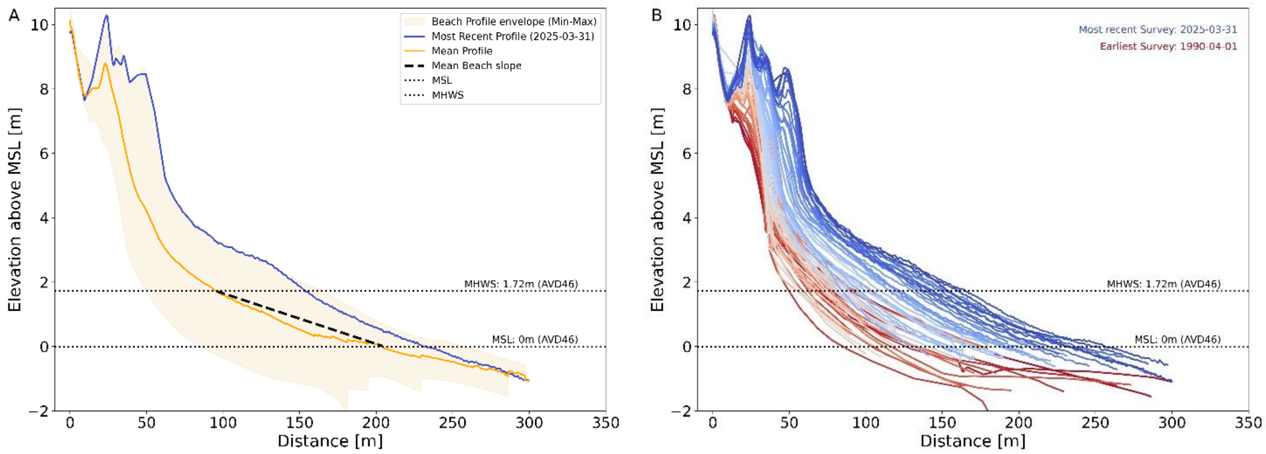

Figure 4.3: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Piha beach.

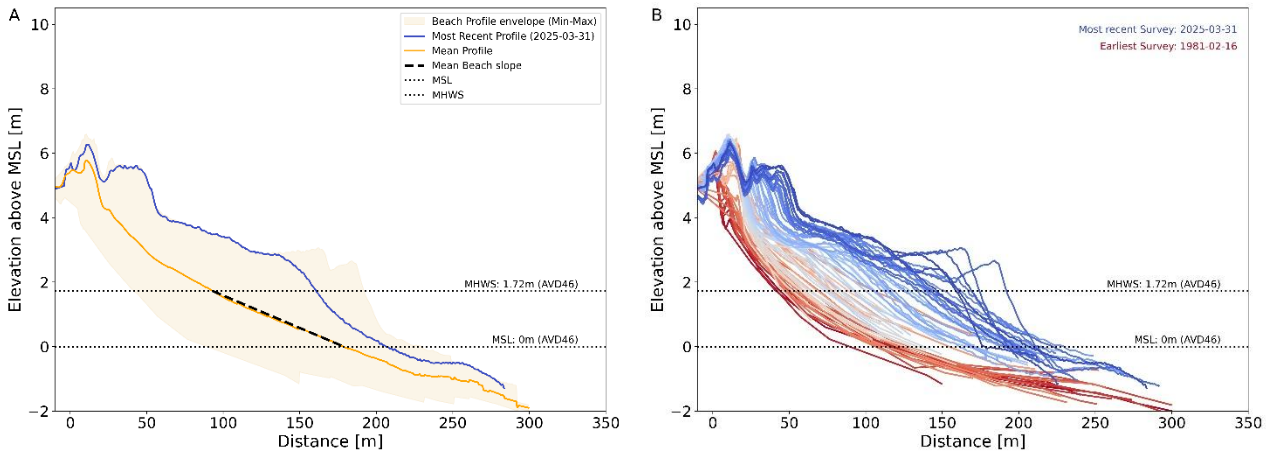

Figure 4.4: Beach envelope (A), and historic beach profile record (B) for Profile 4 at Piha beach.

4.1.1.2 Beach volume

Across all profiles, a long-term trend of accretion (sand gain) is evident, with beach-wide averaged volume accreting at 13.7 $m^3/m/yr$ at the lower beach and 7.7 $m^3/m/yr$ at the upper beach, throughout the monitoring period (Figure 4.5; Table 4.1). The average volume of the beach has increased considerably since 1993, increasing from 263 m^3/m to 696 m^3/m at the lower beach and 174 m^3/m to 341 m^3/m at the upper beach, with a noticeable increase in the rate of growth after 2004 (Figure 4.5). Since the last assessment (Boyle, 2016), the rate of beach volume growth has accelerated across all profiles, with Profile 2 showing the fastest rates of volume gain for both the lower (38.7 $m^3/m/yr$) and upper (24.5 $m^3/m/yr$) beach (Table 4.1).

Despite the substantial overall accretion of all profiles at Piha Beach, there have been large fluctuations in beach volume at both the lower and upper beach throughout the monitoring record, with periods of sand loss and stability interrupting the overall record of accretion (Figure 4.5). These fluctuations in beach volume shown at Profile 4 (Figure 4.5) are likely due to storm events where higher water levels and wave heights allow more wave energy onto the beach to transport sediment. Further investigation of storm response and recovery at Piha Beach will be conducted in future beach group specific reports, see Section 1.

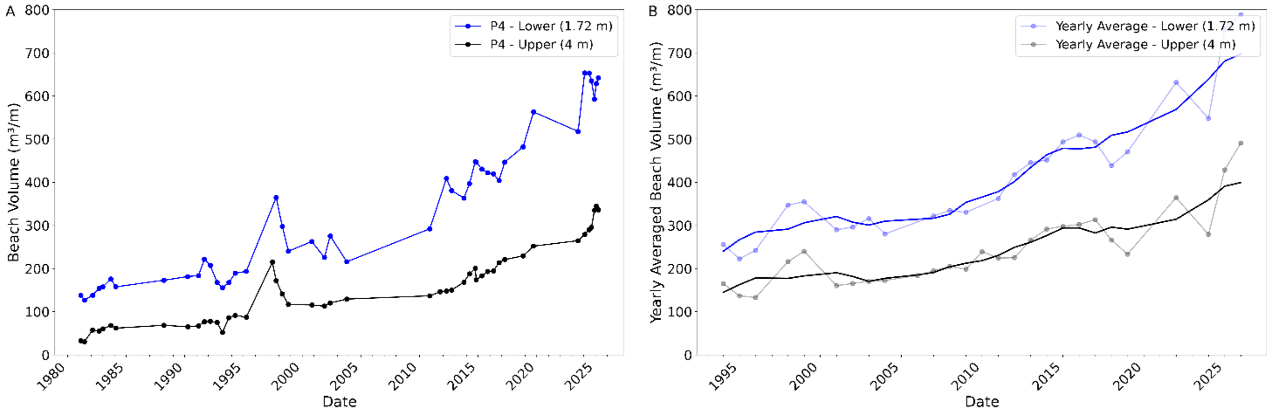

Figure 4.5: Beach volume changes at the lower (1.72 m (MHWS)) and upper (4 m) contours. A) Beach volume timeseries at Profile 4, and B) beach-wide averaged volume timeseries.

4.1.1.3 Beach width

Similar to trends in beach volume, and beach envelope, Piha Beach exhibits a steady increase in beach width throughout the monitoring record (Figure 4.6). Beach-wide averaged width exhibits a long-term trend of accretion at a rate of 2.9 m/yr at the lower beach and 1.3 m/yr at the upper beach leading to accretion and flattening of the beach profile (Figure 4.6; Table 4.1). Long-term accretion is recorded at every beach profile at Piha beach where the lower beach has widened by an average 108 m and the upper beach by 47 m between 1993 and 2025 (Table 4.1).

Since the last assessment (Boyle, 2016), the rate of accretion of the lower and upper beach has accelerated at all profiles with Profile 2 exhibiting the highest rates of accretion at the lower (7.3 m/yr) and upper (2.6 m/y) beach (Table 4.1).

Like beach volume, beach width also shows considerable variability throughout the monitoring record (Figure 4.6; Table 4.1). Piha beach has experienced many episodic reductions in beach width likely in response to storm events. Variations in beach width are considerably larger in the lower beach than upper beach, where the upper beach exhibits steady accretion with few fluctuations throughout the monitoring record (Figure 4.6; Table 4.1).

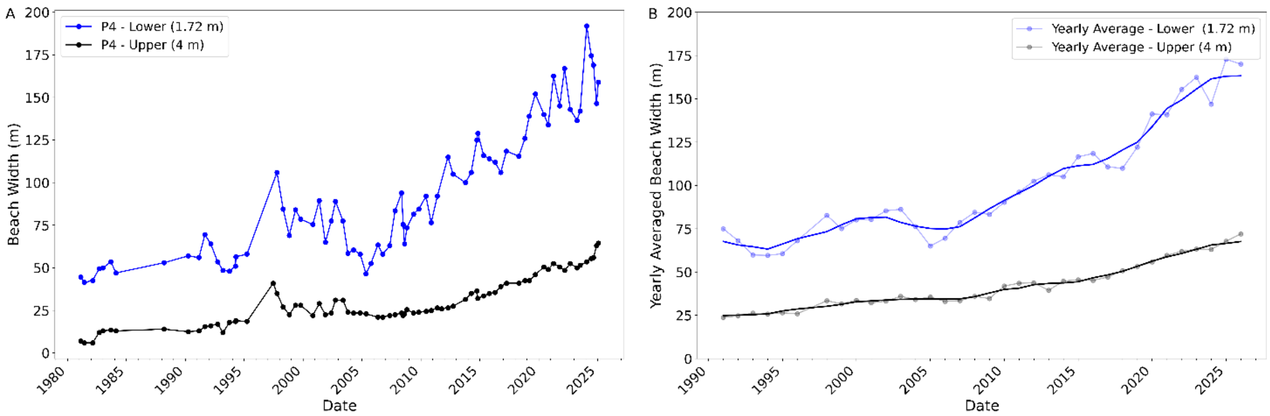

Figure 4.6: Beach width changes at the lower (1.72 m (MHWS)) and upper (4 m) contours. A) Beach width timeseries at Profile 4, and B) beach-wide averaged width timeseries.

4.1.1.4 Foredune dynamics

The foredune at Profiles 1, 3 and 4 show considerable vertical accretion and seaward progradation throughout the monitoring period (Figure 4.7). However, changes in the position and height of the foredune are not uniform between profiles. The foredune at Profile 1 is the only foredune to exhibit vertical accretion and seaward progradation throughout the entire monitoring record, increasing 1.3 m in elevation and migrating nearly 20 m seaward (Figure 4.7). At Profile 3, the foredune accreted approximately 2.0 m between the 1990s and 2010s before rapidly migrating seaward. While the foredune at Profile 4 experienced rapid accretion early in the monitoring record but has since migrated landward and reduced in elevation slightly (Figure 4.7). In contrast, the foredune at Profiles 2 and 5 experienced an overall reduction in elevation between the 1990s and 2020s (Figure 4.7). At Profile 5, situated closest to the southern end of the beach, the foredune initially increased in height while simultaneously migrating landward before subsequently decreasing in elevation and moving seaward from the 2000s onward (Figure 4.7). The foredune at Profile 2 experienced a severe reduction in height early in the monitoring record, followed by steady accretion from the 2010s, nearly recovering to its 1990s elevation.

Although periods of landward migration are evident, all profiles exhibit a long-term trend of seaward dune migration. Notably, Profile 2 displays the most significant seaward advance, with the foredune migrating approximately 20 m between the 1990s and 2020s.

Refer to Appendix B to see changes in foredune height and position for each profile individually.

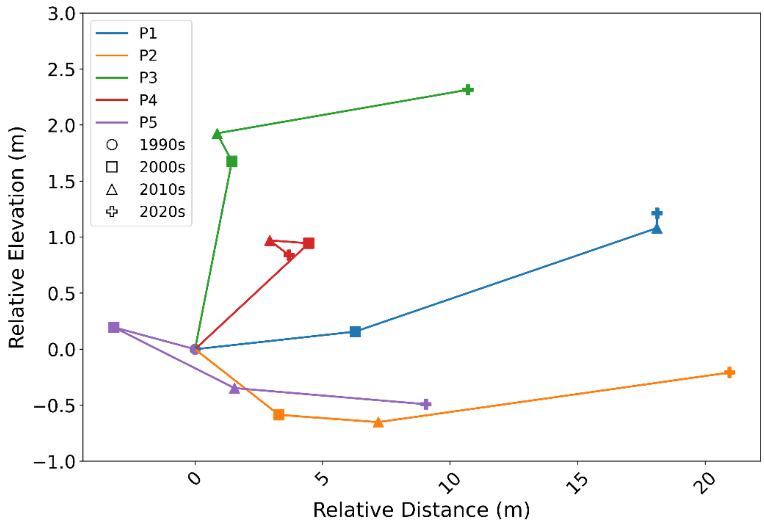

Figure 4.7: Change in maximum foredune position at Profiles 1-5 at Piha Beach from the 1990s. Horizontal and vertical changes are reduced to zero to aid comparison.

4.1.2 Muriwai Beach

Four beach profiles are monitored at Muriwai Beach. Profile 1 is the most northern profile located 25 km from Motutara Road at the southern end of the beach. Profile 2 is located 15 km north of Motutara Road, while Profile 3 and Profile 4 are located at the southern end of the beach situated in front of the golf club and carpark, respectively (Figure 4.8). The monitoring record started in 1981 at Profile 3, while Profiles 1, 2 and 4 were initiated in 1990.

Figure 4.8: The position of the beach profiles 1-4 at Muriwai beach.

4.1.2.1 Beach envelope

Profile 1 and 3 have been selected to represent Muriwai Beach: Profile 1 is the most northern profile while Profile 3 is situated in the south and has the longest monitoring record, starting in 1981. Muriwai Beach has the largest beach envelope of all beaches within the Auckland region (Figure 4.9; Figure 4.10). The largest vertical (11 m) and horizontal (102 m) fluctuations are recorded at Profile 3 (Figure 4.10). The largest horizontal fluctuations occur in the intertidal zone while the largest vertical fluctuations occur in the upper beach.

At Profile 1, the most recent survey (10/04/2025) is situated below the average profile, only reaching 30% of the extent of the maximum beach envelope (Figure 4.9). Similarly, the most recent survey at Profiles 2 and 3 are below the average profile (particularly from the toe of the foredune to the upper beach) indicating that that the current beach surface is close to its lowest level on record (Figure 4.10). The results corroborate findings from earlier studies (Dahm, 2002; Brander and Short, 2000) that the shoreline at Muriwai beach has been, and is continuing, to retreat. It is important to note that since the last assessment (Boyle, 2016), the lower limits of the beach envelope at Profile 1 have been exceeded, indicating recent beach levels have dropped below previously recorded lows (Figure 4.9).

In contrast, the most recent survey at Profile 4 (10/04/2025) has accreted above the average profile and now reaches 80% of the maximum extent of the beach envelope (Figure 4.11). Notably, Profile 4 underwent dune restoration and replanting projects in 2009 and 2015 (Carpenter and Klinac, 2015; Auckland Council, 2016) that appear to have supported accretion of the dune at this location. However, it is important to note that despite the 2009 dune restoration, the dune was in close proximity to the minimum extent of the beach envelope in 2014, suggesting that other factors have likely contributed to these localised changes (Boyle, 2016).

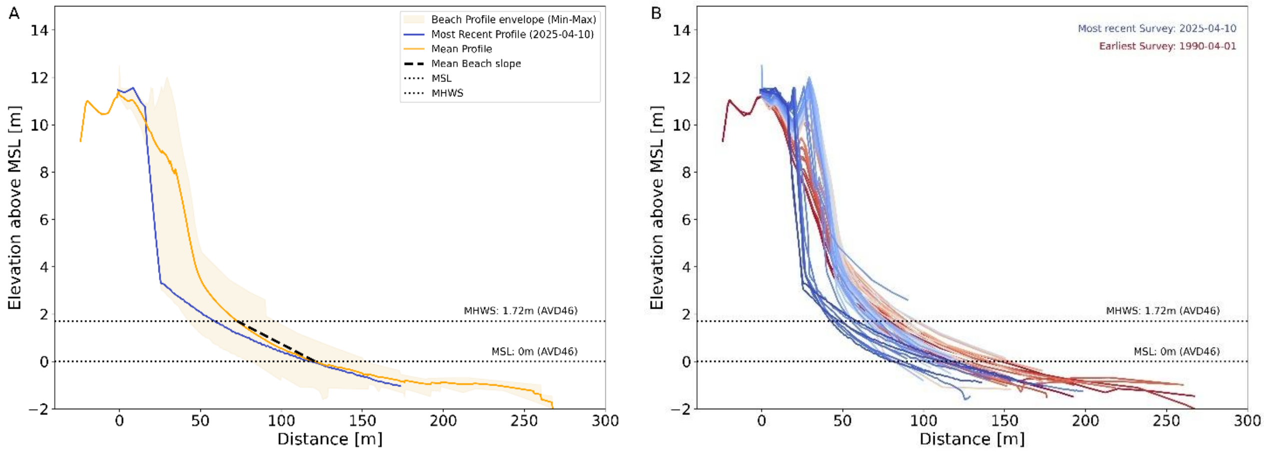

Figure 4.9: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Muriwai beach.

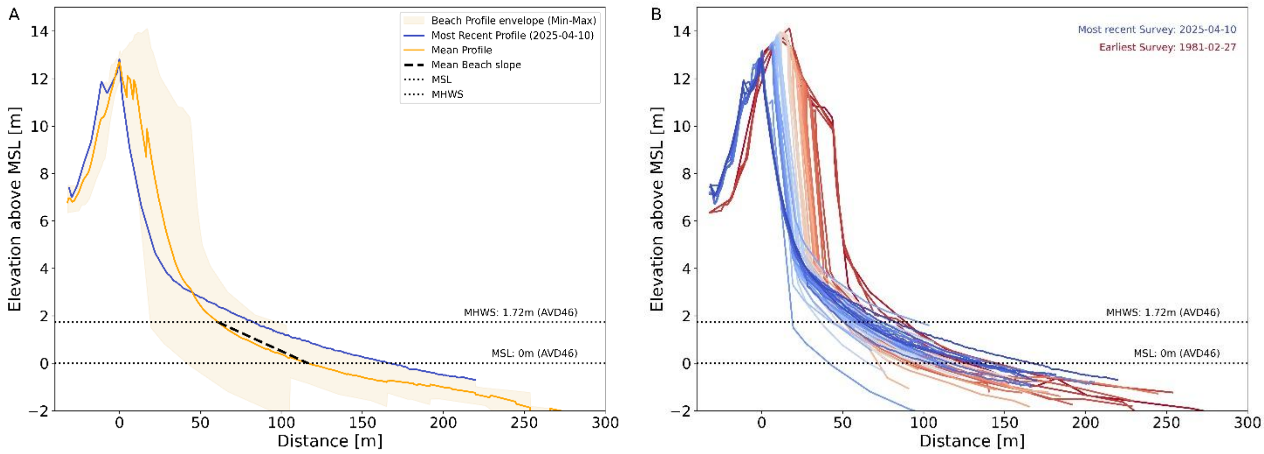

Figure 4.10: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Muriwai beach.

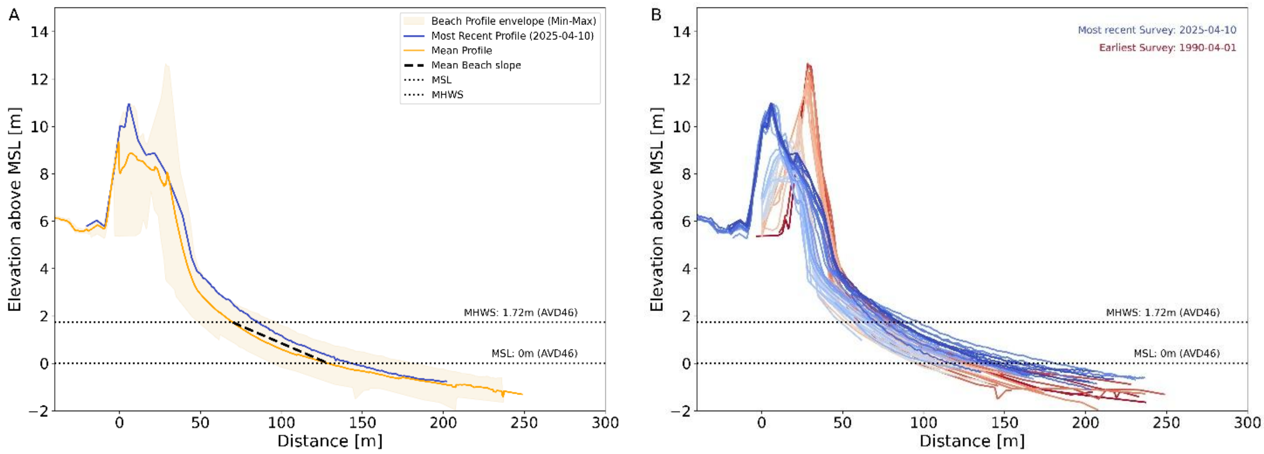

Figure 4.11: Beach envelope (A), and historic beach profile record (B) for Profile 4 at Muriwai beach.

4.1.2.2 Beach volume

Beach-wide averaged volumes illustrate a long-term trend of erosion at Muriwai Beach at both the lower (-3.8 m^3/m/yr) and upper (-4.2 m^3/m/yr) beach (Figure 4.12). However, patterns in beach volume across the monitoring record vary considerably between the beach profiles at Muriwai. Profile 1 and 2 experienced rapid growth throughout the monitoring period until approximately

2010, where both profiles thereafter experienced erosion, Profile 1 at a much faster rate of -26.3 m^3/ m/yr and -23.1 m^3/ m/yr at the lower and upper beach, respectively (Table 4.1).

Profile 3 similarly exhibits long-term reductions in beach volume at -9.4 m^3/m/yr, and -10.6 m^3/m/yr at the lower and upper beach, respectively. However, erosion rates have slowed since 2014 to 0.2 m^3/m/yr and -0.7 m^3/m/yr, respectively. In contrast to the northern profiles, Profile 3 and Profile 4 do not experience periods of growth between ~1995 and 2010; instead, both show reductions in beach volume during this time.

Profile 4 has predominantly experienced erosion throughout the monitoring period, reducing in beach volume by 43% between 1990 and 2014 (Boyle, 2014). Post 2014, the trend shifted to accretionary with rates of 12.5 m^3/m/yr and 11.3 m^3/m/yr at the lower and upper beach, respectively (Table 4.1). It is important to note that dune restoration projects have been undertaken at South Muriwai in 2009 and 2015 and may have some impact on the observed trends (Carpenter and Klinac, 2015). However, it is unlikely dune restoration alone has caused the considerable accretion recorded since 2014.

Large short-term fluctuations in beach volume throughout the monitoring record suggest storm events displace large amounts of sand on the West Coast and will be investigated in future reporting (Figure 4.12). Although more severe at the lower beach, fluctuations of the upper beach throughout the monitoring record indicate that the upper beach is also impacted by changes in wave conditions and sediment supply. In addition to substantial intra-beach variability, beach-wide averaged volume shows a clear decadal cyclical pattern throughout the record likely reflecting changes in climate oscillations such as the El-Nino Southern Oscillation, Interdecadal Pacific Oscillation, or the Southern Annual Mode (Bryan et al., 2008; Godoi et al., 2016).

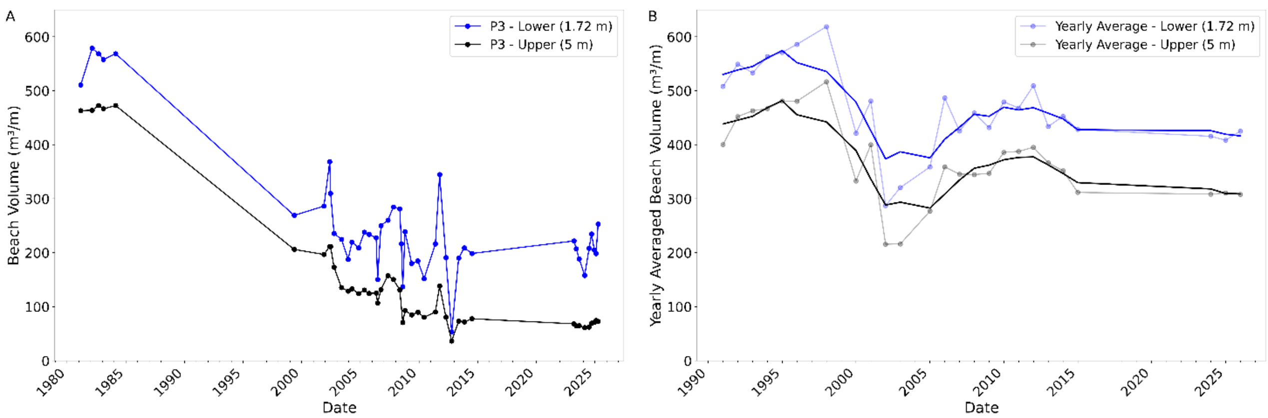

Figure 4.12: Beach volume changes at the lower (1.72 m (MHWS)) and upper (5 m) contours. A) Beach volume timeseries at Profile 3, and B) beach-wide averaged volume timeseries.

4.1.2.3 Beach width

Consistent with beach volume, beach-wide averaged width indicates long-term erosion at Muriwai beach eroding at -0.1 m/yr at the lower beach and -0.3 m/yr at the upper beach (Figure 4.13). Notably, beach-wide averaged erosion of the lower beach is not statistically significant (Table 4.2). There is considerable intra-beach variability where Profile 1 exhibits long-term erosion at -0.8 m/yr and -0.4 m/yr at the lower and upper beach, respectively. However, since the last assessment (Boyle, 2016), rates of erosion have accelerated at both the lower and upper beach (Table 4.1). Profile 2 exhibits long-term stability but has experienced a period of erosion since 2014 with more rapid rates at the lower beach leading to overall retreat and steepening of the beach profile (Table 4.1).

Similar to Profile 1, Profile 3 exhibits long-term trends of erosion, however, since the last assessment (Boyle, 2016), the lower beach has transitioned to accretion at a rate of 0.4 m/yr, while the upper beach has exhibited stability (Table 4.1). Similarly at Profile 4, short-term rates of accretion at the lower beach has accelerated to 2.3 m/yr, and the upper beach trend has switched from erosion to accretion at 1.4 m/yr since 2014 (Table 4.1). Large fluctuations in beach width can also be observed throughout the monitoring record coinciding with large storm events such as Cyclone Lola and Cyclone Gabrielle in 2023 (Figure 4.13).

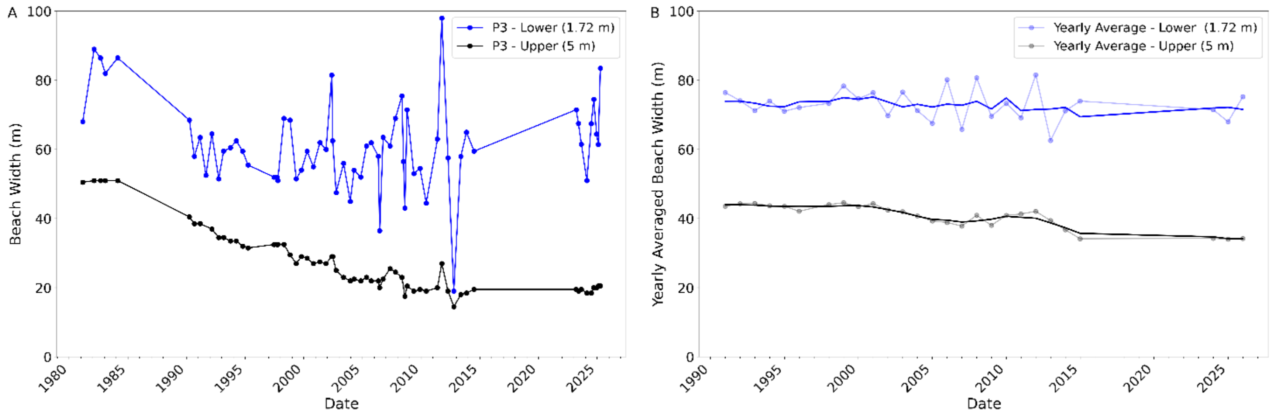

Figure 4.13: Beach width changes at the lower (1.72 m (MHWS)) and upper (5 m) contours. A) Beach width timeseries at Profile 3, and B) beach-wide averaged width timeseries.

4.1.2.4 Foredune dynamics

Similarities between changes in the height and position of the foredune can be observed between the northern (Profiles 1-2) and southern (Profiles 3-4) ends of the beach. The northern profiles exhibit an overall increase in height and seaward migration of the maximum dune position across the monitoring period (Figure 4.14). However, the foredune at Profile 1 has experienced a reduction in elevation and landward movement post 2020.

At the southern end of the beach the foredune exhibits an overall reduction in height and landward migration throughout the monitoring record (Figure 4.14). However, the position of the dune at Profile 4 has shown a recent increase in height and seaward migration, a result of the dune restoration project (Auckland Council, 2016).

Refer to Appendix B to see changes in foredune height and position for each profile individually.

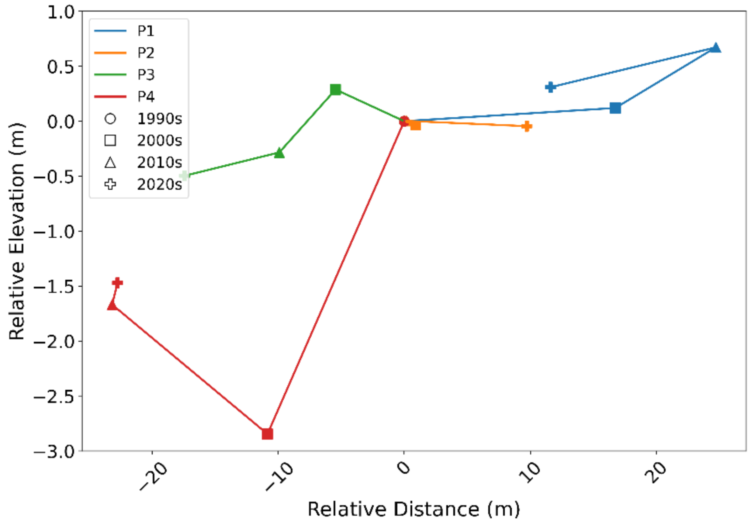

Figure 4.14: Change in maximum foredune position at Profiles 1-4 at Muriwai Beach from the 1990s. Horizontal and vertical changes are reduced to zero to aid comparison.

4.1.3 Discussion

Piha and Muriwai beach are exposed to similar wave conditions, and situated within the northward littoral drift system, but these beaches exhibit contrasting medium to long-term trends of coastal change. Piha Beach is accreting (gaining sand), with all surveyed profiles showing a long-term trend of accretion. These results align with previous studies of Auckland's west coast (King et al., 2006; Kench, 2008; Boyle, 2014). Accretion rates are relatively consistent along the beach, with the lower beach accumulating sand at a faster rate than the upper beach, leading to a gradual flattening and advance of the beach profile. Furthermore, accretion rates have accelerated at all profiles since 2014 (Table 4.1). Despite dune replanting efforts primarily focusing on South Piha, the northern profile (Profile 1) has exhibited similar accretion trends throughout the monitoring record (Table 4.1).

In contrast, Muriwai Beach has exhibited a long-term trend of erosion (losing sand), with a net loss in sediment volume over the study period (1990s-2025). Since 2014, erosion rates have accelerated at the northern profiles (Profiles 1-2), with more pronounced sediment loss occurring in the lower beach. This has led to a steepening and retreat of the beach profile (Table 4.1). However, historical erosional trends changed to accretion at South Muriwai from 2014, indicating that local processes such as sediment supply or wave angle may have altered, leading to sediment accumulation in the south. This will be investigated further in future reporting (Table 4.1).

The opposing long-term trends of beach change at Muriwai and Piha is likely due to disparities in sediment supply and beach specific controls (King et al., 2006; Blue and Kench, 2017; Ford and Dickson, 2018). Patterns of sediment deposition along Auckland's west coast remain uncertain, but research suggests that the Manukau ebb-tidal delta plays a significant role influencing sediment availability and beach change on the west coast. Ford and Dickson (2018) suggest that the Manukau ebb-tidal delta acts as a temporary store of sediment and is characterised by cyclical breaching events that release pulses of sediment that migrate north along the coast, driving periods of rapid beach change (King et al., 2006; Hart and Bryan, 2008; Blue and Kench, 2017; Ford and Dickson, 2018).

The deposition and storage of sediment at Auckland's west coast beaches is likely driven by local factors such as accommodation space, foredune stability, and hydrodynamics (Dahm, 2002; King et al., 2006; Boyle, 2014). However, sediment transport on the West Coast is still poorly understood. Nearshore bathymetric surveys are required to get a better understanding of sediment concentration and transport in the littoral system. Headlands likely play a role, Piha, being enclosed by headlands, likely retains sediment more effectively within its system, limiting loss to adjacent beaches. In contrast, Muriwai Beach, a much larger and less constrained system, may experience greater dispersion of any sediment deposited on the beach, or transport the sediment northward beyond the surveyed area.

While the long-term trends at Muriwai and Piha differ significantly, both beaches experience similar short-term fluctuations in response to storm events. Notable reductions in beach volume and width were recorded in 2023 following the impacts of Cyclone Gabrielle and Cyclone Lola. Similar fluctuations were observed in response to high-energy storm events in 2005 and 2008 (Boyle, 2016).

4.2 Group 2 – Open East Coast beaches

Pākiri and Omaha beaches, located on the northern east coast of Auckland (Figure 1. 1), are exposed to smaller wave conditions than the west coast beaches. The average wave height is 0.93 m, increasing slightly during winter to 1.0 m, with the 99th percentile wave height reaching 3.5 m (Figure 4.15).

Pākiri Beach is one of the most natural beaches on the east coast, with minimal human development and a well-preserved dune system. The 14 km long beach is constrained by headlands, Cape Rodney and Te Arai Point, but is exposed to tropical cyclones from the north and deep low-pressure systems from the southeast. Sand extraction has occurred at the northern end of Pākiri since the 1940s under various resource consents. In-shore sand mining ceased in February 2025, while offshore extraction is currently authorised under temporary consents due to expire in mid-2026. A decision to decline applications for continued offshore sand extraction beyond 2026 is currently under appeal in the High Court (Auckland Council, 2023).

Omaha Beach, approximately 4 km long, is located on a fine-grained Holocene sandspit that separates Whangateau Harbour from Little Omaha Bay. It is embayed by headlands, Ti Point and Karamuroa Point, on either side, providing shelter from southerly and southeasterly waves, though it remains exposed to waves from the north and northeast (Dougherty, 2011). In 1978, three storms caused an average of 12 m of erosion, prompting the construction of three groynes at the northern end of the beach in 1979 to mitigate future storm impacts (Schofield, 1985). Development at Omaha began in the 1960s, and today, the sandspit is highly developed, with 75% of the foredune backed by residential housing.

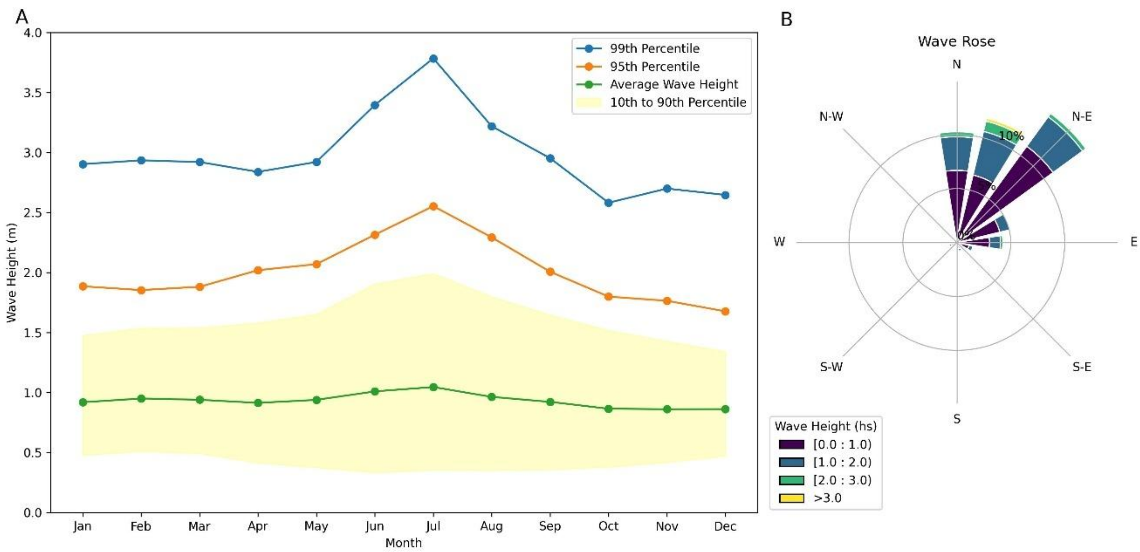

Figure 4.15: Wave summary statistics for the open east coast of Auckland (Oceanum, 2025). A) wave height and B) wave rose.

4.2.1 Pākiri Beach

Eight beach profiles are monitored at Pākiri Beach. Profiles start at the northern end of the beach (Profile 2A) and extend to Profile 9 at the southern end of the beach providing coverage of the entire beach (Figure 4.16). The monitoring record begins in 1978 at Profiles 4, 5, 6, 7 and 8, while Profile 3 was initiated in 1981 and Profiles 2A and 9 were set up in 1989 (Table 2. 1).

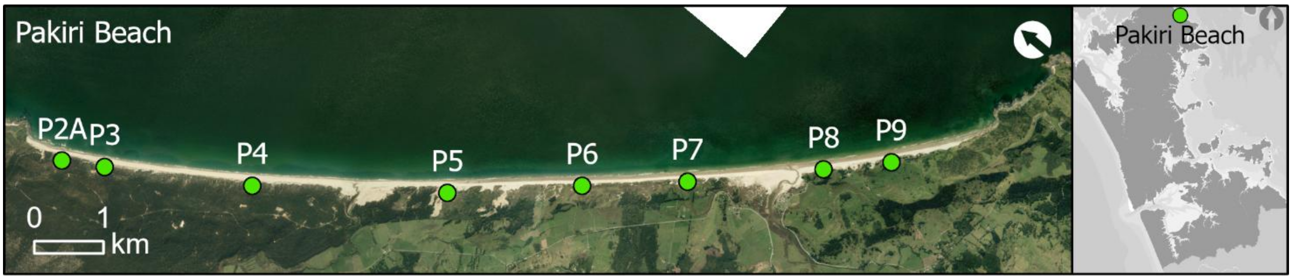

Figure 4.16: The position of the beach profiles 2A - 9 at Pākiri Beach.

4.2.1.1 Beach envelope

Pākiri Beach is backed by a well-preserved dune system that serves as a sand reservoir, allowing the beach to naturally adjust in response to storms. Exposed to relatively high wave conditions, sand is frequently transported and deposited, resulting in a broader beach envelope and greater fluctuations compared to the nine other East Coast beaches (Figure 1. 1). Pākiri exhibits horizontal and vertical variations of up to 100 m and 6.5 m, respectively, throughout the monitoring period (Figure 4.17; Figure 4.18).

The most recent survey (27/05/2025) at every beach profile on Pākiri Beach falls below the average profile (Figure 4.17; Figure 4.18). Profile 4 reaches 23% of the beach envelope, while Profile 6 extends to just 6% (Figure 4.18). Notably, the toe of the foredune at most profiles is at its most landward position on record. Since the last assessment (Boyle, 2016), the lower extent of the beach envelope has reduced across all profiles indicating that many profiles, particularly Profiles 4-9 lie at or near their lowest levels on record (Appendix A). These findings align with plan-shape coastal-change analysis conducted by Dickson et al., (2022).

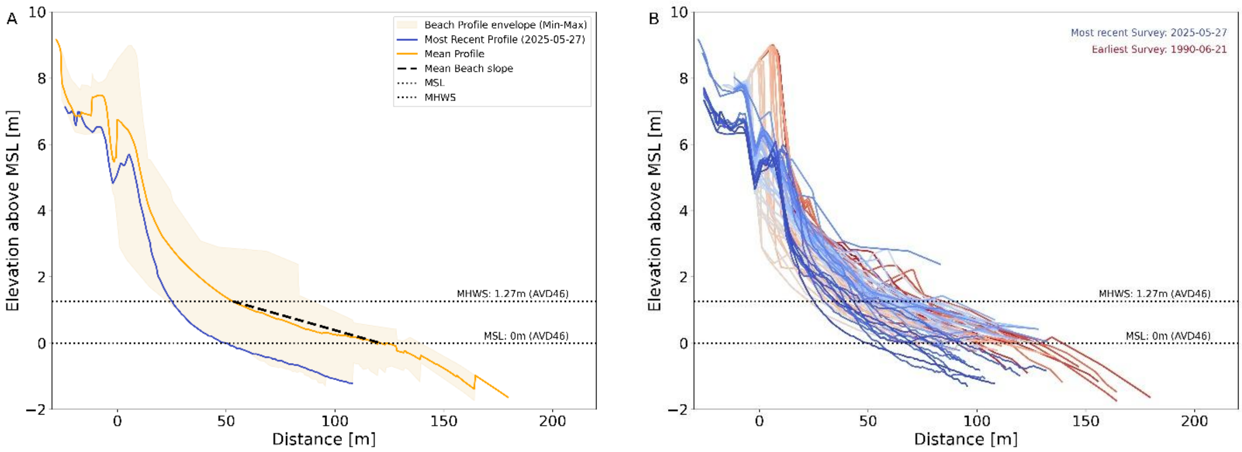

Figure 4.17: Beach envelope (A), and historic beach profile record (B) for Profile 2A at Pākiri Beach.

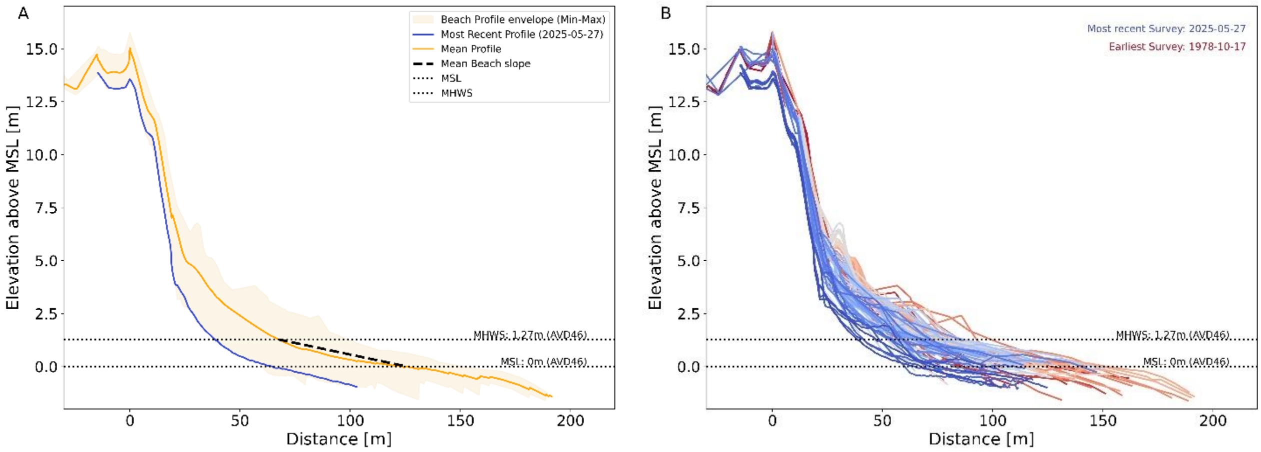

Figure 4.18: Beach envelope (A), and historic beach profile record (B) for Profile 6 at Pākiri Beach

4.2.1.2 Beach volume

Beach-wide averaged volume indicates a long-term trend of erosion at Pākiri Beach exhibiting erosion rates of -2.8 $m^3/m/yr$ and -1.5 $m^3/m/yr$, at the lower and upper beach respectively (Figure 4.19; Table 4.1). All profiles exhibit erosion at the lower beach with erosion rates ranging from -1.1 to -3.8 $m^3/m/yr$ (Table 4.1). However, long-term trends at the upper beach are variable, with Profiles 2A, 5, 6 and 9 exhibiting erosion, while the remaining profiles exhibit stability or accretion, suggesting sediment is being transported and stored in the foredune.

A cyclical pattern of volume change occurs approximately every 7-10 years across the beach. Three cycles have been recorded throughout the monitoring period, with peak phases of volume gain reaching 427 m^3/m in 1994, 333 m^3/m in 2004, and 374 m^3/m in 2017, followed by periods of sediment loss (Table 4.1).

Since the last assessment in 2014 (Boyle, 2016), sediment loss has accelerated at all profiles, indicating that Pākiri Beach is currently in an erosive phase. Erosion rates have accelerated at both the upper and lower beach, particularly at Profile 7, where rates of volume loss have intensified from -1.1 $m^3/m/yr$ and 0.1 $m^3/m/yr$ to -12.5 $m^3/m/yr$ and -8.8 $m^3/m/yr$ at the lower and upper beach, respectively (Table 4.1).

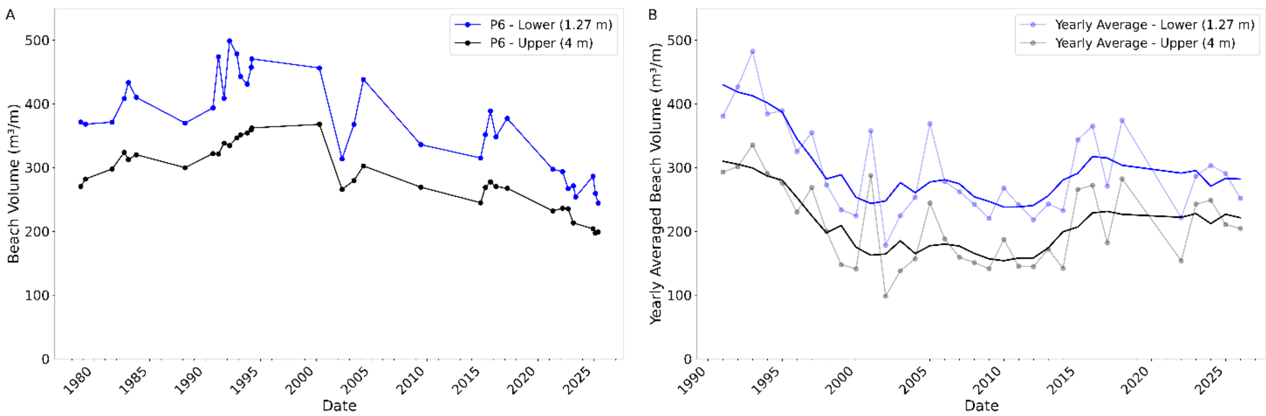

Figure 4.19: Beach volume changes at the lower (1.27 m (MHWS)) and upper (4 m) contours. A) Beach volume timeseries at Profile 6, and B) beach-wide averaged volume timeseries.

4.2.1.3 Beach width

Beach-wide averaged width shows a long-term trend of erosion at both the lower (-0.7 m/yr) and upper (-0.3 m/yr) beach with the average lower beach width decreasing from 85.9 m and 48.5 m in 1990, to 65.4 m and 39.1 m in 2025, at the lower and upper beach, respectively (Figure 4.20; Table 4.1).

The lower beach at Pākiri exhibits large short-term fluctuations in width throughout the monitoring period likely in response to storm events (Figure 4.20). Additionally, medium-term changes in both the lower and upper beach width closely follow the cyclic patterns observed in beach volume. Lower beach width peaked at 116 m in 1994, 113 m in 2004, and 94 m in 2017, aligning with phases of increased beach volume (Figure 4.19; Figure 4.20).

Since the last assessment (Boyle, 2016), erosion rates have accelerated at both the lower and upper beach (Table 4.1). However, the lower beach has experienced a more pronounced acceleration of erosion, with rates at Profile 3 rising from -0.6 m/yr to -2.3 m/yr, while the upper beach erosion rate has increased from 0.0 m/yr to -1.2 m/yr, leading to retreat and steeping of the beach profile (Table 4.1).

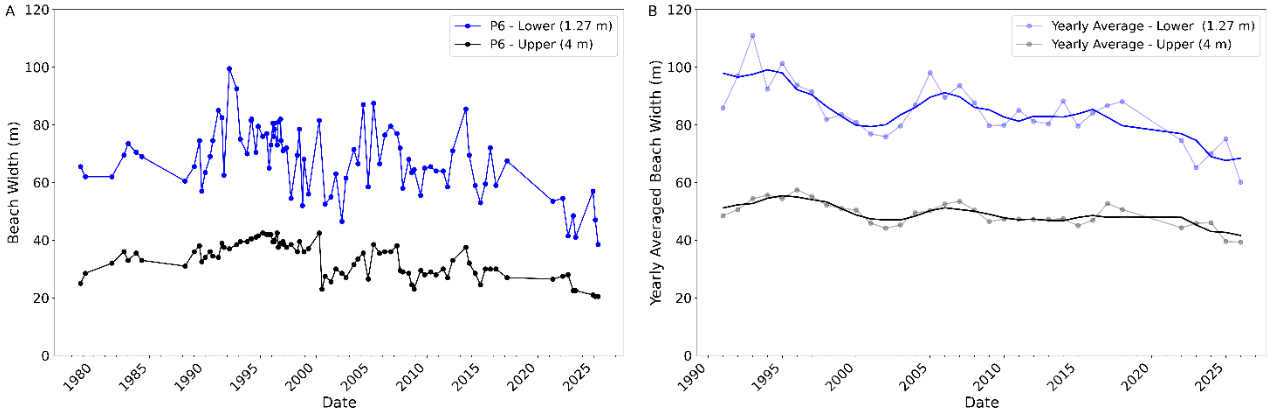

Figure 4.20: Beach width changes at the lower (1.72 m (MHWS)) and upper (4 m) contours. A) Beach width timeseries at Profile 6, and B) beach-wide averaged width timeseries.

4.2.1.4 Foredune dynamics

As discussed in the limitations section (Section 2.1.1), many historical beach surveys did not cover the entire beach profile, resulting in gaps in the monitoring record. Consequently, dune position at Pākiri is only reported for Profiles 2A, 3, 6, and 7 (Figure 4.21). Refer to Appendix B to see changes in foredune height and position for each profile individually.

Since the 1990s, the maximum dune height has lowered at all reported profiles (Figure 4.21). Profile 2A experienced the greatest reduction in elevation, with an average decrease in the maximum position of the dune of 3 m. Profile 2A and 3 experienced periods of dune accretion during the 2010s, migrating seaward and increasing the height of the dune. However, subsequent erosion caused the foredune to reduce in elevation and migrate landward (Figure 4.21). Although all profiles reduced in height throughout the monitoring period, Profile 2A and 7 exhibit a net seaward migration of the dune while Profile 6 recedes landward nearly 15 m (Figure 4.21).

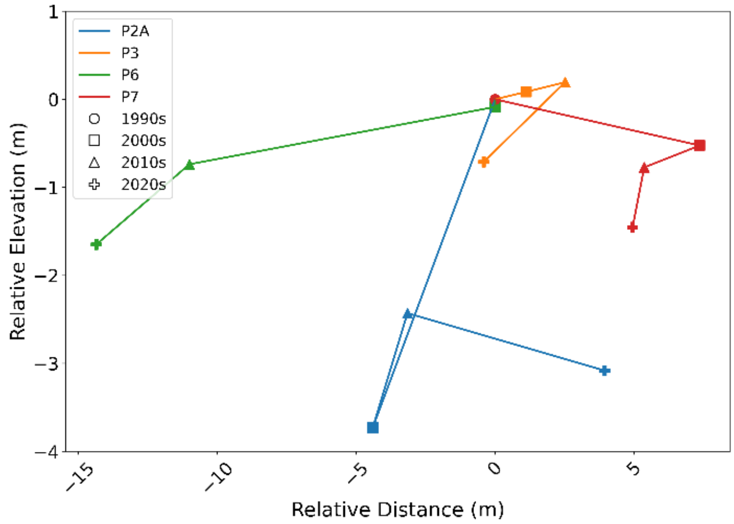

Figure 4.21: Change in maximum foredune position at Profiles 2A, 3, 6 and 7 at Pākiri Beach from the 1990s. Horizontal and vertical changes are reduced to zero to aid comparison.

4.2.2 Omaha Beach

Nine beach profiles are monitored at Omaha Beach covering the entire stretch of the shoreline. Profile 1 starts at the southern end of the beach extending to Profile 8 and 9 at the northern end of the beach that monitor the shoreline in front of the groynes (Figure 4.22). Omaha boasts the longest monitoring record in the Auckland region with Profiles 2, 3, 5, 6 and 7 starting in the 1960s, Profile 4 in 1978 and the remaining profiles in 1993 (Table 2. 1).

Figure 4.22: The position of the beach profiles Profile 1 - 9 at Omaha Beach.

4.2.2.1 Beach envelope

Despite being backed by residential properties, the dune system at Omaha Beach remains relatively wide, with at least two dune ridges (including the foredune) behind the beach face. The beach envelope at Omaha is broad, with maximum horizontal and vertical excursions of up to 120 m and 8 m, respectively (Figure 4.23; Figure 4.24). Profiles 6 and 7 exhibit the largest beach envelopes while Profiles 1, 7 and 8 exhibit the smallest (Appendix A).

Both natural and anthropogenic factors have driven significant changes in the beach profile at Omaha. The upper limit of the beach envelope at Profile 4 is likely influenced by dune management and reshaping works near the surf club, which temporarily elevated the beach profile and dune by approximately 1 m. In contrast, the minimum extent of the beach envelope across Profiles 2-7 reflects the impact of the 1978 storm events that caused severe erosion across the entire beach (Kench, 2008; Dougherty, 2011).

The most recent survey (26/05/2025) at Profiles 1-6 is near or at the upper limits of the beach envelope, suggesting a healthy sand reservoir (Figure 4.23). However, the northern profiles 7-9 are closer to the average profile position, with the most recent surveys at these sites reaching 67%, 54%, and 27% of the maximum beach envelope, respectively (Figure 4.24). Profile 9, sits very close to its lowest recorded range. This profile is behind the first rock groyne, which separates it from the rest of the beach.

Since the last assessment (Boyle, 2016), Profiles 1, 3, 5 and 6 have exceeded the upper limits of the beach envelope indicating recent beach levels have increased above previously recorded highs (Figure 4.23). In contrast, Profiles 8 and 9 have recently exceeded the lower limits of the beach envelope indicating the northern profiles lie at or near their lowest levels on record (Figure 4.24). It is important to note that monitoring at Profiles 8 and 9 only began in 1993, limiting long-term comparisons of the position of the beach profile within the beach envelope.

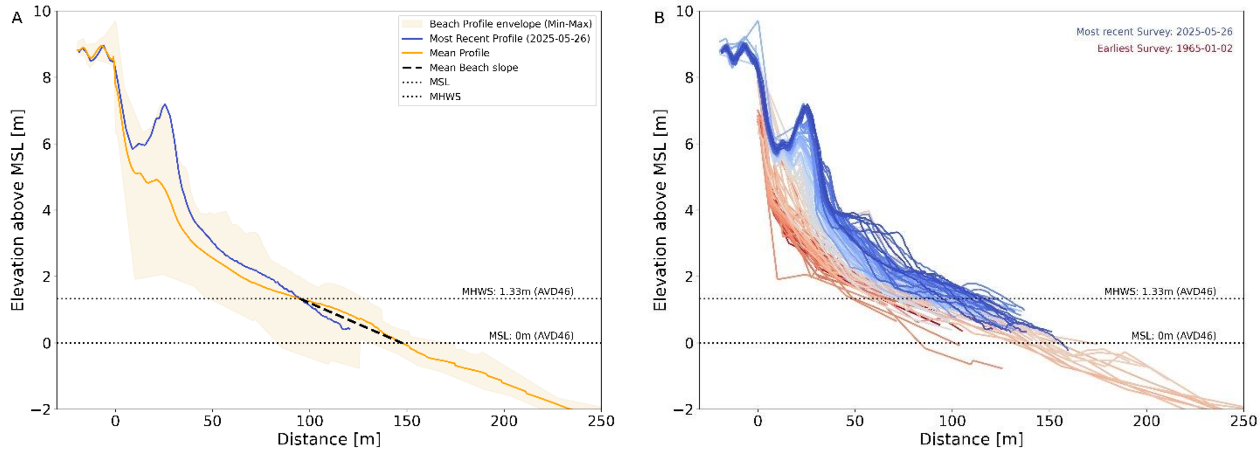

Figure 4.23: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Omaha Beach.

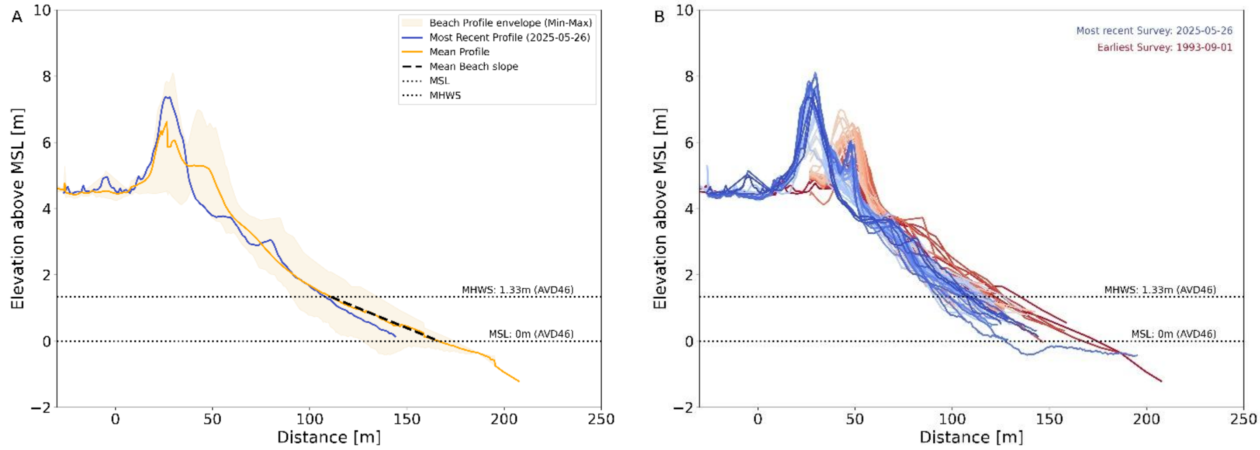

Figure 4.24: Beach envelope (A), and historic beach profile record (B) for Profile 8 at Omaha Beach.

4.2.2.2 Beach volume

Beach-wide averaged volume indicates a long-term trend of accretion at Omaha Beach, with higher rates of accretion at the upper (1.2 $m^3/m/yr$), than the lower (0.1 $m^3/m/yr$) beach (Figure 4.25). However, it is important to note that these trends are not statistically significant, likely due to the contrasting behaviour of individual profiles (Table 4.2). Trends in beach volume change vary across profiles, Profiles 1-7 show a long-term increase in beach volume at both the lower and upper beach (Figure 4.25), while Profiles 8 and 9, situated at the northern end of the beach exhibit long-term erosion, contrasting with the rest of the beach (Table 4.1). Accretion at Profiles 1-7 is relatively consistent at both the lower and upper beach although rates are slightly higher at the upper beach (Table 4.1).

Since the last assessment (Boyle, 2016) Profiles 1-7 have continued to gain in volume (Table 4.1). However, it is interesting to note that the most rapid growth has shifted from the upper beach to the lower beach, suggesting a recent change in sediment deposition and transport resulting in sediment now accumulating on the beach face rather than being transported into the dune system. This shift has led to a recent flattening of the beach profile (Table 4.1).

At the northern end of the beach (Profiles 8-9) trends of volumetric change have also shifted since 2014 where Profile 8 has transitioned into a period of growth, with volume increasing by 1.0 m³/m/yr and 1.2 m³/m/yr at the lower and upper beach, respectively (Table 4.1). Meanwhile, erosion at Profile 9 has accelerated since the last assessment (Boyle, 2016) with volume loss increasing from -2.7 m³/m/yr to -8.4 m³/m/yr at the lower beach and from -1.0 m³/m/yr to -15.0 m³/m/yr at the upper beach (Table 4.1).

Large short-term fluctuations in beach volume are evident at both the lower and upper beach throughout the monitoring period, coinciding with high-energy events such as the July 2000 storm event (Boyle, 2016) and Cyclone Gabrielle in 2023 (Figure 4.25). Like Pākiri Beach, decadal scale cyclical patterns can be observed throughout the beach averaged monitoring record with peaks in beach volume observed around 2000 and 2010 (Figure 4.25).

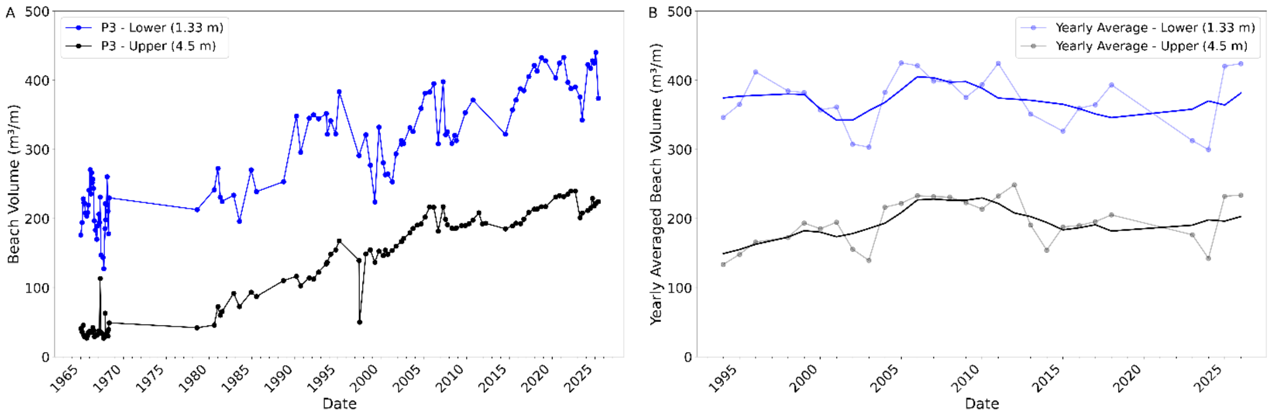

Figure 4.25: Beach volume changes at the lower (1.33 m (MHWS)) and upper (4.5 m) contours. A) Beach volume timeseries at Profile 3, and B) beach-wide averaged volume timeseries.

4.2.2.3 Beach width

Like beach volume, beach width shows a long-term trend of accretion at the upper beach increasing from 20.4 m to 39.8 m between 1993 and 2025 at a rate of 0.5 m/yr (Figure 4.26; Table 4.2). Beach-wide averaged width at the lower beach has increased slightly from 107.8 m to 111.2 m since the 1990s, and exhibits a long-term trend of stability, however this is not statistically significant (Table 4.2). Accretion of the upper beach and relative stability of the lower beach has led to accretion and steepening of the beach profile (Figure 4.26).

Patterns in beach width vary between profiles where Profiles 1-5 exhibit long-term accretion at both the lower and upper beach, with relatively consistent growth rates, whereas Profiles 6 and 7, show slightly faster accretion at the upper beach (Table 4.1). In contrast, Profiles 8 and 9 show long-term erosion at both the lower and upper beach (Table 4.1).

Consistent with changes in beach volume the rate of beach accretion has accelerated at the lower beach at Profiles 1-5 since the last assessment (Boyle, 2016), leading to accretion and flattening of the beach profile (Table 4.1). In contrast, short-term trends indicate that rates of accretion at Profile 6 have slowed, while rates at Profile 7 have transitioned to erosion, with rates of -0.4 m/yr and -0.2 m/yr at the lower and upper beach, respectively. Erosion at Profiles 8 and 9 has remained relatively consistent, except at Profile 9, where upper beach erosion has accelerated from -0.6 m/yr to -3.0 m/yr (Table 4.1).

Fluctuations in beach width largely reflect those observed in beach volume, with the lower beach experiencing significant variability throughout the monitoring record, likely in response to high-energy events (Figure 4.26). The cycle observed in patterns of beach volume at Omaha can also be seen in lower beach averaged width, although the pattern is weaker and less discernible (Figure 4.26).

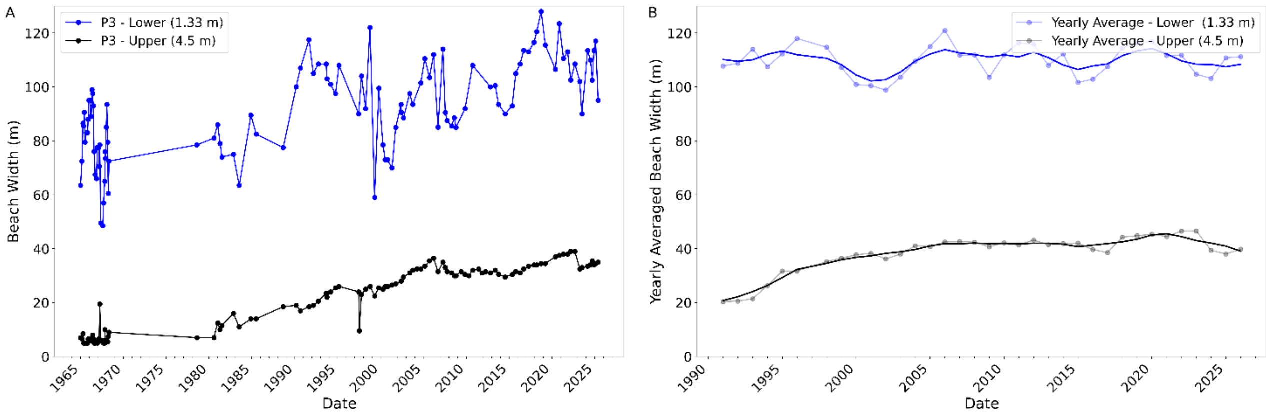

Figure 4.26: Beach width changes at the lower (1.33 m (MHWS)) and upper (4.5 m) contours. A) Beach width timeseries at Profile 3, and B) beach-wide averaged width timeseries.

4.2.2.4 Foredune dynamics

Vertical and horizontal movement of the foredune is highly variable between the beach profiles at Omaha Beach, although spatial patterns of dune behaviour can be observed (Figure 4.27). At the southern end of the beach (Profiles 1 and 2), the dune position has remained relatively stable throughout the monitoring period. However, the highest point of the dune at Profile 1 has decreased in height by approximately 0.8 m (Figure 4.27). In contrast, the maximum dune position at Profiles 3, 4, and 8 has increased in height by up to 2 m while migrating landward (Figure 4.27).

At Profile 6, where monitoring records extend back to the 1960s, the foredune experiences erosion in response to the 1978 storms, followed by long-term recovery as the dune migrated seaward and increased in height over the next 40 years (Figure 4.27). At Profile 9, located in the northern section of the beach and separated from the rest of the beach profiles by a rock groyne, the foredune has remained relatively stable, migrating landward only 2 m and reducing in height by only 0.4 m since 1993 (Figure 4.27).

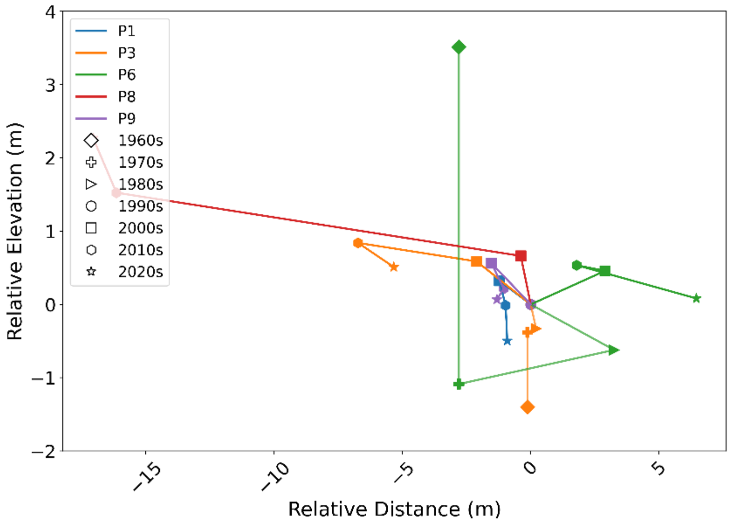

Figure 4.27: Change in maximum foredune position at Profiles 1, 3, 6 and 8 at Pakiri Beach from the 1960s. Horizontal and vertical changes are reduced to zero to aid comparison.

4.2.3 Discussion

Pākiri Beach and Omaha Beach exhibit contrasting long-term trends, with Pākiri experiencing sustained erosion while Omaha undergoes overall accretion. These divergent trends can likely be attributed to both their distinct geographic settings and human interventions. Omaha Beach has experienced dune renourishment and groyne construction in an attempt to reduce erosion (Schofield, 1985), while Pākiri Beach has undergone no beach protection measures but has been subject to offshore sand mining since the 1940s (Auckland Council, 2023).

Beyond these anthropogenic influences, the two beaches differ geomorphologically. Omaha Beach is constrained geologically by headlands and retains northward-transported sediment due to the rock groynes constructed in 1979 (Schofield, 1985). Pākiri Beach, a much larger and less constrained system, may experience greater dispersion of any sediment deposited on the beach.

Despite their disparate long-term trends, changes in beach volume and width at both Pākiri and Omaha Beach exhibit cyclical patterns throughout the monitoring record, with phases of sediment accumulation and loss. Decadal fluctuations in the El Niño–Southern Oscillation (ENSO) represent a potential control on beach erosion and accretion patterns on Auckland's beaches (Boyle, 2016; Figure 4.28). ENSO significantly influences New Zealand's climate, particularly ocean surface temperature and wind patterns, which in turn affect wave height, direction, and period, driving changes at the beach (Gorman, 2003; Godoi et al., 2016).

Changes in beach volume and width do not consistently align with ENSO phases, and it is difficult to determine the role of ENSO in beach change at Pakiri and Omaha without further statistical analysis, such as cross-correlation. For example, between 2006 and 2013, Omaha Beach exhibited a peak in sand volume that coincided with a strong La Niña phase (Figure 4.28). In contrast, Pakiri Beach experienced a reduction in sediment volume over the same period. Future reports will leverage newly available wave data to investigate the relationship between beach dynamics at Pākiri and Omaha and broader climatic oscillations such as ENSO.

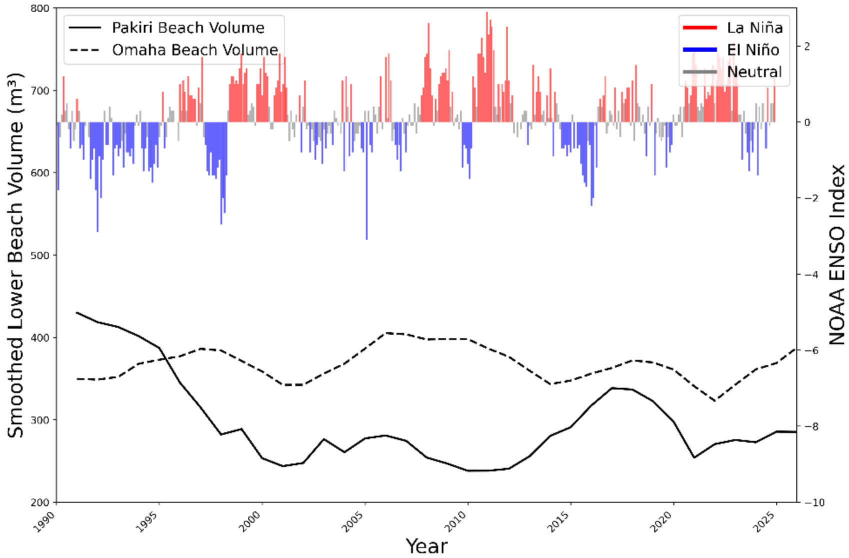

Figure 4.28: Average beach volume at Pākiri (solid line) and Omaha (dashed line) displayed with ENSO trends measured by SOI values (http://www.cpc.ncep.noaa.gov/data/indices/soi).

4.3 Group 3 – Inner Hauraki Gulf

The inner Hauraki Gulf beach group consists of six beaches; Long Bay, Browns Bay, Campbells Bay, Milford Beach, Takapuna Beach and Cheltenham Beach, all located on the east coast of Auckland within the inner Hauraki Gulf. These beaches have lower wave exposure than the open east coast beaches with an average wave height of 0.36 m that varies seasonally only marginally, however the 99th percentile wave height increases to 1.6 m in winter (Figure 4.29).

Long Bay is the least developed beach within the inner Hauraki Gulf group with the foredune backed by a regional park. Bounded by cliffed headlands, Piripiri Point to the north and Toroa Point to the south, sediment movement at Long Bay is relatively constrained with limited exchange within and outside the beach system. The remaining beaches in the inner Gulf group are urban beaches backed by roads or residential property immediately landward of the upper beachface, and many have hard structures such as sea walls or rock revetments in place. Alongside seawall construction, some inner Gulf beaches have undergone sand transfer or dune reshaping or planting programmes, which have influenced beach profile evolution over time (Baverstock, 2003).

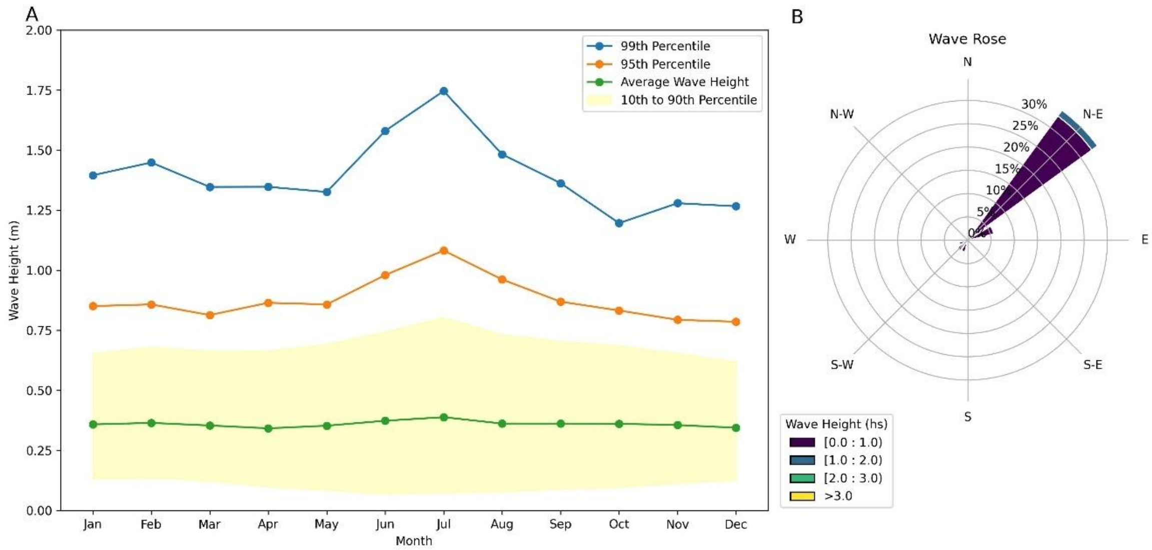

Figure 4.29: Wave summary statistics for the inner Hauraki Gulf of Auckland (Oceanum, 2025). A) wave height and B) wave rose.

4.3.1 Long Bay

Long Bay is monitored with two beach profiles: Profile 1 at the southern end of the beach and Profile 2 at the northern end (Figure 4.30). Both profiles are backed by a small vegetated foredune that backs onto a regional park. Profile 1 has the longest monitoring record, first surveyed in 1982 while Profile 2 started in 1990 (Table 2. 1).

Figure 4.30: The position of the beach profiles 1-2 at Long Bay.

4.3.1.1 Beach envelope

The beach envelope at Long Bay is the largest within the inner Hauraki Gulf group with vertical and horizontal fluctuations reaching 2 m and 50 m, respectively (Figure 4.31; Figure 4.32). The most recent profile (18/04/2025) at both Profile 1 and Profile 2 lie at the average profile at the upper beach but below it at the lower beach, extending to 30% and 35% of the total beach envelope, respectively (Figure 4.31; Figure 4.32). Notably, the toe of the foredune at Profile 2 is at its most landward (eroded) position on record.

Since the last assessment (Boyle, 2016), the beach envelope has expanded, with the lower limits of the beach envelope decreasing at both profiles (Figure 4.31; Figure 4.32). This suggests Long Bay has experienced increased variability recently, with notable beach elevation dropping below previously recorded lows.

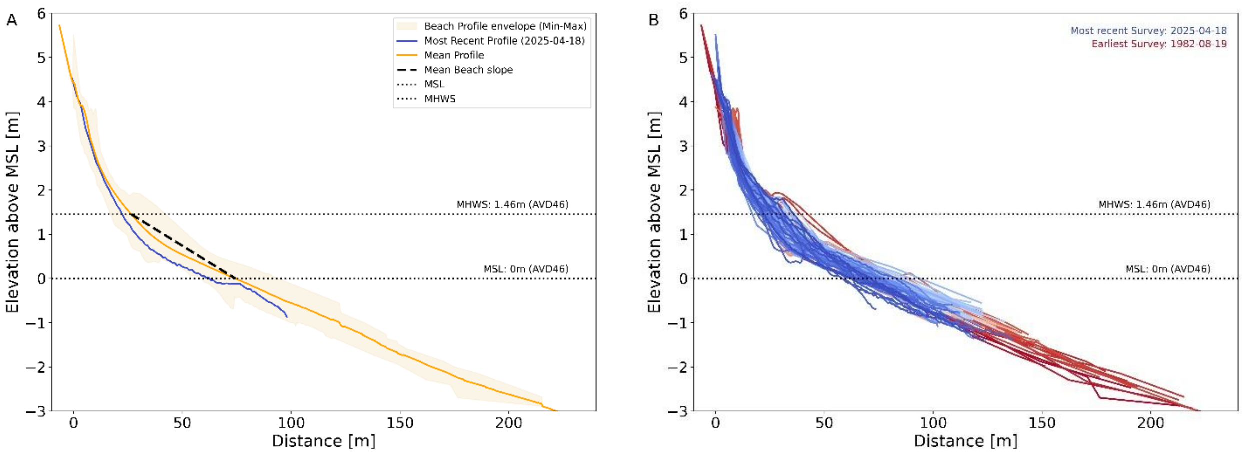

Figure 4.31: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Long Bay.

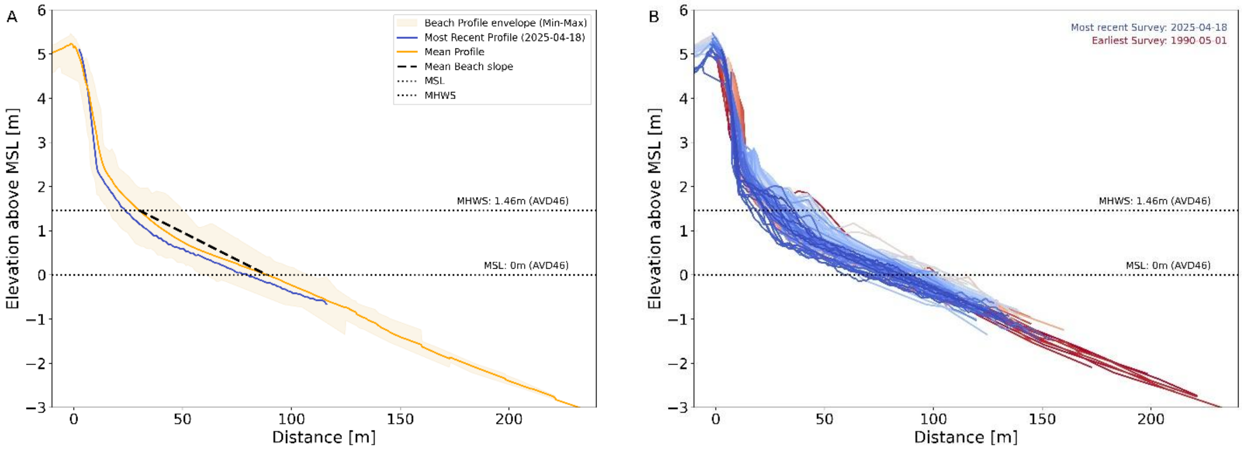

Figure 4.32: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Long Bay.

4.3.1.2 Beach volume

Beach-wide averaged volume shows a long-term trend of erosion at the lower (-0.6 m^3/m/yr) and upper (-0.2 m^3/m/yr) beach (Figure 4.33). However, erosion rates are not consistent across the beach with Profile 2 experiencing higher rates of erosion at both the lower and upper beach (Table 4.1). Both profiles experience considerable intra-annual variability throughout the monitoring period with the lower beach more severely impacted than the upper beach (Figure 4.33).

Short-term trends suggest the southern end of the beach has experienced substantial growth of the lower (1.6 m^3/m/yr) and upper (0.7 m^3/m/yr) beach since the last assessment (Boyle, 2016). Whereas the northern end of the beach has seen as acceleration in erosion increasing rates to -0.7 m^3/m/yr at the lower beach and -1.0 m^3/m/yr at the upper beach (Table 4.1).

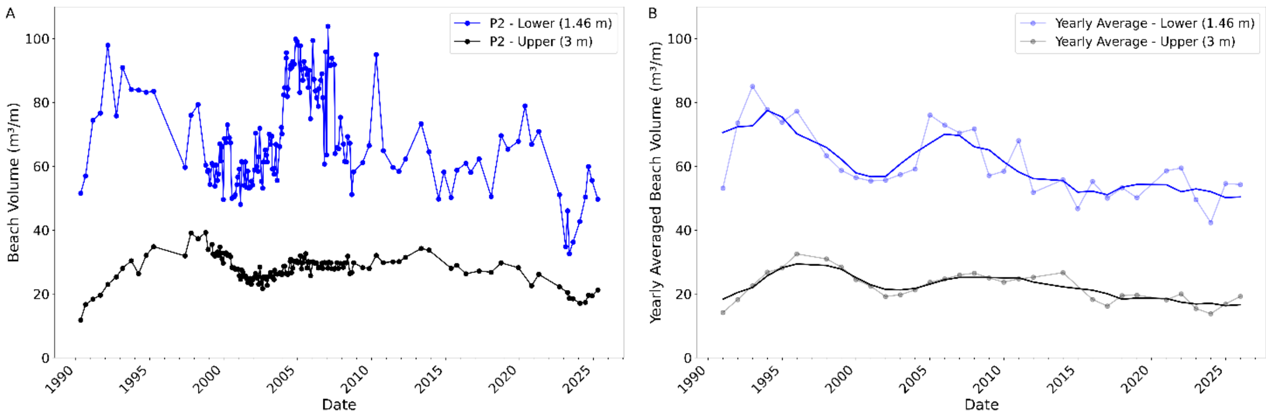

Figure 4.33: Beach volume changes at the lower (1.46 m (MHWS)) and upper (3 m) contours. A) Beach volume timeseries at Profile 2, and B) beach-wide averaged volume timeseries.

4.3.1.3 Beach width

Consistent with patterns in beach volume, beach-wide averaged width shows a long-term trend of erosion at Long Bay with rates of -0.3 m/yr at the lower beach and -0.1 m/yr at the upper beach, leading to longer-term retreat and steepening of the beach profile (Table 4.1; Figure 4.34).

Since the previous assessment by Boyle (2016), Profile 1 has experienced a period of accretion at both the lower and the upper beach, with beach width increasing at rates of 0.7 m/yr and 0.2 m/yr, respectively (Table 4.1). In contrast, Profile 2 displays a reversal in recent trends where accretion has occurred at the lower beach while the upper beach has experienced erosion leading to recent flattening of the beach (Table 4.1).

Long Bay experiences considerable intra-annual variability, with larger fluctuations observed at the lower beach (Figure 4.34). Like beach volume, a decadal cyclical cycle can be observed in patterns of beach width, which might reflect changes in climatic oscillations and will be explored in future reporting.

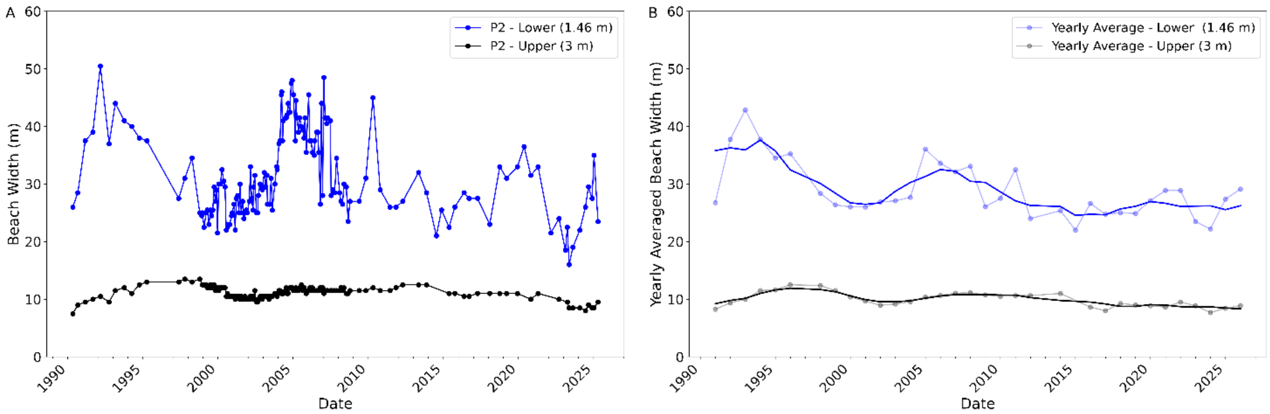

Figure 4.34: Beach width changes at the lower (1.46 m (MHWS)) and upper (3 m) contours. A) Beach width timeseries at Profile 2, and B) beach-wide averaged width timeseries.

4.3.1.4 Beach rotation

The BOI indicates a predominant anticlockwise rotation at Long Bay throughout the monitoring period, driven by higher long-term rates of erosion at the northern end of the beach relative to the southern end. However, the BOI also reveals substantial interannual variability, with several periods of clockwise rotation interrupting the long-term trend (Figure 4.35). Notably, a five-year phase of clockwise rotation is observed between 2000 and 2005, driven by accretion at the northern end and erosion at the southern end of the beach. This period coincides with an El Niño phase, which will be explored in greater detail in future reporting.

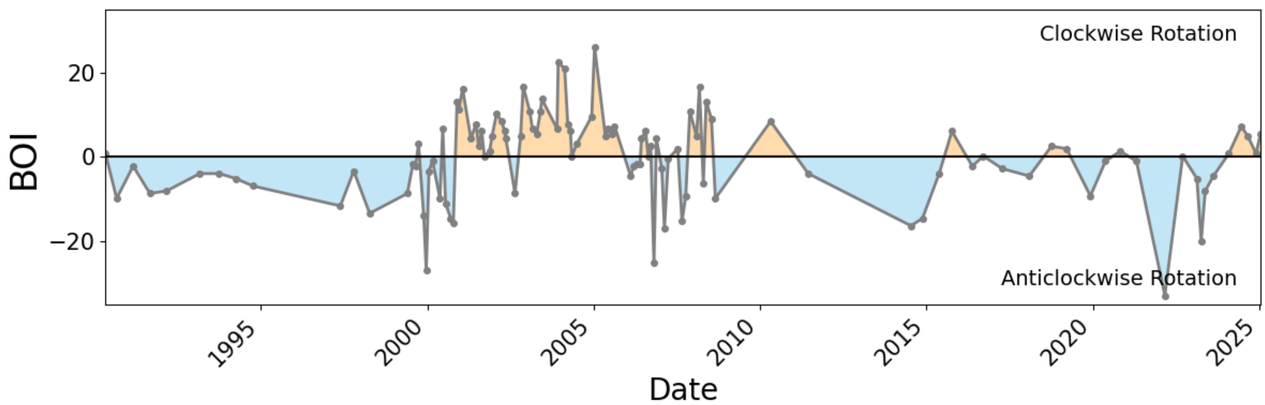

Figure 4.35: Beach oscillation index (BOI) at Long Bay indicating relative rotational behaviour of the beach (clockwise or anticlockwise) through time.

4.3.2 Takapuna Beach

Takapuna Beach is monitored by three beach profiles situated at the northern (Profile 1), middle (Profile 2) and southern (Profile 3) ends of the beach (Figure 4.36). Takapuna is a small urban beached backed by a seawall along the entire beach. Beach monitoring began in 1998 at all profiles (Table 2. 1).

Figure 4.36: The position of the beach profiles 1-3 at Takapuna Beach.

4.3.2.1 Beach envelope

Due to relatively low wave exposure, in addition to the seawall that runs along the beach, the beach envelope at Takapuna is narrow with vertical fluctuations of up to 1.3 m and horizontal fluctuations of up to 35 m consistent across all three profiles (Figure 4.37).

The most recent survey (01/04/2025) shows sand levels at Takapuna Beach are currently below the long-term average, with Profiles 1-3 occupying only 44%, 49%, and 35% of the maximum beach envelope, respectively. Since the last assessment (Boyle, 2016), the beach envelope has expanded, primarily due to the lowest limits of the beach envelope decreasing across all profiles. This expansion reflects an increase in the severity of beach profile fluctuations, with recent beach levels falling below previously recorded lows. However, beach elevation exhibits substantial seasonal variability, and while the magnitude of fluctuations appears to be increasing, there is no clear directional trend (Figure 4.37).

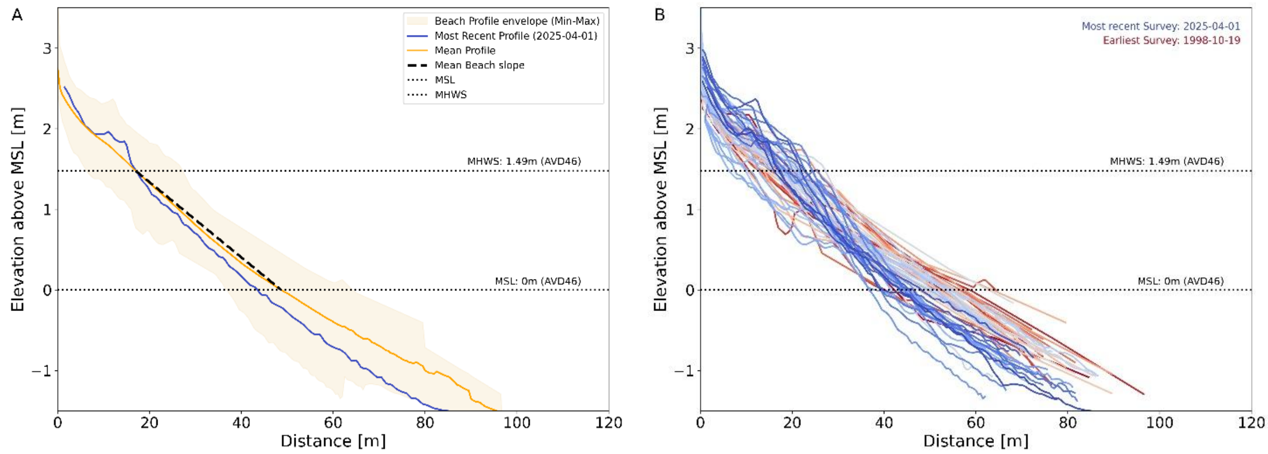

Figure 4.37: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Takapuna Beach.

4.3.2.2 Beach volume

Beach-wide averaged volume at Takapuna Beach indicates a weak erosional trend of -0.1 m^3/m/yr at the lower beach (Figure 4.38; Table 4.2). These findings align with earlier assessments suggesting relative stability at Takapuna (Kench, 2008; Boyle, 2014). In contrast, the upper beach exhibits a positive long-term trend, with beach-wide accretion occurring at a rate of 0.2 m^3/m/yr (Figure 4.38). It is important to note that these trends are not statistically significant (Table 4.2).

Spatial variability is evident along Takapuna beach. Profiles 1 and 2 show long-term accretion, whereas Profile 3, located at the southern end of the beach, exhibits long-term erosion, with volumetric losses of -0.2 m^3/m/yr at the lower beach and -0.3 m^3/m/yr at the upper beach (Table 4.1). Since the last assessment (Boyle, 2016), all profiles have experienced a loss in beach volume. Notably, Profile 3 has undergone accelerated erosion, with short-term loss rates increasing to -0.4 m^3/m/yr and -0.7 m^3/m/yr at the lower and upper beach, respectively (Table 4.1).

Short-term fluctuations in beach volume are evident across all profiles (Figure 4.38). Beach change at Takapuna Beach is dominated by seasonal adjustments rather than long-term patterns, with sand accumulation typically occurring in the calmer months and erosion dominating during the stormier winter period. The influence of Cyclone Lola on sediment dynamics at Takapuna Beach is addressed in the case study presented in Section 6.

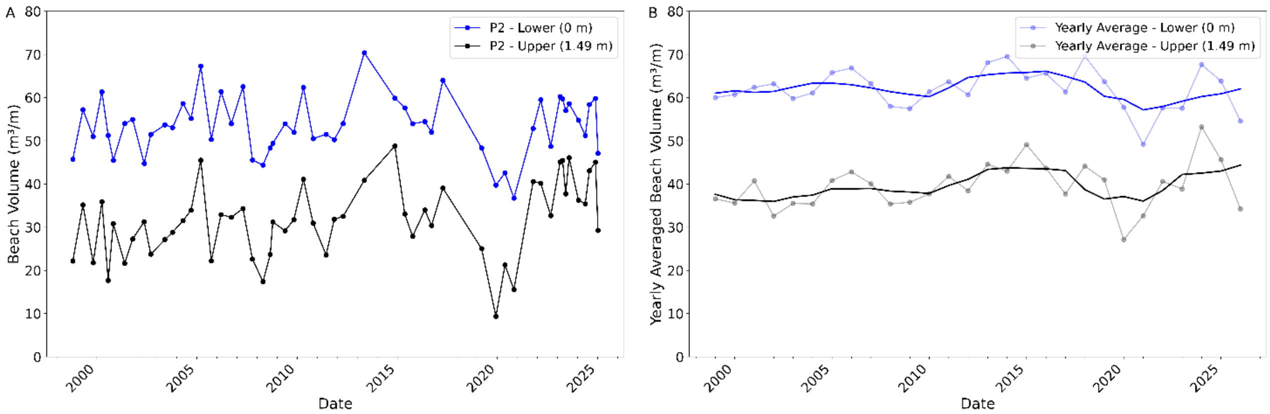

Figure 4.38: Beach volume changes at the lower (0 m (MSL)) and upper (1.49 m (MHWS)) contours. A) Beach volume timeseries at Profile 2, and B) beach-wide averaged volume timeseries.

4.3.2.3 Beach width

Beach-wide averaged width at Takapuna indicates erosion at a rate of -0.4 m/yr at the lower beach (Figure 4.39). Long-term rates of erosion of the lower beach increase northward along the beach from -0.1 m/yr at Profile 3 to -0.6 m/yr at Profile 1 (Table 4.1). In contrast, beach-wide averaged width of the upper beach is synonymous with beach volume exhibiting long-term accretion at 0.1 m/yr (Figure 4.39).

Since the last assessment (Boyle, 2016), erosion has accelerated at all profiles at both the lower and upper beach (Table 4.1). However, erosion of the lower beach is occurring at a faster rate at all profiles, leading to retreat and steepening of the beach profile (Table 4.1).

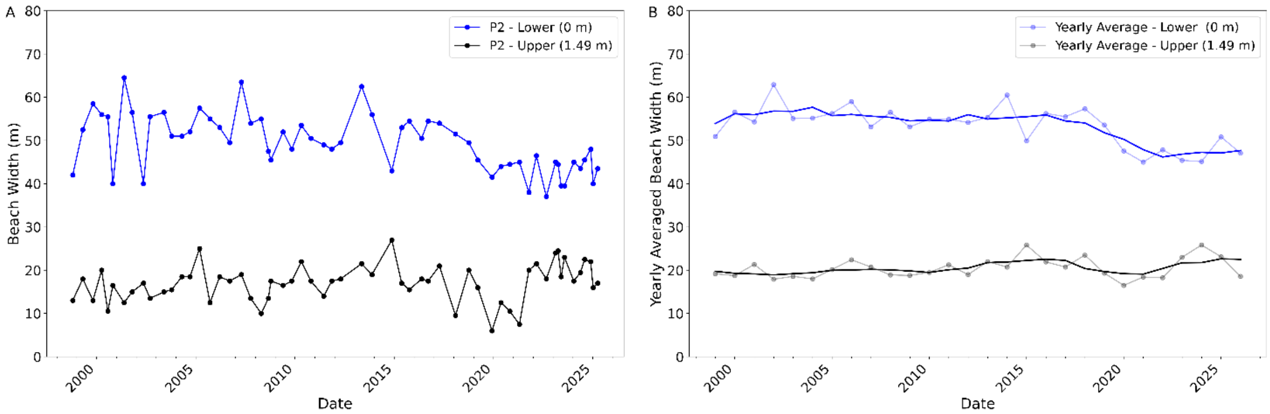

Figure 4.39: Beach width changes at the lower (0 m (MSL)) and upper (1.49 m (MHWS)) contours. A) Beach width timeseries at Profile 2, and B) beach-wide averaged width timeseries.

4.3.2.4 Beach rotation

The BOI exhibits a cyclical pattern of rotation at Takapuna Beach, with the direction of beach rotation (clockwise or anticlockwise) changing every 5-10-years throughout the monitoring period (Figure 4.40). Periods of clockwise rotation, associated with accelerated erosion at the southern end, are observed between 1998-2004 and again from 2008 to 2017 (Figure 4.40).

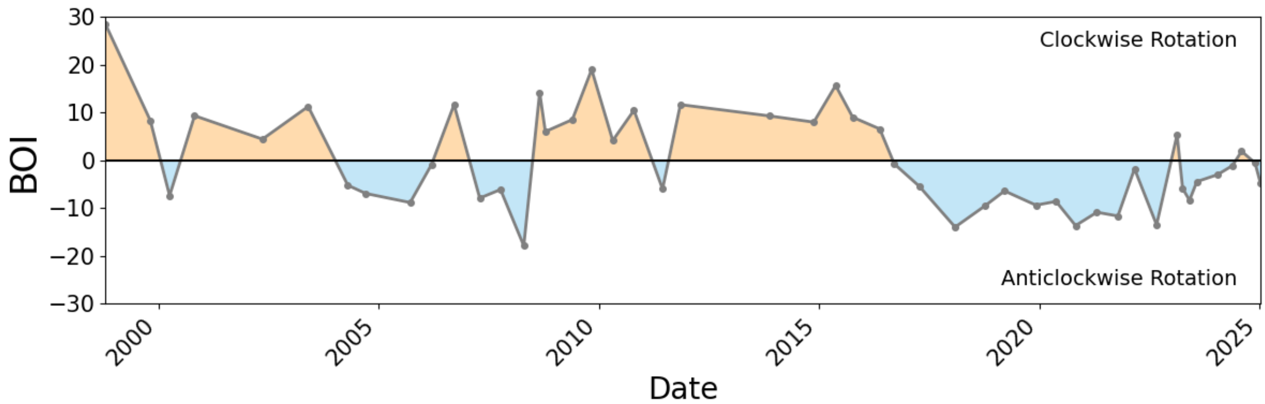

Figure 4.40: Beach oscillation index (BOI) at Takapuna Beach indicating relative rotational behaviour of the beach (clockwise or anticlockwise) through time.

4.3.3 Browns Bay

Browns Bay has two profiles situated in the northern (Profile 1) and southern (Profile 2) ends of the beach (Figure 4.41). An urban beach, Browns Bay has a seawall that runs along the northern end of the beach and is picked up at the start of Profile 1, while a rock revetment runs along the southern end of the beach. The monitoring record for both profiles began in 1998. Please note monitoring was suspended between 2015 and 2022 impacting short-term rates of change.

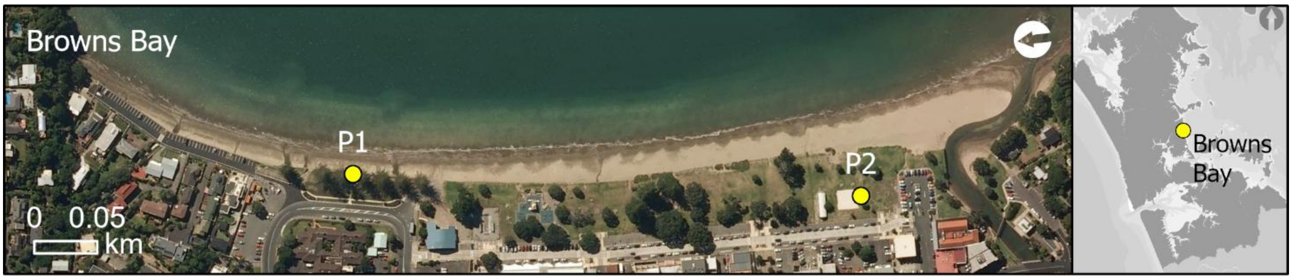

Figure 4.41: The position of the beach profiles 1-2 at Browns Bay.

4.3.3.1 Beach envelope

Consistent with other inner Gulf beaches, Browns Bay beach exhibits a relatively small beach envelope at both beach profiles (Figure 4.42; Figure 4.43). However, the southern end of the beach (Profile 2) exhibits the larger beach envelope, with horizontal and vertical fluctuations of up to 60 m and 2.4 m, respectively, compared to 36 m and 2 m, at the northern end of the beach (Profile 1).

The most recent survey (16/04/2025) indicates relatively high sand levels, with the more recent profiles at Profile 1 and Profile 2 closely aligning with the average profile, reaching 59% and 76% of the beach envelope, respectively (Figure 4.42; Figure 4.43). However, Browns Bay experiences substantial intra-annual fluctuations, with sand levels regularly reaching both the upper and lower limits of the beach envelope each year (Figure 4.42; Figure 4.43). As a result, sand levels are likely to fluctuate throughout the year in response to changing wave conditions.

Since the last assessment (Boyle, 2016), the lower limit of the beach envelope at Profile 1, particularly at the upper beach, has expanded, indicating increasingly large fluctuations in beach elevation (Figure 4.42). Recent beach levels have dropped below previously recorded lows, with the lowest elevation on record occurring in 2023, following Cyclones Gabrielle and Lola. This triggered coastal works at the southern end of Browns Bay including removal of exposed legacy rock rip-rap and reconstruction of a formalised rock revetment, balanced by dune reshaping and replanting at the wider reserve edge. For more details on storm impacts on Auckland beaches, see the case study in Section 6.

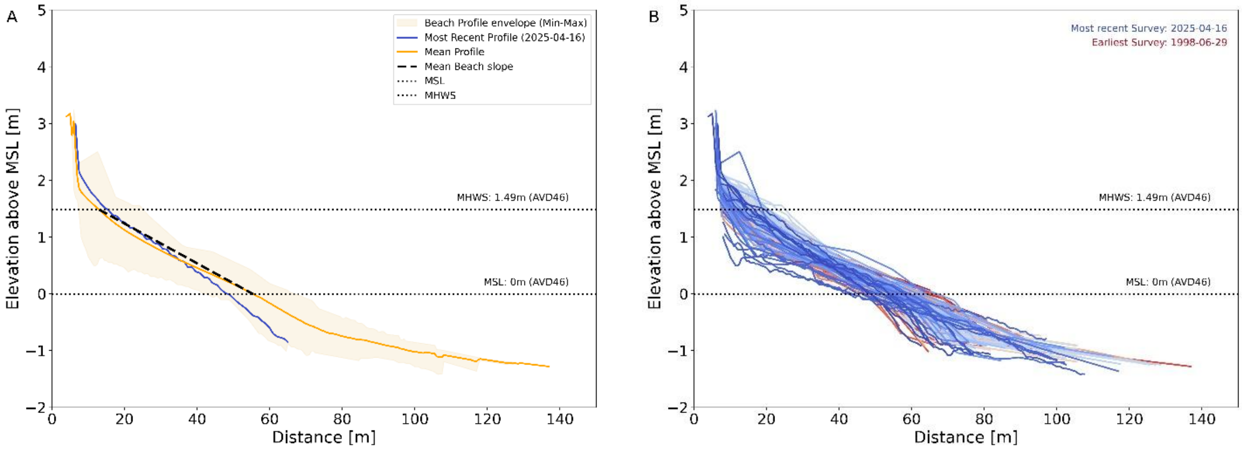

Figure 4.42: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Browns Bay.

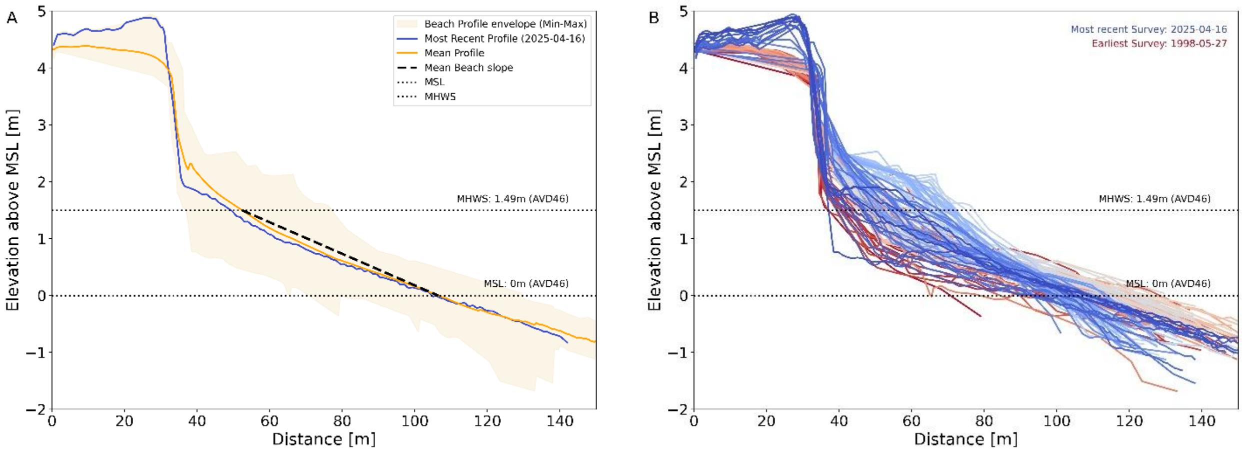

Figure 4.43: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Browns Bay.

4.3.3.2 Beach volume

Beach-wide averaged volume at Browns Bay indicates long-term trends of erosion at the lower beach at rates of -0.2 m³/m/yr, and accretion of the upper beach at 0.2 m³/m/yr (Figure 4.44). These trends are consistent at both Browns Bay profiles with erosion rates of up to -0.2 m³/m/yr at the lower beach and accretion rates up to 0.1 m³/m/yr at the upper beach (Table 4.1). However, it is important to note that beach-wide averaged trends are not statistically significant, likely due to varying phases of volume change throughout the monitoring period (Table 4.2). The monitoring record shows a period of rapid accretion of beach volume between 2000-2006, followed by erosion until 2016, and a subsequent phase of relative stability (Figure 4.44).

Short-term rates indicate a recent period of beach volume growth at Browns Bay with accretion rates of up to 1.2 m³/m/yr at the lower beach, and 0.8 m³/m/yr at the upper beach (Table 4.1). However, it is important to note that these rates only reflect changes between 2022 and 2025, as monitoring was suspended between 2015 and 2022. Consequently, the short-term rates are based on limited data and primarily capture the increase in beach volume since monitoring resumed in 2022 (Figure 4.44).

Like other inner Gulf beaches, Browns Bay experiences considerable intra-annual fluctuations in beach volume at both the lower and upper beach, with the upper beach volume frequently reducing to 0 m³/m/yr throughout the monitoring period (Figure 4.44).

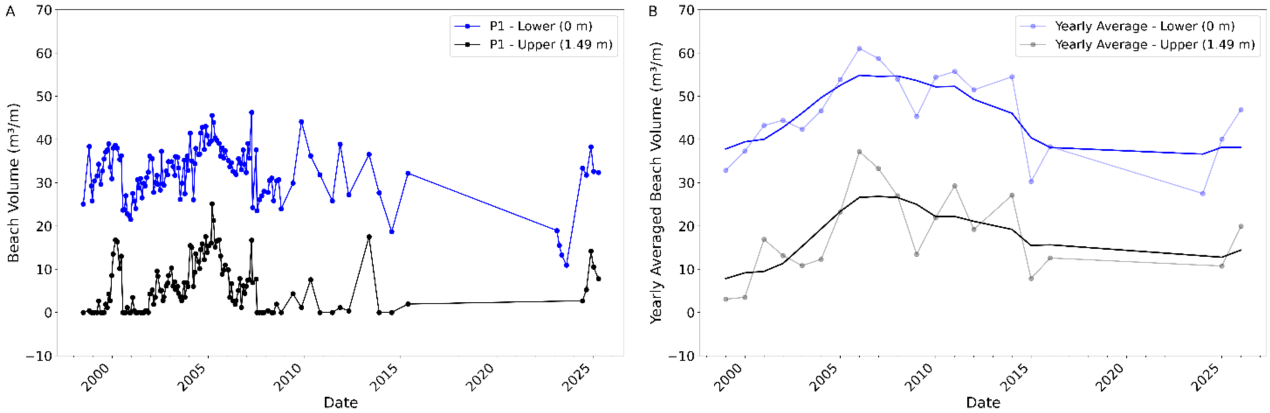

Figure 4.44: Beach volume changes at the lower (0 m (MSL)) and upper (1.49 m (MHWS)) contours. A) Beach volume timeseries at Profile 1, and B) beach-wide averaged volume timeseries.

4.3.3.3 Beach width

Consistent with trends in beach volume, beach-wide averaged width at Browns Bay indicates a long-term trend of erosion at the lower beach, at a rate of -0.3 m/yr (Figure 4.45). The upper beach exhibits long-term stability: however, this trend is not statistically significant (Table 4.2). More rapid erosion of the lower beach throughout the monitoring record has led to a steepening of the beach profile.

Since the last assessment (Boyle, 2016), both profiles have experienced accretion at both the lower and upper beach (Table 4.1). However, as these short-term rates only reflect beach change since monitoring resumed in 2022, they should be interpreted with caution due to the limited temporal record.

Like beach volume at Browns Bay, beach width exhibits considerable intra-annual variability at both the upper and lower beach across the monitoring period (Table 4.1; Figure 4.45), highlighting the dynamic nature of inner Gulf beaches and the influence of short-term processes.

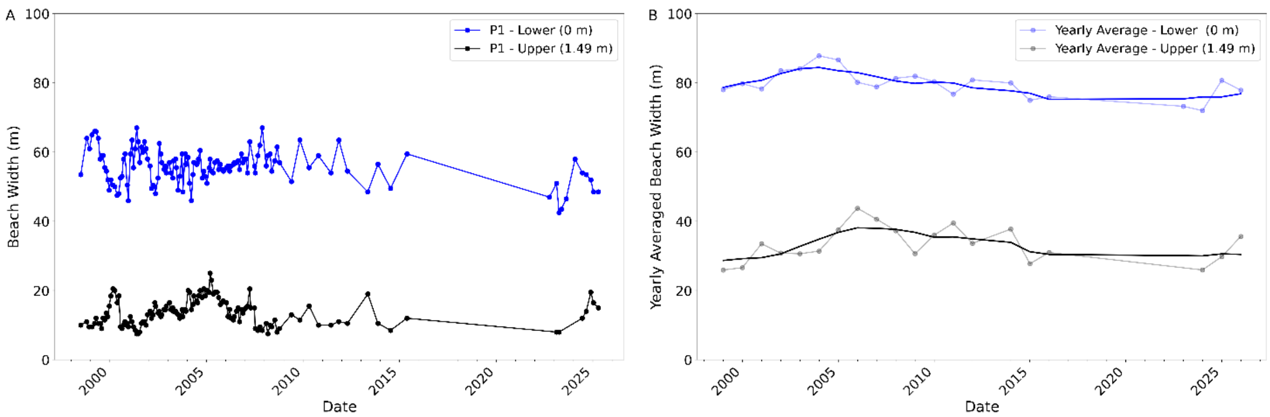

Figure 4.45: Beach width changes at the lower (0 m (MSL)) and upper (1.49 m (MHWS)) contours. A) Beach width timeseries at Profile 1, and B) beach-wide averaged width timeseries.

4.3.3.4 Beach rotation

The BOI indicates substantial interannual variability at Browns Bay, with periods of alternating clockwise and anticlockwise rotation on approximately three to five-year cycles throughout the monitoring period (Figure 4.46). This pattern is most apparent between 2000 and 2010, where the availability of higher-frequency survey data enhances the temporal resolution (Figure 4.46). Clockwise rotation driven by periods of rapid accretion at the northern end of the beach is most notable between 2005-2008. It is important to note the lack of data between 2015 and 2022 creates a period of apparent clockwise rotation that may not reflect actual beach behaviour.

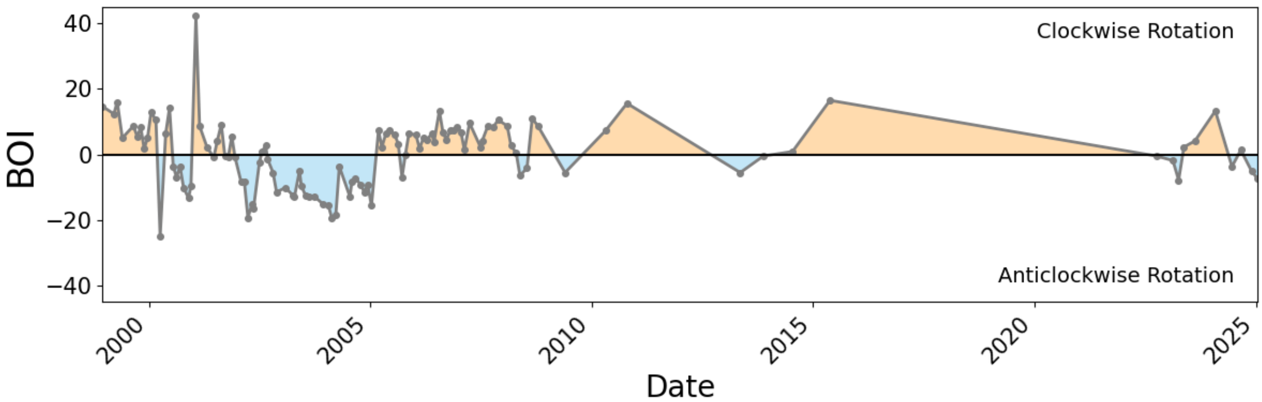

Figure 4.46: Beach oscillation index (BOI) at Browns Bay indicating relative rotational behaviour of the beach (clockwise or anticlockwise) through time.

4.3.4 Campbells Bay

Campbells Bay is monitored with two beach profiles situated in the central section of the beach (Figure 4.47). The entire shoreline at Campbells Bay is armoured with either a seawall or rock revetment and both profiles start at the top of a seawall. The monitoring record for both profiles began in 1998. Please note monitoring was suspended between 2015 and 2022 impacting short-term rates of change.

Figure 4.47: The position of the beach profiles 1-2 at Campbells Bay.

4.3.4.1 Beach envelope

Consistent with other inner Gulf beaches, Campbells Beach exhibits a small beach envelope at both profiles, with maximum horizontal and vertical excursions of 32 m and 1.8 m, respectively (Figure 4.48; Figure 4.49).

The most recent beach profile (16/04/2025) at Profile 1 and Profile 2 lie below the average profile, reaching only 35% and 38% of the beach envelope, respectively (Figure 4.48; Figure 4.49). This indicates that the beach currently has low sand levels. However, like other inner Gulf beaches, Campbells Beach experiences large intra-annual fluctuations, often nearing both the upper and lower limits of the beach envelope within a year. Therefore, current sand levels do not necessarily suggest a long-term loss of sediment from the beach system.

The last assessment (Boyle, 2016) observed a substantial reduction in the beach level in July 2014, extending the lower limits of the recorded beach envelope and setting a new recorded low. Since then, the beach profile has fluctuated within the beach envelope without exceeding its previous upper or lower limits (Figure 4.48). It is important to note that monitoring at Campbells Beach was suspended between 2015 and 2022, meaning any fluctuations during this period are not recorded in the monitoring record.

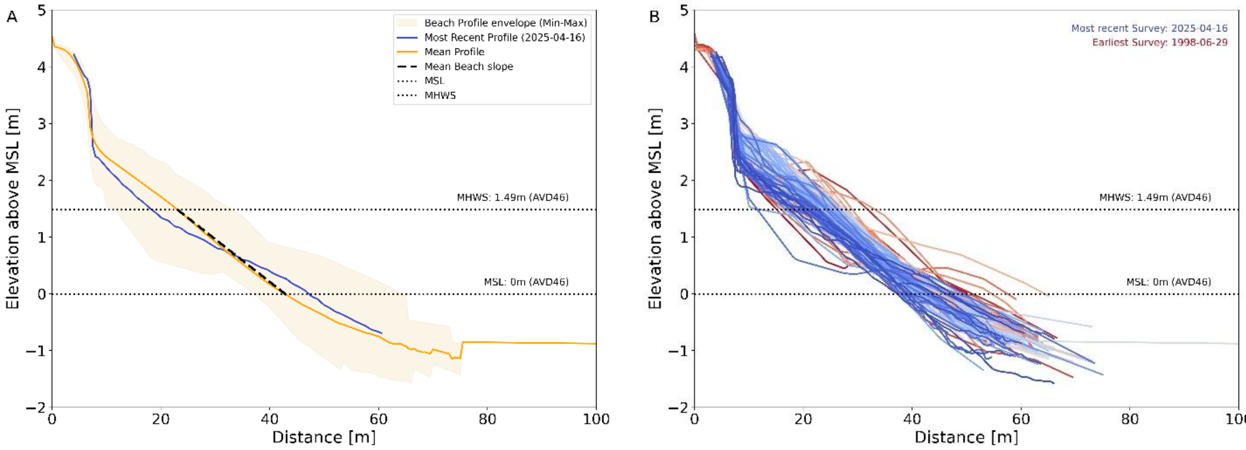

Figure 4.48: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Campbells Bay.

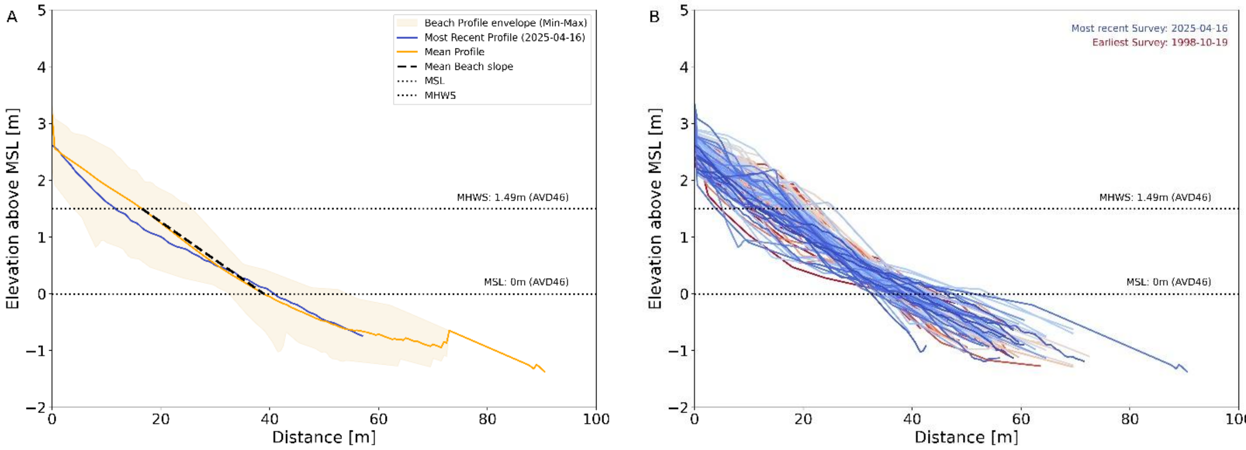

Figure 4.49: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Campbells Bay.

4.3.4.2 Beach volume

Beach-wide averaged volume at Campbells Bay indicates a long-term trend of erosion, occurring at both the lower (–0.3 m³/m/yr) and upper (-0.4 m³/m/yr) beach (Figure 4.50). However, it is important to note that these trends are not statistically significant, although the direction and magnitude of change suggests a possible erosional pattern that could become more evident with continued observation (Table 4.2).

The erosional trend is relatively consistent across the beach, with Profiles 1 and 2 both exhibiting similar rates of erosion, reaching up to –0.4 m³/m/yr (Table 4.1). Since the last assessment (Boyle, 2016), short-term records indicate a reversal in recent trends where both profiles show an increase in beach volume. However, these trends are heavily influenced by a substantial volume loss recorded in 2014, and by the lack of monitoring data between 2014 and 2022. As such, the current short-term rates should continue to be monitored to support further interpretation (Figure 4.50).

As observed across many inner Gulf beaches, Campbells Bay is characterised by considerable interannual variability in beach volume (Figure 4.50). In particular, high-energy events in 2007 and 2014 resulted in abrupt losses of approximately 50% of the beach volume, illustrating the site's sensitivity to episodic storm events. These changes in beach volume align with the fluctuations in beach envelope extents discussed previously.

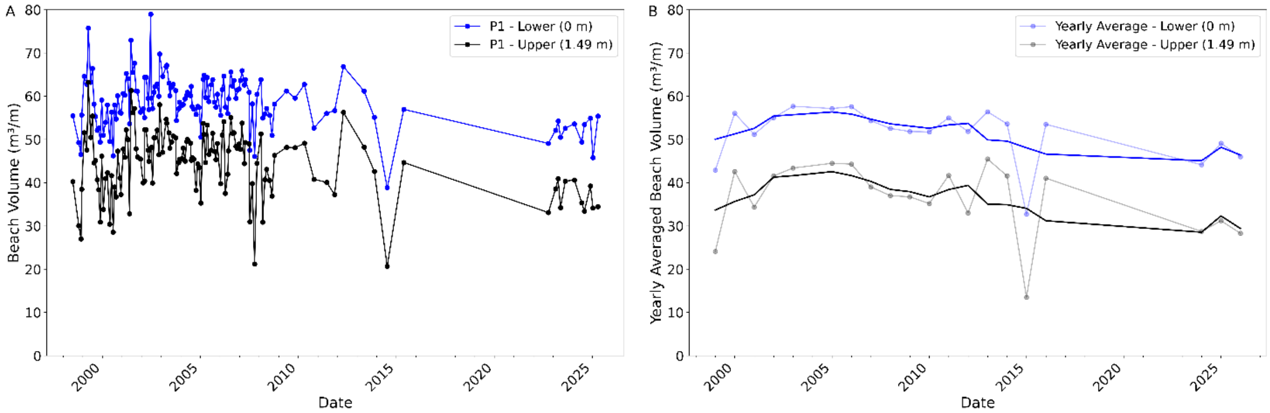

Figure 4.50: Beach volume changes at the lower (0 m (MSL)) and upper (1.49 m (MHWS)) contours. A) Beach volume timeseries at Profile 1, and B) beach-wide averaged volume timeseries.

4.3.4.3 Beach width

Consistent with observed changes in beach volume, beach-averaged width at Campbells Bay exhibits a long-term erosional trend, with rates of –0.1 m/yr and –0.2 m/yr at the lower and upper beach, respectively (Figure 4.51). Similar to erosional trends in beach volume at Campbells Bay, these trends are not statistically significant, however, the consistent negative slopes – particularly on the upper beach – may indicate an emerging erosional pattern (Table 4.2).

Since the last assessment (Boyle, 2016), short-term rates of change indicate accelerated erosion of the lower beach, with rates of -0.5 m/yr at Profile 1 and -0.6 m/yr at Profile 2 (Table 4.1). In contrast, the upper beach has accreted at rates of 0.4 m/yr and 0.3 m/yr at Profiles 1 and 2, respectively, resulting in a steepening beach profile (Table 4.1).

Notably, the 2014 storm event appears to have eroded sediment from the upper beach and deposited it on the lower beach, resulting in unusually low upper beach sand levels at the start of the short-term analysis period (Figure 4.51). This likely contributed to the high short-term accretion rates recorded at the upper beach.

Considerable intra-annual variability is recorded throughout the monitoring record with slightly larger fluctuations at Profile 2 with standard deviations of 4.1 m and 4.5 m for the lower and upper beach, respectively (Table 4.1).

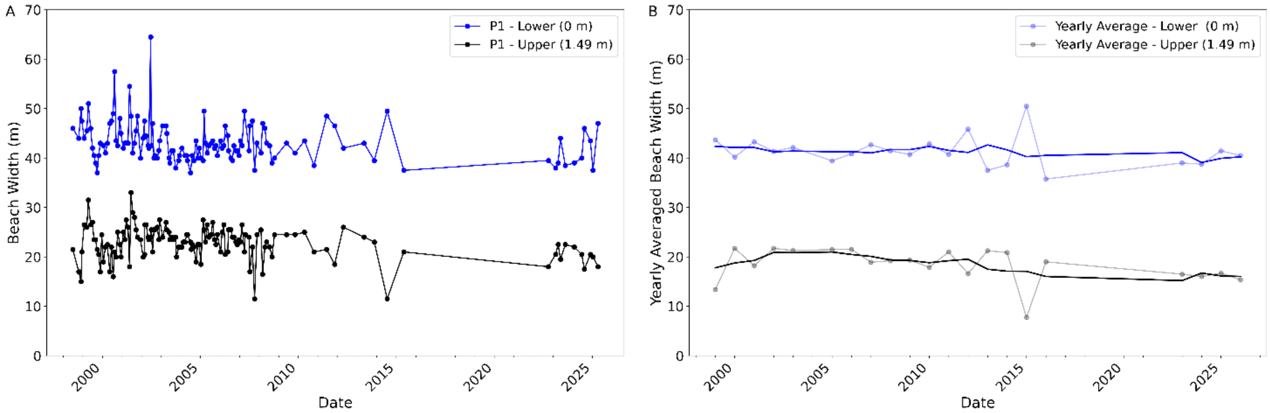

Figure 4.51: Beach width changes at the lower (0 m (MSL)) and upper (1.49 m (MHWS)) contours. A) Beach width timeseries at Profile 1, and B) beach-wide averaged width timeseries.

4.3.4.4 Beach rotation

The BOI at Campbells Bay indicates a long-term anticlockwise rotation of the beach driven by erosion of the northern end of the beach (Figure 4.52). However, the direction of beach rotation is not consistent throughout the monitoring period with frequent and rapid switches between clockwise and anticlockwise beach rotation recorded. Unlike other inner Gulf beaches, which typically exhibit rotational phases lasting 5-10 years, Campbells Bay is characterised by shorter rotational cycles, with directional shifts occurring approximately every 1-2 years.

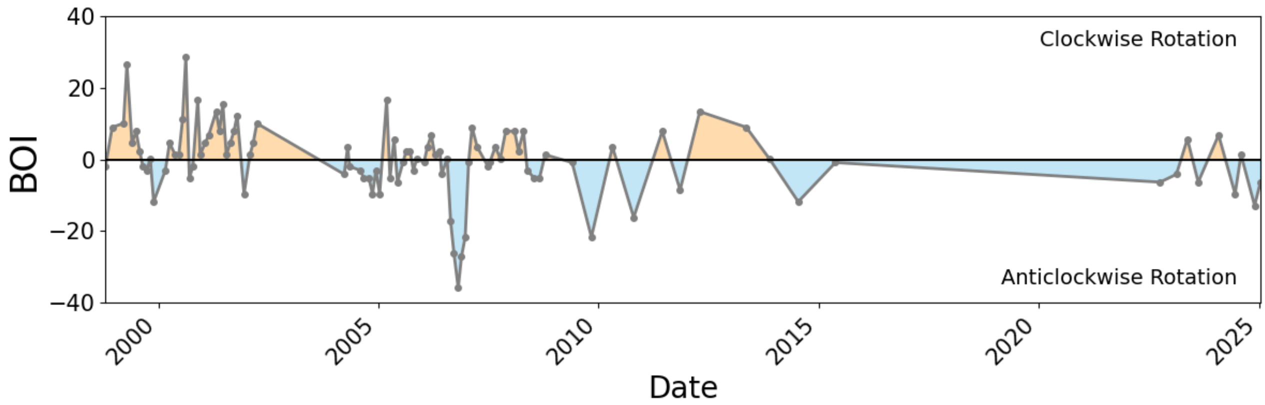

Figure 4.52: Beach oscillation index (BOI) at Campbells Bay indicating relative rotational behaviour of the beach (clockwise or anticlockwise) through time.

4.3.5 Milford Beach

Milford Beach is monitored with five beach profiles covering the northern (Profiles 1-2), central (Profile 3), and southern (Profiles 4-5) beach (Figure 4.53). The monitoring record begins in 1998 at all profiles and like other inner Gulf beaches has a break in the data between 2015 and 2022 due to a suspension of monitoring efforts.

Figure 4.53: The position of the beach profiles (P1-P5) at Milford Beach.

4.3.5.1 Beach envelope

Consistent with other inner Gulf beaches, Milford Beach is characterised by a relatively narrow beach envelope, with maximum horizontal and vertical excursions of 36 m and 2.3 m, respectively, across all profiles (Figure 4.54; Figure 4.55).

The current state of Milford Beach varies spatially, with the most recent profile (01/04/2025) occupying different positions within the beach envelope. At the southern end (Profiles 4-5), recent surveys lie below the long-term average profile at both the lower and upper beach. Notably, Profile 4 occupies only 8% of the beach envelope, positioning it at the lowest extent observed across the entire profile record and indicating currently low sand levels at this end of the beach (Figure 4.55). In contrast, the central and northern profiles (Profiles 1-3) have higher sand levels at the upper beach with recent profiles positioned closer to the long-term average, while the lower beach remains near the lower envelope limits. Specifically, Profiles 1, 2, and 3 currently occupy 20%, 50%, and 48% of the envelope, respectively (Figure 4.54).

Milford Beach also exhibits pronounced intra-annual fluctuations, with sand levels varying seasonally and sometimes reaching both high and low extremes within a single year. While variability has persisted throughout the monitoring record, more recent fluctuations at the southern profiles are notably constrained to the lower half of the beach envelope (Figure 4.55). Furthermore, since the last assessment (Boyle, 2016), the lower vertical limits of the beach envelope have expanded, particularly at the lower beach. This suggests that recent beach levels at Milford have dropped below previously recorded lows, highlighting increasing fluctuation severity and potential sediment deficits in this area (Figure 4.54; Figure 4.55).

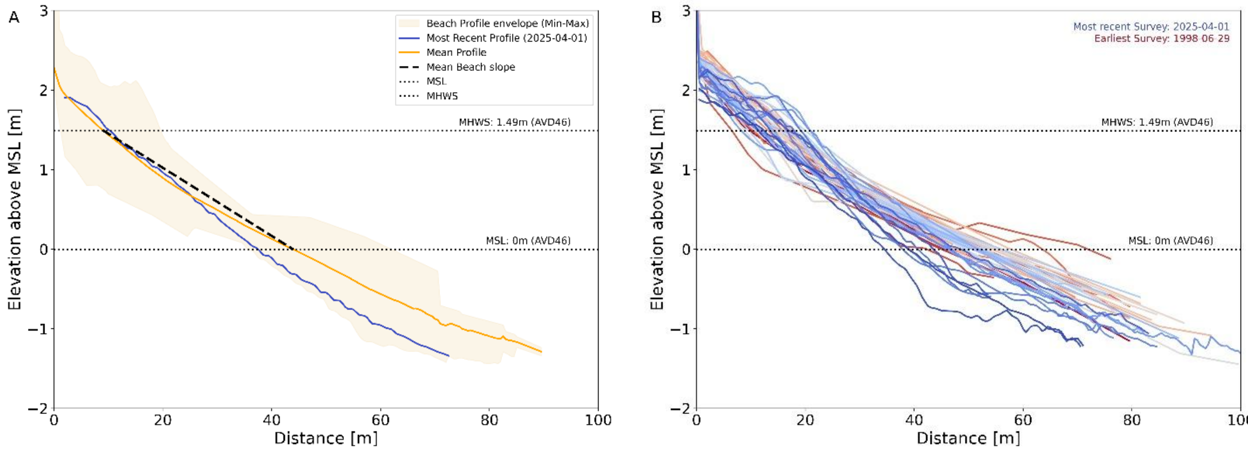

Figure 4.54: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Milford Beach.

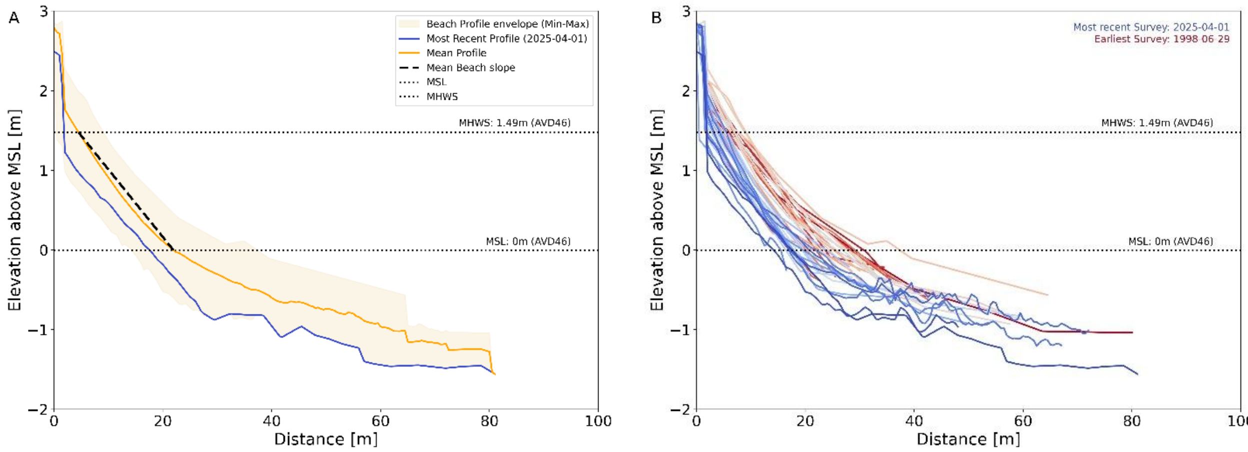

Figure 4.55: Beach envelope (A), and historic beach profile record (B) for Profile 4 at Milford Beach.

4.3.5.2 Beach volume

Beach-averaged volume at Milford beach shows a long-term trend of erosion in the lower beach (-0.2 $m^3/m/yr$). The upper beach exhibits long-term stability: however, this trend is not statistically significant (Table 4.2; Figure 4.56). Spatial variability is evident across the beach, with the northern end (Profiles 1-2) predominantly exhibiting long-term accretion or stability. Profile 2 demonstrates volume gains of 0.1 $m^3/m/yr$ at the lower beach and 0.3 $m^3/m/yr$ at the upper beach (Table 4.1). In contrast, the southern profiles (Profiles 3-5) have experienced long-term erosion with rates of up to -0.5 $m^3/m/yr$ (Table 4.1). These volumetric changes are consistent with the expansion of beach envelope limits discussed earlier and reflect increasing variability in beach profile positions.

Since the last assessment (Boyle, 2016), short-term records indicate a reversal in recent trends where the northern profiles exhibit recent loss of beach volume, while the southern profiles have experienced a period of growth (Table 4.1). However, as noted in Section 2.1.1, these short-term rates should be interpreted with caution due to gaps in beach profile records between 2015 and 2022, which limit the temporal resolution and reliability of trend detection during this period.

All profiles at Milford Beach experience considerable variability in beach volume, with several instances of upper beach volume declining by more than 50% during high-energy events or seasonal erosion cycles (Figure 4.56).

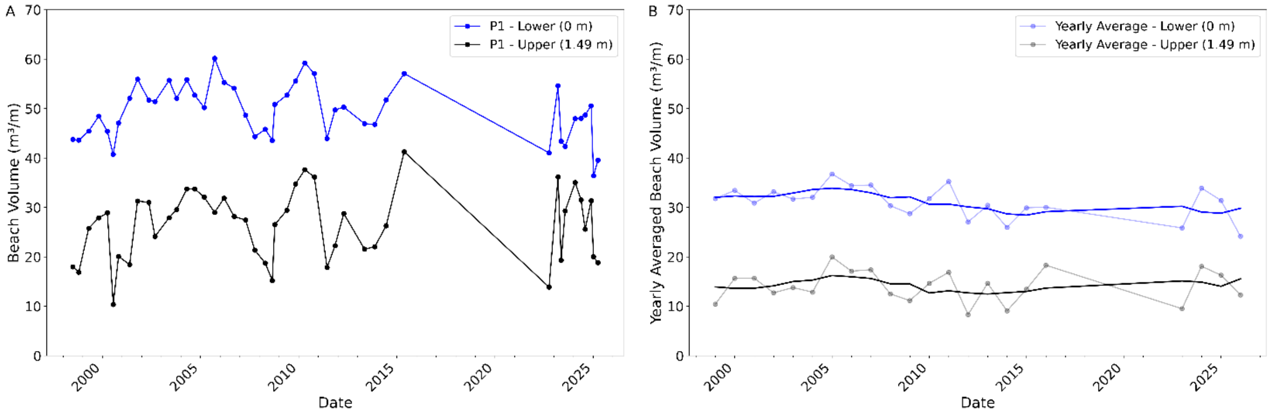

Figure 4.56: Beach volume changes at the lower (0 m (MSL)) and upper (1.49 m (MHWS)) contours. A) Beach volume timeseries at Profile 1, and B) beach-wide averaged volume timeseries.

4.3.5.3 Beach width

Consistent with changes in beach volume, beach-wide averaged width indicates a long-term trend of erosion at the lower beach (-0.4 m/yr) while the upper beach exhibits stability. However, it is important to note that the upper beach trend is not statistically significant (Table 4.2). More rapid erosion of the lower beach throughout the monitoring period has resulted in steepening of the beach profile (Figure 4.57). Long-term erosion of the lower beach is consistent across all five beach profiles with rates up to -0.5 m/yr, whereas the upper beach exhibits accretion or stability at the northern and central profiles and erosion at rates of -0.2 m/yr at the southern profiles (Table 4.1).

Recent trends in beach width mirror those in beach volume where short-term rates show a reversal in recent trends. Since the last assessment (Boyle, 2016), erosion rates at the northern profiles have accelerated, while many of the southern profiles have experienced recent accretion or stability (Table 4.1). Milford Beach experiences considerable Intra-annual fluctuations of beach width throughout the monitoring record with the most severe fluctuations recorded at the lower beach (Figure 4.57).

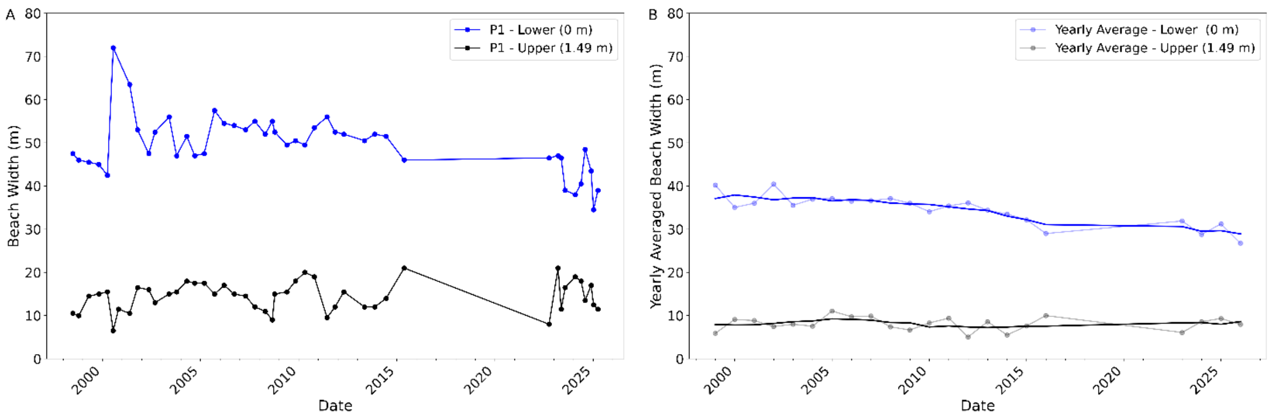

Figure 4.57: Beach width changes at the lower (0 m (MSL)) and upper (1.49 m (MHWS)) contours. A) Beach width timeseries at Profile 1, and B) beach-wide averaged width timeseries.

4.3.5.4 Beach rotation

The BOI at Milford Beach reveals relatively limited rotation of the beach compared to other inner Gulf Beaches. A notable exception is the 2001 event, during which substantial accretion of the northern beach drove pronounced clockwise beach rotation. For the majority of the monitoring period, beach rotation remains minimal, reflecting relatively uniform erosion across the lower beach. However, recent accelerated erosion of the northern end has resulted in a slight anticlockwise rotation of the beach (Table 4.1; Figure 4.58).

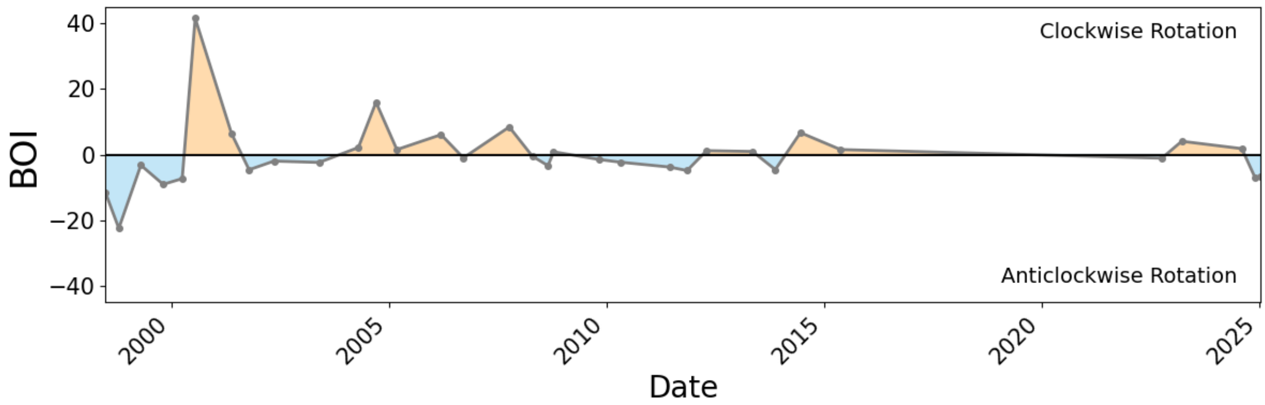

Figure 4.58: Beach oscillation index (BOI) at Milford Beach indicating relative rotational behaviour of the beach (clockwise or anticlockwise) through time.

4.3.6 Cheltenham Beach

Cheltenham Beach is the southernmost beach of the inner Gulf beaches located at the tip of the North Shore Peninsula. Cheltenham is monitored by three beach profiles located at the northern (Profile 1), central (Profile 2) and southern (Profile 3) ends of the beach (Figure 4.59). The monitoring record begins in 1998 for Profile 1 and 2000 for Profiles 2 and 3. Like other inner Gulf beaches, monitoring was suspended between 2015 and 2022.

Figure 4.59: The position of the beach profiles 1-3 at Cheltenham Beach.

4.3.6.1 Beach envelope

Like other inner Gulf beaches, Cheltenham Beach is characterised by a relatively small beach envelope. However, the beach envelope varies considerably alongshore, with a wider envelope observed at the northern end of the beach (Profile 1), with horizontal and vertical fluctuations reaching 31 m and 2.1 m, respectively (Figure 4.60). In contrast, the southern end (Profile 3) exhibits a much narrower envelope, with horizontal and vertical fluctuations of only 12 m and 1.3 m, respectively (Figure 4.61). The historical profile record at Profile 1 clearly shows long-term accretion of the beach profile where the position of the beach profile has progressively moved upward and seaward throughout the monitoring record (Figure 4.60). In contrast, Profiles 2 and 3 show considerable intra-annual variability, with no clear long-term erosion or accretion of the beach profile (Figure 4.61).

Current sand levels at Cheltenham Beach also differ significantly alongshore with the most recent survey (01/04/2025) at Profile 1 reaching 92% of the maximum beach envelope, indicating high sand levels at the northern end of the beach. Since the last assessment (Boyle, 2016), the maximum limits of the beach envelope at this profile have expanded, suggesting that northern Cheltenham Beach has recently experienced higher sand levels than previously recorded. However, sand levels decrease moving southward along the beach, with the most recent profiles at Profiles 2 and 3 reaching 70% and 54% of the maximum envelope extent, respectively (Figure 4.60; Figure 4.61). At the central profile (Profile 2), the most recent survey lies close to the average profile across the entire cross-section. Like Profile 1, sand levels at this location have increased since 2014, when they were at the lowest recorded extent (Boyle, 2016). In contrast, the southern end of the beach (Profile 3) shows comparatively low sand levels, with the most recent profile lying near the lower limits of the beach envelope on the beach face. Notably, since 2014, while sand levels on the beach face have decreased at Profile 3, the beach envelope below mean sea level has expanded, indicating increased sand storage below the intertidal zone (Figure 4.61).

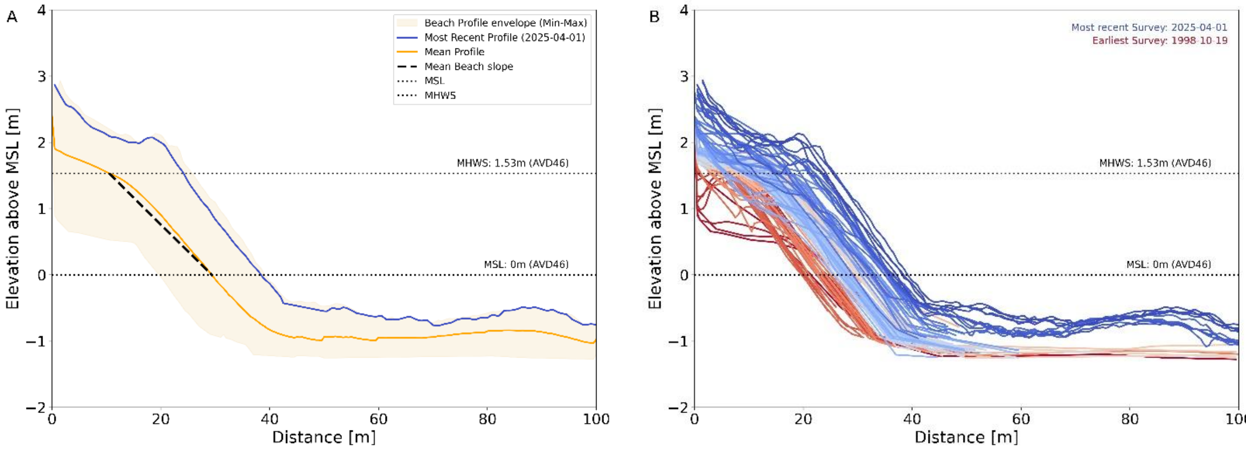

Figure 4.60: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Cheltenham Beach.

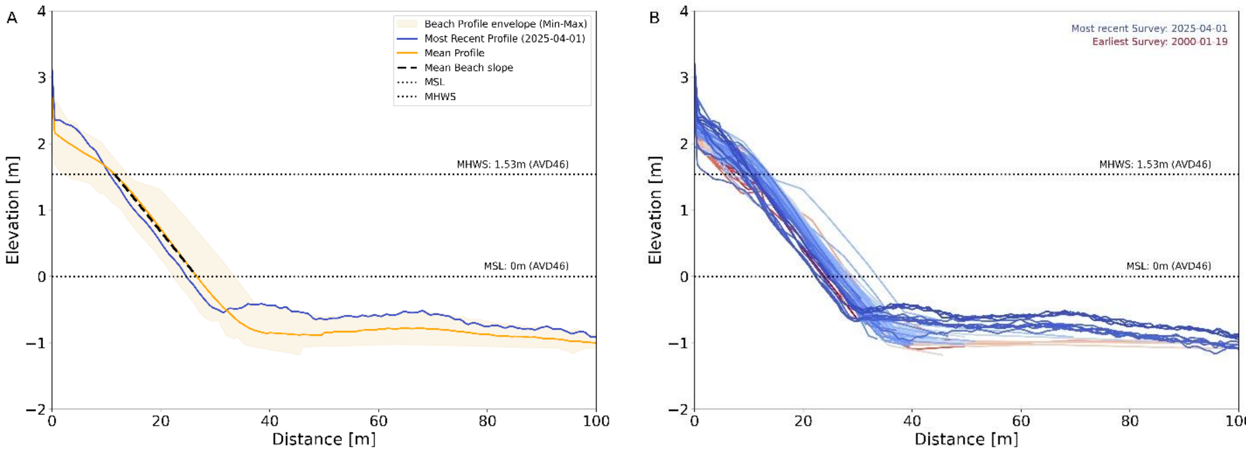

Figure 4.61: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Cheltenham Beach.

4.3.6.2 Beach volume

Beach-wide average volume at Cheltenham Beach shows a long-term trend of accretion, with rates of 0.3 m^3/m/yr at both the lower and upper beach (Figure 4.62). However, substantial intra-beach variability is present. At the northern end (Profile 1), the beach has experienced significant long-term growth, with accretion rates of 1.2 m^3/m/yr and 1.3 m^3/m/yr at the lower and upper beach, respectively. In contrast, the central and southern profiles (Profiles 2-3) have undergone long-term erosion (Table 4.1). These changes in beach volume align with the fluctuations in beach envelope extents discussed above.

Since the last assessment (Boyle, 2016), accretion rates at Profile 1 have slowed, while Profile 2 exhibits a reversal in trend, with recent short-term accretion rates of 0.9 m^3/m/yr at the lower beach, and 1.0 m^3/m/yr at the upper beach (Table 4.1). Conversely, Profile 3 has shown an acceleration in erosion, with short-term rates reaching -0.5 m^3/m/yr at both the lower and upper beach (Table 4.1).

Cheltenham Beach exhibits intra-annual variability at all profiles throughout the monitoring record (Figure 4.62). Notably, Profile 1 demonstrates a decadal-scale cyclical pattern in beach volume, a trend that is not observed at Profiles 2 or 3 (Figure 4.62). Future reporting will explore this in detail.

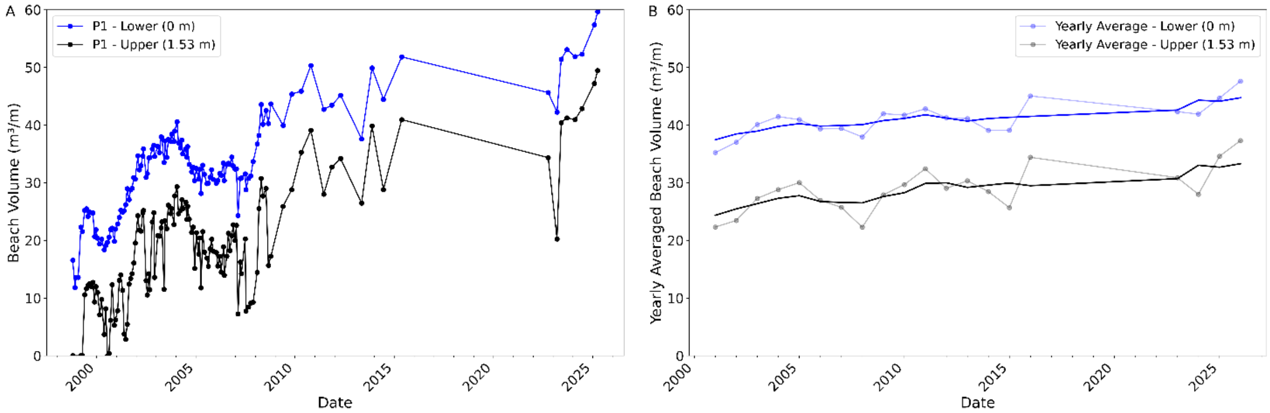

Figure 4.62: Beach volume changes at the lower (0 m (MSL)) and upper (1.53 m (MHWS)) contours. A) Beach volume timeseries at Profile 1, and B) beach-wide averaged volume timeseries.

4.3.6.3 Beach width

Like beach volume, beach-averaged width at Cheltenham Beach shows a long-term trend of accretion at a rate of 0.1 m/yr at the lower and upper beach (Figure 4.63). However, there is considerable intra-beach variability where only Profile 1 shows a long-term trend of accretion at 0.5 m/yr at the lower and 0.6 m/yr at the upper beach. Conversely, Profile 2 exhibits long-term stability and Profile 3 exhibits erosion at rates of up to -0.1 m/yr across the beach profile (Table 4.1). This variability may be influenced by alongshore sediment transport, where erosion at the southern end of the beach supplies sediment to the northern end, resulting in accretion.

Recent trends in beach width similarly match those of beach volume where accretion rates slow in the north of the beach (Profile 1) to 0.1 m/yr and 0.3 m/yr at the at the lower and upper beach, respectively. In the central beach (Profile 2), the trend switches from stability to accretion, while erosion rates accelerate to -0.2 m/yr in the south (Profile 3) (Table 4.1). Like other inner Gulf beaches beach monitoring was paused between 2015 and 2022, limiting the data available to calculate short-term rates of change.

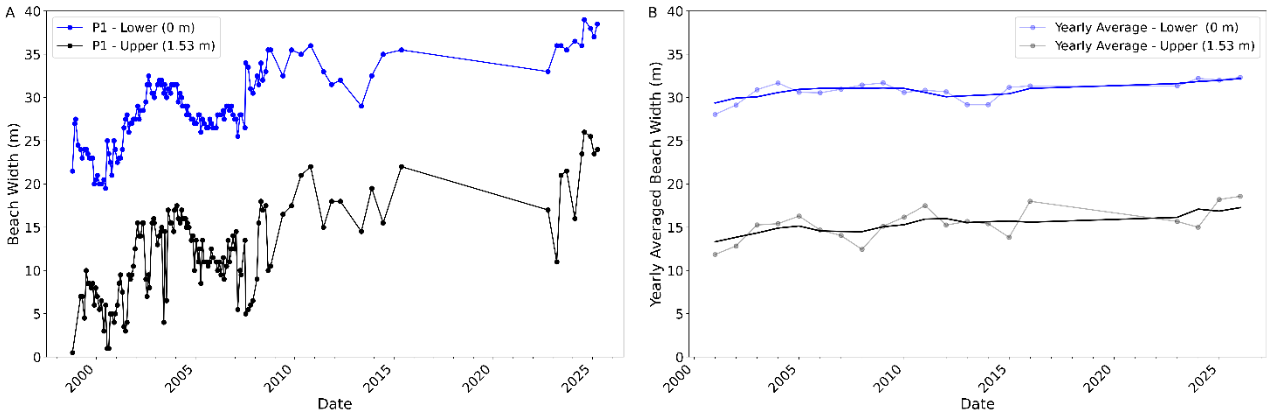

Figure 4.63: Beach width changes at the lower (0 m (MSL)) and upper (1.53 m (MHWS)) contours. A) Beach width timeseries at Profile 1, and B) beach-wide averaged width timeseries.

4.3.6.4 Beach rotation

The BOI at Cheltenham Beach indicates a long-term clockwise rotation at the beach driven by substantial accretion of the northern beach and erosion of the southern beach (Table 4.1; Figure 4.64). However anticlockwise beach rotation is evident at the start of the monitoring record (between 1998 and 2007) driven by erosion of the northern beach while the rest of the beach remained stable. Unlike other inner Gulf beaches, Cheltenham exhibits a cyclical pattern of beach rotation only during the initial phase of monitoring. Since 2008, clockwise rotation has remained consistent and has progressively increased, indicating an intensifying rotational trend at the beach (Figure 4.64).

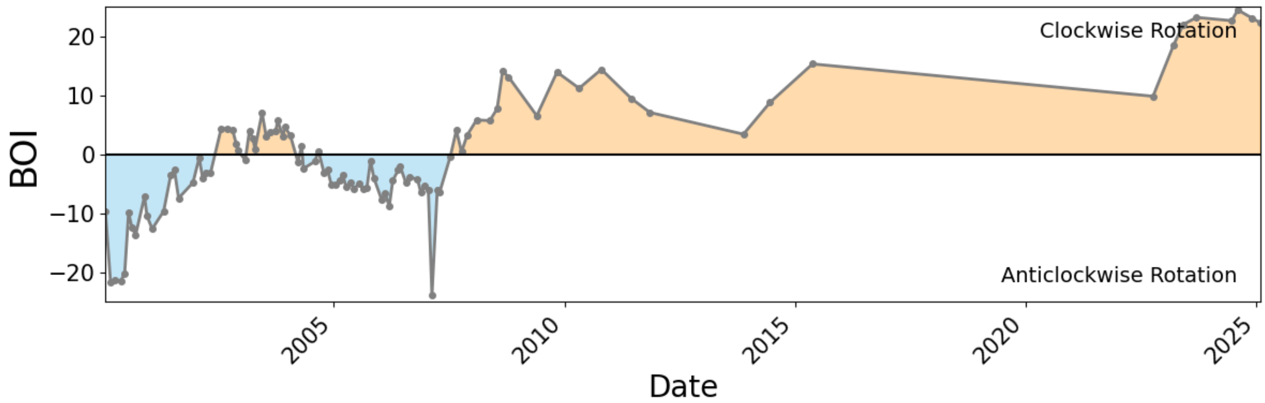

Figure 4.64: Beach oscillation index (BOI) at Cheltenham Beach indicating relative rotational behaviour of the beach (clockwise or anticlockwise) through time.

4.3.7 Discussion

The inner Hauraki Gulf beaches are characterised by high intra-annual variability, with all monitored sites exhibiting event and seasonal-scale fluctuations in beach profile position, volume, and width. Despite their relatively sheltered settings, this variability reflects the sensitivity of these beaches to seasonal and storm-driven processes. In contrast to the west coast and open east coast beaches, most inner Gulf beaches lack natural dune systems and are instead backed by hard coastal infrastructure such as seawalls and roads. This constrains sediment storage capacity, and the ability of the beach to migrate landward in response to high-energy events. Instead, relatively high energy waves strip sediment from the beach face substantially lowering the beach multiple times a year. In most cases, the lowered beach state recovers quickly as calmer conditions following the high-energy event e.g. lower-energy, longer-period waves, gradually transport sediment back onto the beach (Phillips et al., 2015; Dodet et al., 2019).

In recent years, the magnitude of fluctuations appears to have increased at many inner Gulf beaches. Since the last assessment (Boyle, 2016), the lower vertical limits of the beach envelope have been exceeded at many sites, indicating that recent beach elevations have dropped below historically recorded lows. This may reflect a sediment deficit, where limited sediment availability means that high-energy events more readily erode the beach, expanding the lower bounds of the envelope. Alternatively, or in combination, it may reflect a change in the frequency or severity of recent high-energy events. Hindcast wave analysis suggests that 2023 was one of the stormiest years on record, although significant wave height was not exceptional, the duration of storm events was the highest on record, see Case Study (Section 6).

While these beaches share similar environmental settings, they exhibit substantial inter- and intra-beach variability in coastal change trends. Long Bay and Campbells Bay have experienced progressive erosion throughout their respective monitoring records, whereas Takapuna and Cheltenham beaches have shown long-term accretion. In addition to this variability in long-term trends, decadal-scale cyclical patterns are evident at Long Bay, Takapuna, and the northern end of Cheltenham Beach. It is possible that sediment oscillations may also be influenced by larger-scale climate drivers, such as the El Niño–Southern Oscillation, the Interdecadal Pacific Oscillation or the Southern Annular Mode (Gorman, 2003; Godoi et al., 2016). These patterns will be explored in more detail in future Coastal Programme reporting.

It is important to note that monitoring at Browns Bay, Campbells Bay, Milford Beach, and Cheltenham Beach was suspended between 2015 and 2022, following earlier assessments that beach change at these four beaches was very similar and each exhibited overall long-term stability (Kench, 2008; Boyle, 2016). However, these beaches were reinstated in the monitoring programme from 2022 due to growing interest in regional sediment dynamics and beach-specific coastal management. As a result, short-term trends for these sites should be interpreted with caution, as they reflect only the period since 2022, rather than the full post-2014 record. Limited data availability across this interval may skew short-term rate calculations and obscure underlying trends.

4.4 Group 4 – Tāmaki Strait

Maraetai Beach and Kawakawa Bay, located along the Tāmaki Strait, are exposed to the lowest wave energy conditions in the Auckland region, with an average wave height of 0.2 m (Figure 4.65). Sheltered by Waiheke Island, Ponui Island, and the Coromandel Peninsula, these beaches are largely protected from long-period wave energy originating from the north and east. However, both beaches are still exposed to short-period waves from northwest to northeast and notable effects are observed at these beaches during storm conditions. While the average wave height remains relatively stable throughout the year, the 99th percentile wave height peaks at 0.7 m during winter months (Figure 4.65).

Maraetai Beach is a small, steep, embayed beach bounded by a rocky headland to the west and Maraetai Point to the east. The central portion of the beach is backed by Auckland Transport's seawall that protects the road, whereas the western and eastern margins of the beach are backed by coastal reserve and road.

Kawakawa Beach, enclosed by Pawhetau Point to the west and Raukura Point to the east, is the most protected beach considered within this report, sheltered from longer period northerly swells by Waiheke Island and Ponui Island. It is tidally dominated and characterised by intertidal flat sediments including shellfish remains, muds, and silts (Boyle, 2014). Kawakawa beach is backed by a narrow reserve and a road that runs parallel along the backshore in front of two residential developments. Both Maraetai Beach and Kawakawa Bay have undergone multiple historical sand transfer efforts to redistribute sediment within the beach system.

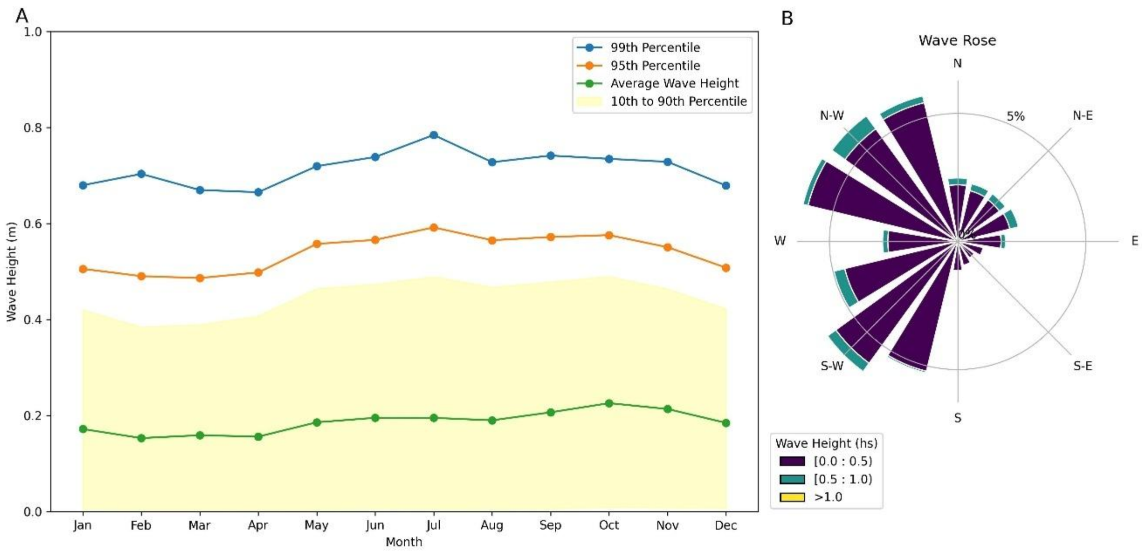

Figure 4.65: Wave summary statistics for the Tāmaki Strait, Auckland (Oceanum, 2025). A) wave height and B) wave rose.

4.4.1 Maraetai Beach

Four beach profiles are used to monitor the beach at Maraetai, evenly spaced across the beach with Profile 1 at the eastern and Profile 4 at the western end of the beach (Figure 4.66). The monitoring record starts in 1998 at all beach profiles. Dune restoration works were undertaken in 2011 and 2014 in front of the carpark, in between Profile 3 and Profile 4. Furthermore, intermittent operational transfer of sand has taken place along the beach following a storm event in 2007 that damaged the seawall and eroded the beach.

Figure 4.66: The position of the beach profiles (P1-P4) at Maraetai Beach.

4.4.1.1 Beach envelope

Maraetai Beach is a steep reflective beach with low wave energy at the shoreline and a narrow beach envelope exhibiting maximum horizontal and vertical fluctuations of 2.5 m and 1.9 m across all profiles (Figure 4.67; Figure 4.68). The most recent profile (12/05/2025) at profiles 1-3 lies close to the average profile and occupies 49%, 44% and 59% of the beach envelope, respectively, suggesting current sand levels are relatively good across the beach (Figure 4.67). However, like the inner Gulf beaches, Maraetai exhibits considerable inter-annual variability in response to seasonal and storm driven wave conditions and recent fluctuations at Profiles 1-3 have been constricted to the lower half of the beach envelope suggesting sand levels have reduced throughout the monitoring period (Figure 4.67). In contrast, the most recent survey at Profile 4 is at the upper limits of the beach envelope and occupies 99% of the envelope (Figure 4.68).

Since the last assessment (Boyle, 2016), the beach envelope at Profile 4 has expanded considerably with the upper limits of the envelope increasing by over 1 m since 2014 (Boyle, 2016). Conversely the lower limits of the beach envelope at Profiles 1-3 have expanded since 2014, indicating that recent sand levels at the western end of Maraetai have dropped below previously recorded lows highlighting the sediment deficit in the area (Figure 4.67).

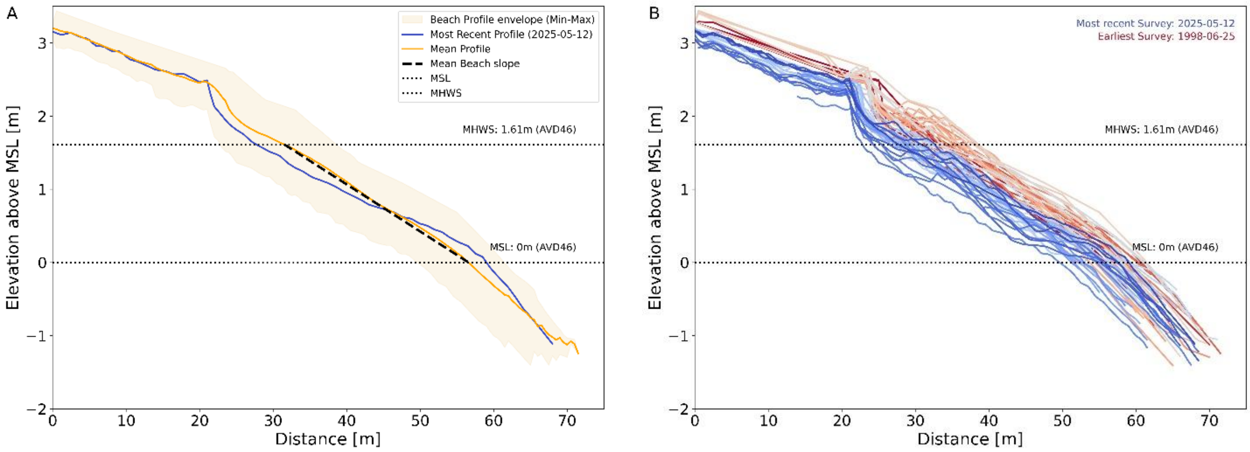

Figure 4.67: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Maraetai Beach.

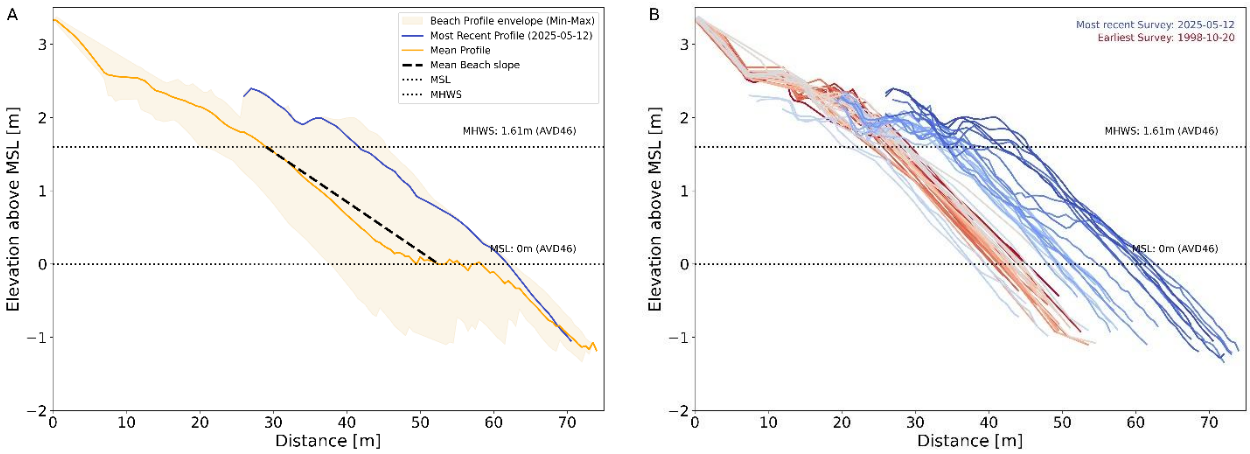

Figure 4.68: Beach envelope (A), and historic beach profile record (B) for Profile 4 at Maraetai Beach.

4.4.1.2 Beach volume

Beach-wide averaged volume at Maraetai Beach indicates a long-term trend of erosion, with rates of approximately -0.2 $m^3/m/yr$ at the lower and -0.3 $m^3/m/yr$ at the upper beach (Figure 4.69). However, considerable intra-beach variability is evident. The western end of the beach (Profiles 1-3) exhibits long-term erosion, with Profiles 1 and 3 experiencing rates of up to -0.8 $m^3/m/yr$. In contrast, Profile 4, located at the eastern extent of the beach, shows rapid accretion, with long-term rates of 0.9 $m^3/m/yr$ at both the lower and upper beach (Table 4.1). These patterns suggest that Maraetai Beach is influenced by a strong eastward longshore sediment transport, driven by prevailing wave and current conditions.

Since the last assessment (Boyle, 2016), accretion at Profile 4 has accelerated significantly, with recent rates reaching 3.5 $m^3/m/yr$ at the lower beach and 2.9 $m^3/m/yr$ at the upper beach (Table 4.1). In contrast, rates of erosion at the western profiles have remained relatively unchanged at Profile 1, while Profiles 2 and 3 have experienced a slowing of erosion (Table 4.1). Notably, the near tripling of accretion rates at Profile 4 suggests that the sediment contributing to growth at the eastern end of Maraetai may be originating from additional sources or could be partly attributed to recent dune restoration activities in the area (Boyle, 2014). Maraetai Beach also experiences large fluctuations in beach volume throughout the monitoring record indicating that beach change is sensitive to event and seasonal-scale changes in wave and water level conditions (Figure 4.69).

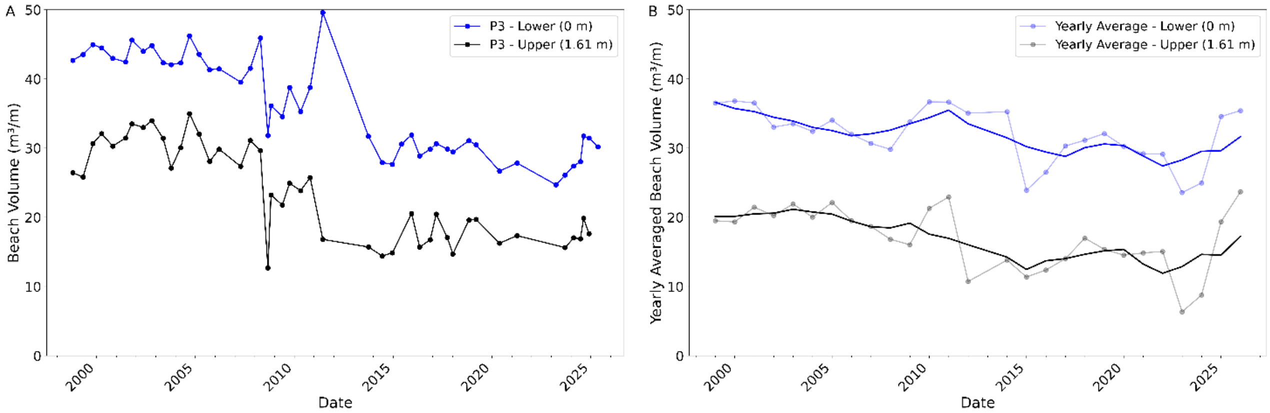

Figure 4.69: Beach volume changes at the lower (0 m (MSL)) and upper (1.61 m (MHWS)) contours. A) Beach volume timeseries at Profile 3, and B) beach-wide averaged volume timeseries.

4.4.1.3 Beach width

Maraetai Beach exhibits beach-wide averaged erosion of the lower beach, with rates of -0.1 m/yr, and stability at the upper beach, leading to overall retreat and flattening of the beach profile (Table 4.1). While these trends are not statistically significant, they may indicate an emerging erosional pattern at the lower beach that could become more evident with continued monitoring (Table 4.2).

These trends are consistent across the western profiles (Profiles 1-3), which exhibit long-term erosion rates of up to -0.4 m/yr at the lower beach and -0.5 m/yr at the upper beach. In contrast, Profile 4 at the eastern end shows long-term accretion, with rates of 0.6 m/yr and 0.5 m/yr at the lower and upper beach, respectively (Table 4.1).

Short-term trends in beach width also reflect those of beach volume, with rates of erosion at the western profiles predominantly remaining stable at the lower beach but slowing at the upper beach leading to recent steepening of the beach profile. In contrast, accretion at Profile 4 has accelerated substantially (Table 4.1). These consistent spatial patterns in both volume and width further support the influence of eastward sediment transport along the beach.

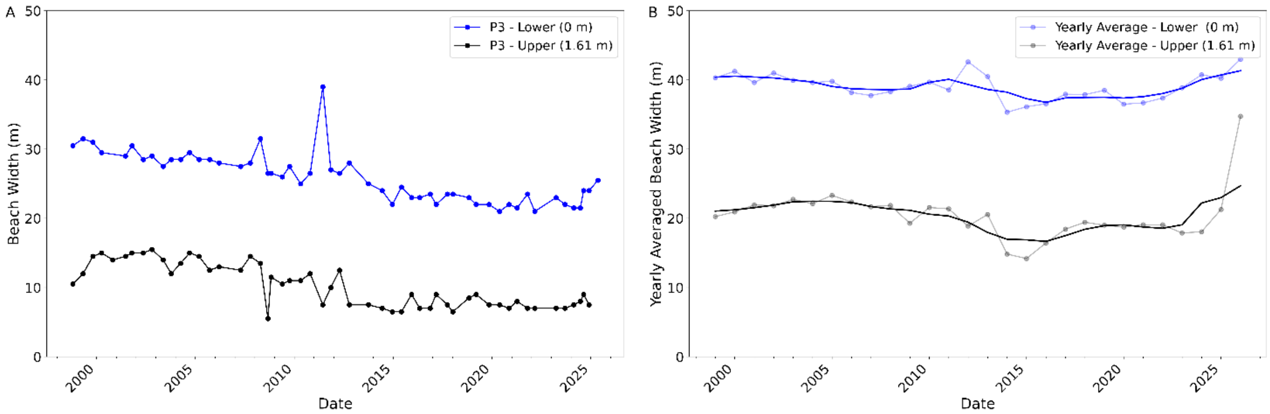

Figure 4.70: Beach width changes at the lower (0 m (MSL)) and upper (1.61 m (MHWS)) contours. A) Beach width timeseries at Profile 3, and B) beach-wide averaged width timeseries.

4.4.2 Kawakawa Bay

Kawakawa Bay is the southernmost Auckland beach located in the north of the Tāmaki Strait, just north of the Auckland-Waikato border. Four beach profiles are used to monitor Kawakawa Bay, which consists of two small bays separated by Whitford Point. Profile 1 and 2 cover the western bay and Profile 3 and 4 cover the east (Figure 4.71). The monitoring record begins in 1998 at all four beach profiles (Table 2. 1). Furthermore, it is important to note that both sand transfer and stream recutting efforts have been undertaken at Kawakawa Bay to redistribute sediment accumulating at stream mouths.

Figure 4.71: The position of the beach profiles (P1-P4) at Kawakawa Bay.

4.4.2.1 Beach envelope

Exposed to low wave energy and tidally dominated, Kawakawa Bay exhibits a narrow beach envelope, particularly at the upper beach, where maximum horizontal and vertical fluctuations reach approximately 40 m and 0.5 m, respectively. The beach envelope is widest at the lower beach across all profiles, with Profiles 2 and 4 showing particularly broad envelopes around mean sea level (MSL), suggesting sediment accumulates in the lower profile before being redistributed across the beach face (Figure 4.72; Figure 4.73). The most recent profile (12/05/2025) lies above the long-term average at all beach profiles, occupying 68%, 80%, 76% and 69% of the beach envelope at Profiles 1-4, respectively, suggesting a good amount of sediment currently on the beach.

Profiles 2 and 4, which exhibit the widest beach envelopes, also show clear accretion trends throughout the monitoring record, with the most recent profiles located further seaward than historical profiles (Figure 4.73). It is important to note that Profile 2 and 4 are situated close to stream outlets that likely encourage the deposition and offshore transport of alongshore-transported sediment. In contrast, Profiles 1 and 3 show considerable intra-annual fluctuations within their narrower beach envelopes, frequently approaching both the upper and lower limits within a single year, with no discernible long-term trend in accretion or erosion (Figure 4.72).

Since the last assessment (Boyle, 2016) the lower limits of the beach envelope at Kawakawa Bay have been extended at all profiles with recent beach levels falling below previously recorded lows. Notably, the lowest beach levels at all profiles were recorded in 2023, coinciding with the impacts of Cyclone Gabrielle and Cyclone Lola.

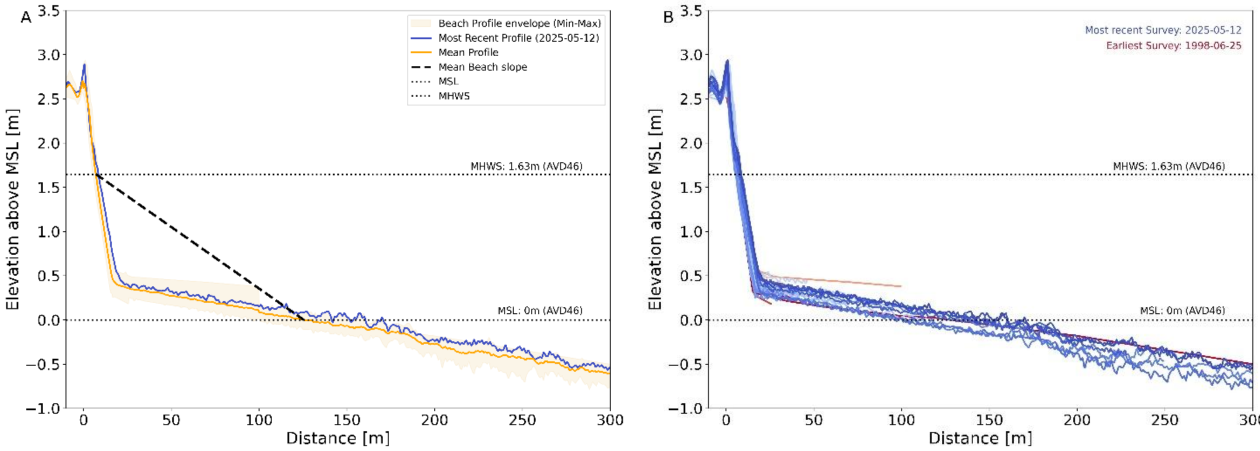

Figure 4.72: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Kawakawa Bay.

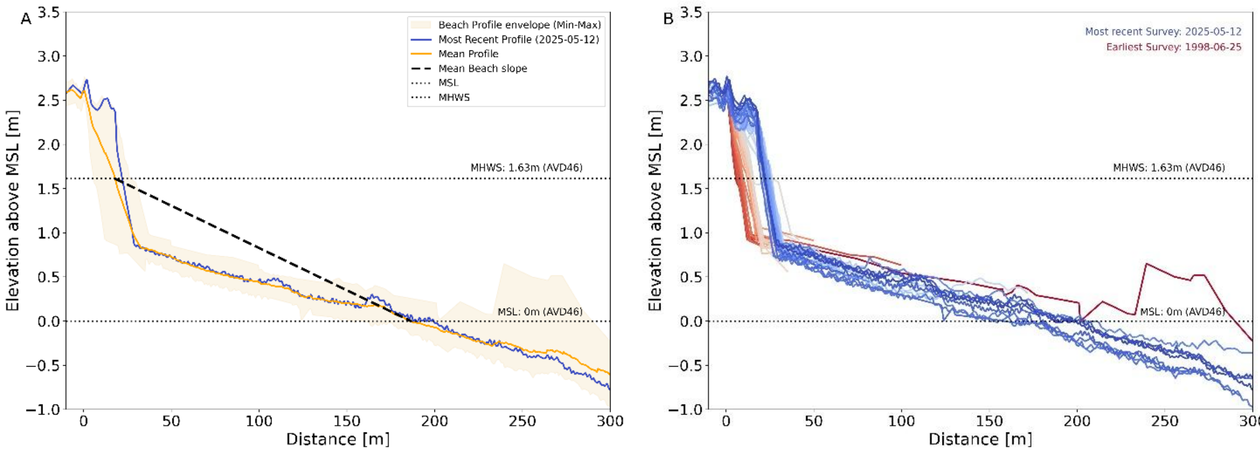

Figure 4.73: Beach envelope (A), and historic beach profile record (B) for Profile 4 at Kawakawa Bay.

4.4.2.2 Beach volume

Beach-wide averaged volume at Kawakawa Bay indicates a long-term trend of accretion at a rate of 1.1 m^3/m/yr at the lower beach, and 0.6 m^3/m/yr, at the upper beach (Figure 4.74). However, considerable intra-beach variability exists. Profile 1 shows long-term stability across the profile, while Profile 2 exhibits long-term accretion at rates of 1.1 m^3/m/yr at the lower beach and 0.4 m^3/m/yr at the upper beach (Table 4.1). On the eastern side of Kawakawa Bay, Profiles 3 and 4 both show volume loss at the lower beach, yet growth at the upper beach, suggesting sediment is being transported from the intertidal zone to the upper beach (Table 4.1).

Short-term trends at Kawakawa Bay are difficult to interpret, as no consistent pattern emerges across the beach. Short-term changes in beach volume are highly variable both within and between profiles, with profiles exhibiting differing responses in the upper and lower beach zones (Table 4.1). At the western end of Kawakawa Bay, short-term rates suggest a period of erosion at Profiles 1 and 2, however this is limited to the upper beach at Profile 1 and the lower beach at Profile 2. At the eastern end, short-term rates suggest a recent period of accretion at Profile 3, with accelerated gains at the upper beach and stability at the lower beach. In contrast, Profile 4 exhibits erosion across the beach profile (Table 4.1). This spatial variability likely reflects the complex interplay of localised processes such as tidal processes, alongshore sediment transport and beach management efforts, rather than a coherent beach-wide trend.

Although Kawakawa Bay is tidally dominated and one of the most sheltered beaches in the Auckland region, considerable short-term fluctuations in beach volume are observed across all four profiles, likely in response to seasonal and storm-related changes in wave conditions (Figure 4.74).

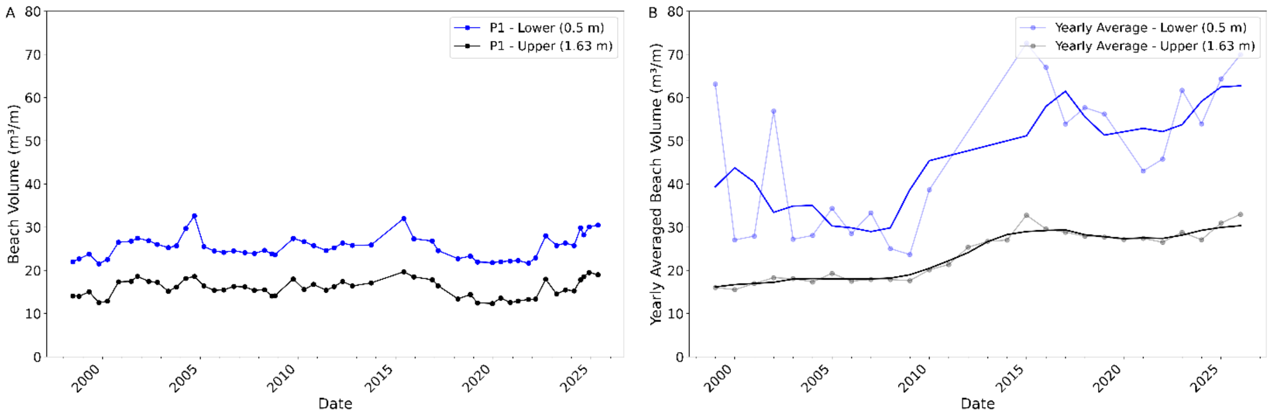

Figure 4.74: Beach volume changes at the lower (0.5 m (MSL)) and upper (1.63 m (MHWS)) contours. A) Beach volume timeseries at Profile 1, and B) beach-wide averaged volume timeseries.

4.4.2.3 Beach width

Beach-wide averaged width at Kawakawa Bay indicates a long-term trend of accretion at rates of 0.8 m/yr at the lower beach and 0.3 m/yr at the upper beach (Figure 4.75). Intra-beach variability of long-term trends mirrors patterns observed in beach volume where Profile 1 exhibits long-term stability, Profile 2 exhibits accretion and Profiles 3 and 4 experience sediment loss at the lower beach but growth of the upper beach (Table 4.1). As a result, beach state varies either side of Whitford Point with long-term flattening at Profile 1 and 2 and steepening at Profile 3 and 4 (Table 4.1). Short-term trends further emphasize the variability in beach change along Kawakawa Bay, with changes in beach width since the last assessment (Boyle, 2016), varying both between and within profiles (Table 4.1).

Consistent with trends in beach volume, beach width is widest closest to the two stream outlets at Kawakawa Bay. Profile 4 situated 100 m west of the Rautawa stream outlet, has an average beach width of 72.3 m and 17.0 m at the lower and upper beach, respectively. In contrast, Profile 1 situated 500 m from the stream outlet, has an average beach width of 16.3 m and 7.1 m at the lower and upper beach, respectively.

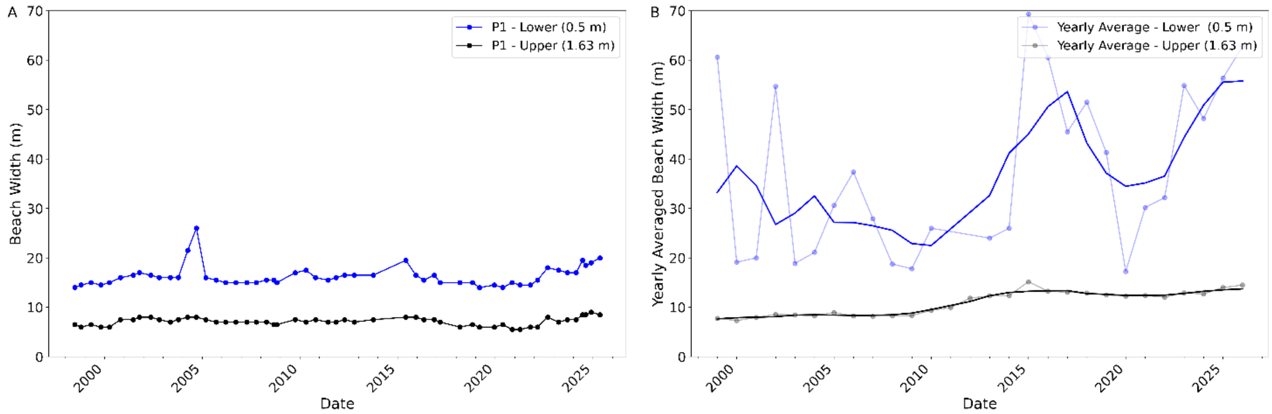

Figure 4.75: Beach width changes at the lower (0.5 m (MSL)) and upper (1.63 m (MHWS)) contours. A) Beach width timeseries at Profile 1, and B) beach-wide averaged width timeseries.

4.4.3 Discussion

Maraetai Beach has undergone considerable morphological change throughout the monitoring period, likely driven by a combination of alongshore sediment transport processes and coastal management interventions (Boyle, 2016). Long-term erosion has affected much of the beach, prompting the construction of a seawall in 2010 to prevent landward shoreline migration into the adjacent road and car park. In addition, sand renourishment or sand transfer efforts were carried out in 2007, 2011, 2014, 2018, and 2023 (Boyle, 2016). Despite these interventions, erosion at the western end of the beach has continued at an increasing rate, with sediment transported eastward, substantially increasing beach width and volume at the eastern end of the beach.

At Kawakawa Bay, beach change appears to be primarily influenced by alongshore sediment transport and sediment accumulation at stream and stormwater outlets along the shore. The most significant increases in beach width and volume are observed near these outlets, particularly at Profile 4, which has experienced sustained accretion at the upper beach throughout the monitoring period. Stream and stormwater outlets influence the pattern of cross-shore sediment transport where high flows can cut channels through the beach profile, move sediment offshore, and intercept sediment that would otherwise be transported further alongshore. At Kawakawa Bay these processes have created fans of shell and sand that extend offshore from the stream mouths and stormwater outlets. In contrast, Profile 1, located at the easternmost end of the beach, has remained relatively stable, with no clear trend of accretion or erosion. With one of the shortest monitoring records in the region, continued observation at Maraetai Beach and Kawakawa Bay is necessary to further investigate the factors influencing their coastal evolution.

Interestingly, beach-averaged width and volume at the lower beach at Kawakawa Bay show a subtle oscillatory signal over the monitoring record, with alternating phases of beach narrowing and widening on decadal scales. Peaks in beach width and volume were recorded in the early 2000s and around 2017, with current trends suggesting that Kawakawa Bay may be approaching another peak (Figure 4.75). These patterns may reflect broader climatic influences, such as the El Niño–Southern Oscillation or the Interdecadal Pacific Oscillation (Gorman, 2003; Godoi et al., 2016). However, this decadal-scale variability is not consistent across all profiles, suggesting localised controls may be driving the signal or masking the signal at some profiles. Continued monitoring is required to extend datasets and better understand the potential influence of these large-scale climate drivers on beach change at Kawakawa Bay.

5 Work in progress

This section provides a brief overview of the coastal monitoring projects that are currently in development and therefore not mentioned in the main report. It aims to provide Aucklanders with a broader understanding of the whole programme and an indication of the type of data that we will make available in the future.

5.1 Auckland bathymetry data

Auckland's CPM Programme commissioned a nearshore bathymetry survey of Auckland's east coast in mid-2024. While the programme routinely collects topographic survey data from the upper beach to just below mean sea level (MSL), these surveys capture only a small portion of the active beach profile – the zone where sediment is moved cross-shore by waves and currents. Sediment movement below MSL (which we can't see or currently measure) represents a significant gap in our understanding of long-term changes in sediment storage and distribution.

Knowledge of sediment below the waterline is crucial for predicting how beaches will respond to storm events. For example, a beach with an offshore sediment deposit may be more resilient to high-energy events, as waves can move this sediment onto the shore. In contrast, a lack of a sediment reserve offshore may hinder post-storm recovery. Nearshore bathymetry data also informs our understanding of alongshore sediment transport and connectivity between beaches.

Understanding these nearshore sediment dynamics is essential for managing coastline resilience. Figure 5.1 shows the locations along Auckland's east coast where bathymetry data has been collected, alongside an example of the data available. This dataset will serve as a benchmark for future comparisons, allowing us to track changes over time.

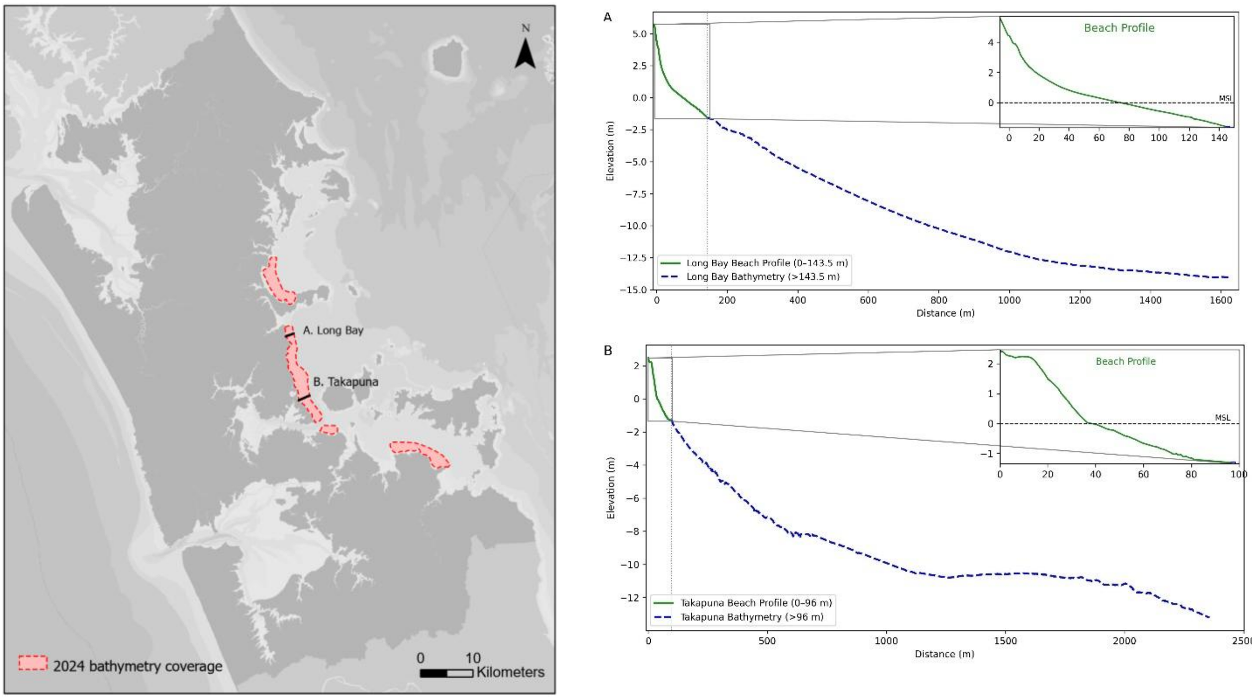

Figure 5. 1: Locations of 2024 nearshore bathymetry survey and A) Long Bay and B) Takapuna example of data availability.

5.2 Drone programme

In late 2024, the CPM Programme acquired a drone and launched a pilot programme to assess the feasibility of incorporating drone-based surveys into long-term beach monitoring, as well as storm response and recovery assessments. Two pilot sites were selected for initial testing: Te Henga (west coast) and Stanmore Bay (east coast).

Throughout 2025, repeated drone surveys will be conducted at both sites to evaluate survey efficiency, data processing time, and the potential benefits of drone-derived data compared to existing Real-Time Kinematic (RTK) GPS methods. This pilot study will help determine whether drone technology could supplement or eventually replace traditional beach survey techniques.

Figure 5.2 presents imagery captured during the initial drone surveys at Stanmore Bay and Te Henga.

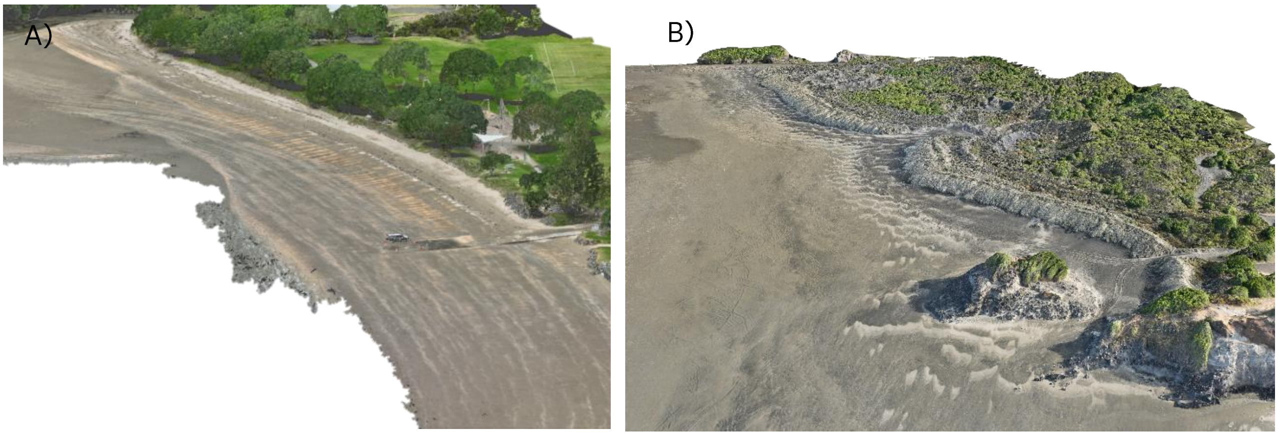

Figure 5. 2: Pilot drone survey at A) Stanmore Bay and B) Te Henga.

5.3 Wave buoy network

In addition to monitoring changes at our coastline, accurate wave and tide observations are essential for understanding the drivers of coastal change in Auckland. These data improve marine forecasts, support safe coastal operations and recreation, and inform the design and resilience of coastal infrastructure.

Auckland Council's CPM Programme has significantly advanced regional understanding of wave dynamics through its wave buoy initiative. We have been monitoring wave conditions since the 1990s with the first wave buoy deployed at the Mokohinau Islands in May 1998 which collected continuous data until February 2004. A second deployment occurred near Anchorite Rock in 2015, operating from February to October. However, in 2023, the wave buoy programme was re-established with the deployment of three buoys across the Hauraki Gulf, creating a regional wave buoy network (Figure 5. 3). These buoys transmit real-time wave data every 30 minutes, greatly enhancing our capacity to analyse long-term coastal trends, assess storm impacts, and monitor beach recovery processes.

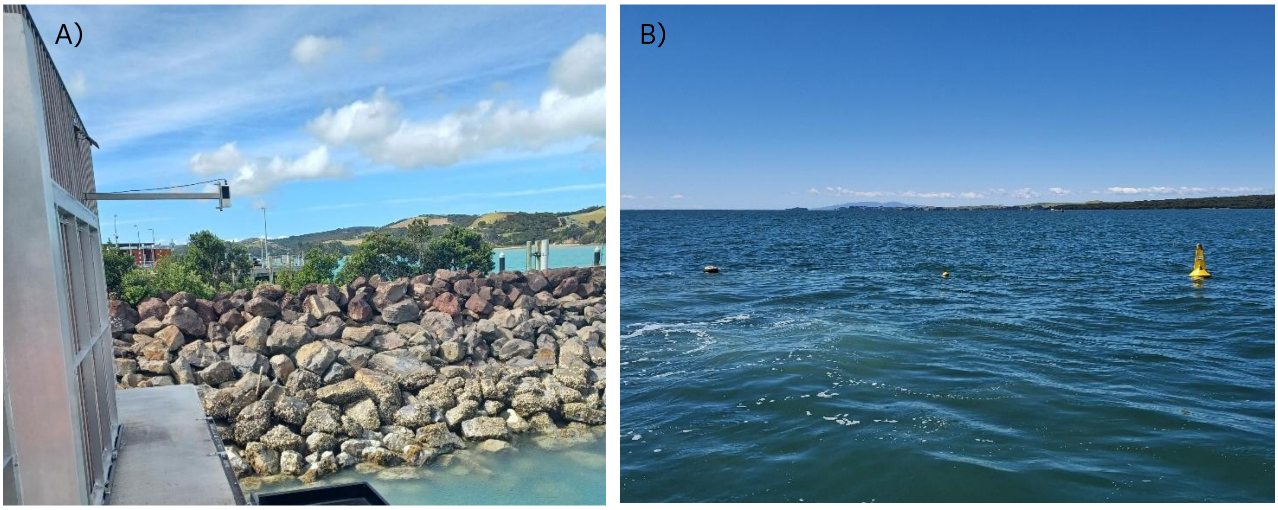

Figure 5. 3: Photograph of A) tidal gauge at Kennedy Point, Waiheke, and B) Rangitoto wave buoy.

5.4 Coastal monitoring cameras

Auckland Council's CPM Programme installed its first coastal monitoring camera at Takapuna Beach in 2023. There are now eight cameras across Tāmaki Makaurau, with a ninth planned for Onetangi Beach, Waiheke, later this year (Figure 5. 4). These cameras capture images every 30 minutes, providing real-time observations of beach conditions. They deliver valuable information on features such as beach slope, seagrass deposits, coastal structures, public use, and seasonal variations. Coastal cameras are particularly effective for assessing storm impacts and post-storm recovery, offering high-frequency, continuous visual records before, during, and after storm events. This imagery enables coastal scientists to track daily changes, document storm responses, and monitor long-term morphological trends, ultimately supporting effective coastal management, hazard prediction, and future coastline forecasting.

Figure 5. 4: Photographs of A) Oneroa beach monitoring camera and B) Te Arai beach monitoring camera.

5.5 Coastal Monitoring Portal

The CPM Programme has recently developed an online portal designed to centralise all historical and real-time coastal data, significantly improving data accessibility and visualisation for users across Auckland (Figure 5. 5). The Coastal Monitoring Portal enhances usability for a wide range of stakeholders – including the public, Iwi, researchers, consultants, and government agencies – many of whom were previously unaware of, or had difficulty accessing, the data.

The portal provides access to a comprehensive suite of coastal datasets, including beach profile surveys, wave buoy and tide gauge records, and time-lapse imagery from beach monitoring cameras. This enables users to view recent changes in sand levels across Auckland's beaches, real-time wave heights and water levels within the Hauraki Gulf, and regular visual records of shoreline conditions. Ongoing data collection will be integrated into the portal, ensuring Aucklanders remain informed about the state of their coastlines.

By increasing transparency and access to scientifically robust coastal and climate change information, the portal helps empower communities, supports evidence-based decision-making, and informs research contributing to the understanding and preservation of our coastal environments.

We encourage the public, including surfers, swimmers, fishers, local residents, and other beach users, to use the portal to check current and forecasted conditions at their local beaches and better understand how Auckland's coastline is changing.

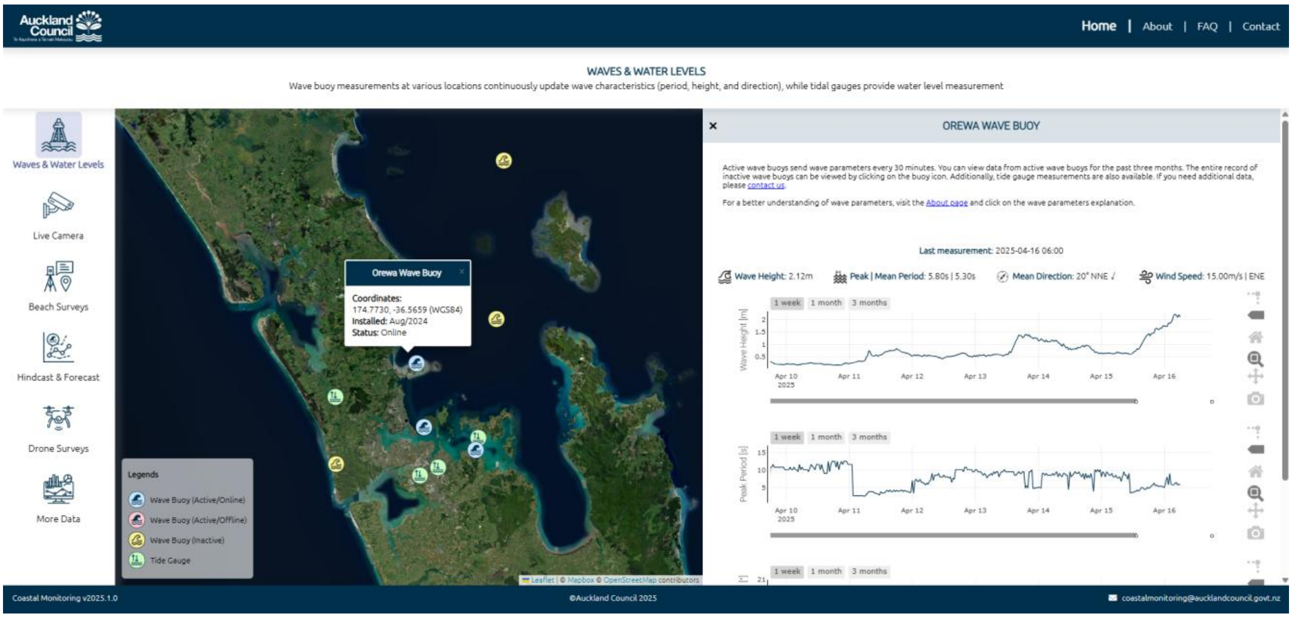

Figure 5. 5: An example of the real-time wave buoy data available through Auckland's Coastal Monitoring Portal.

Auckland's Coastal Monitoring Portal: coastalmonitoring.aucklandcouncil.govt.nz

6 Case study: The response and recovery of Auckland beaches to Cyclone Lola

6.1 Introduction

In addition to reporting on the state and trends of coastal change in Tāmaki Makaurau, this report also draws on newly available monitoring datasets – such as wave conditions, water levels, and coastal camera imagery – to enable detailed investigation of storm impacts on Auckland's beaches. This case study examines the effects of Cyclone Lola (2023) on Takapuna and Ōrewa beaches along the east coast. Ongoing enhancements to the coastal monitoring programme will support more comprehensive analysis of similar events and improve the accessibility of coastal hazard information to the public.

6.2 Context

In 2023, the North Island of New Zealand was significantly impacted by a series of severe storm events, particularly Cyclone Gabrielle (February) and Cyclone Lola (October), which caused extensive damage to infrastructure, homes, communities, and the environment. At the coast, Auckland experienced severe erosion throughout the year. Assessments of the erosional impacts of Cyclone Gabrielle across the North Island revealed widespread erosion from Northland to Hawkes Bay, with some sites showing up to 10 m of dune retreat (Dickson et al., 2024; Ford, 2024).

Hindcast wave data from 2023 indicate several high-energy events, with Cyclone Gabrielle and Cyclone Lola being the most prominent (Figure 6.1). However, when compared with the long-term hindcast record (1978-2024), the maximum wave heights recorded on the east coast of Auckland in 2023 (~2.5 m) were not exceptional, as similar wave heights have been observed repeatedly throughout the historical record (Figure 6.1). Nonetheless, the total duration of time (>250 hours) during which Auckland was exposed to these maximum wave heights in 2023 was the highest on record, substantially exceeding the durations observed in recent years (Figure 6.1). This suggests that while 2023 may not have been characterised by particularly intense individual storm events, the frequency of storm occurrences was notably higher.

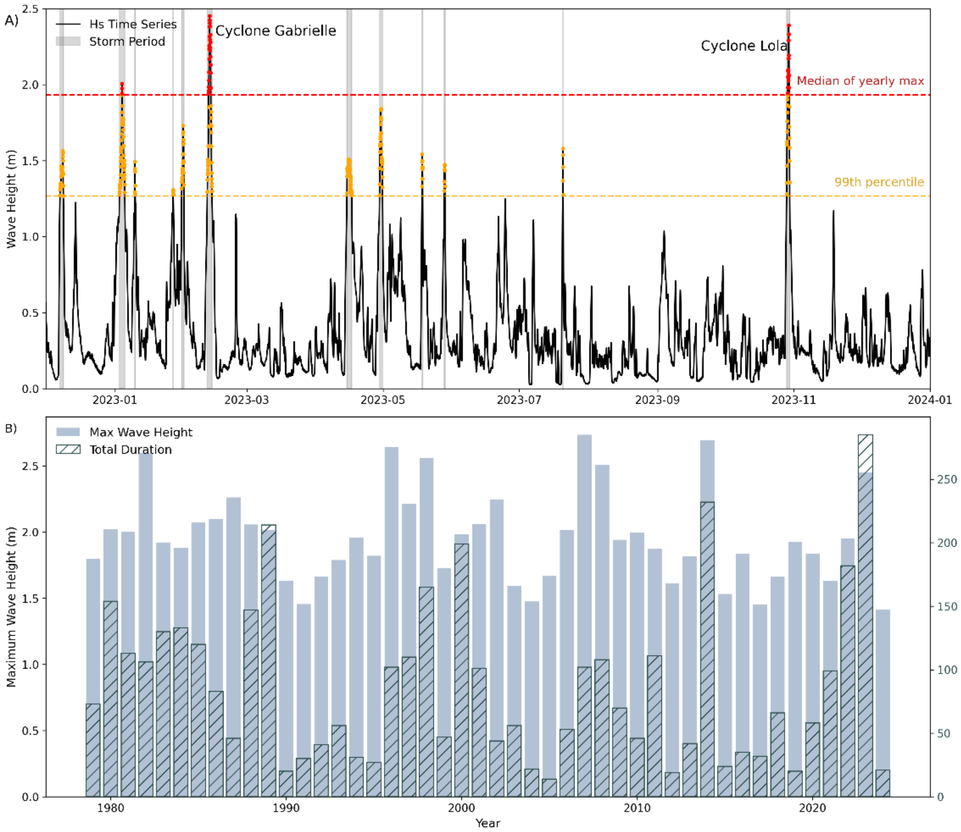

Figure 6.1: A) Hindcast wave conditions at Takapuna during 2023. Events above the 99th percentile and median of yearly max are marked. B) The duration (hours) of the maximum wave height for each year since 1978.

6.2.1 Cyclone Lola

Severe Tropical Cyclone Lola was the strongest out of season tropical cyclone ever recorded in the Southern Hemisphere during the high-quality observation period since 1969. The event originated on October 19th, 2023, as a low-pressure system south of the Solomon Islands. On October the 22nd, it was upgraded to a tropical cyclone (Lola) and then rapidly intensified into a category 5 severe cyclone on the Bureau of Meteorology scale. Over the next four days the cyclone caused widespread damage as it tracked directly across Vanuatu before weakening to a tropical depression by October 26th.

On October 27th, the ex-tropical cyclone entered New Zealand's Tropical Cyclone monitoring area. In the Tasman Sea, it merged with a low-pressure system, and by October 30th, it began impacting northern New Zealand with wind speeds comparable to those associated with Cyclone Gabrielle. The arrival of the ex-tropical cyclone coincided with red-alert King Tides in Auckland. The combined effects of the deep low-pressure system, elevated tide levels, and strong winds led to a prolonged and significant storm surge, which notably impacted Auckland's east coast (Carpenter et al., 2025). Coastal monitoring cameras deployed by Auckland Council's CPM Programme at Ōrewa Beach and Takapuna Beach captured the storm surge's effects on these shorelines.

The Rangitoto wave buoy deployed by Auckland's Coastal CPM Team in the Hauraki Gulf in June 2023 recorded the wave dynamics during Cyclone Lola, indicating maximum wave heights of up to 2.5 m (Figure 6.2). Spectral analysis revealed a substantial increase in wave energy and a broadening of the wave spectrum during the storm event, with two distinct peaks developing on October 30, reflecting high-energy wind and swell waves (Figure 6.2). Unfortunately, in late 2023, when Cyclone Lola impacted New Zealand, only one of three planned east coast wave buoys had been deployed, preventing a comparative analysis of live wave buoy data between Ōrewa and Takapuna. It is likely that wave heights experienced along the open east coast (Ōrewa Beach) were much larger than recorded by the Rangitoto buoy. This was the case during Cyclone Tam (April 2025) where Rangitoto buoy recorded significant wave heights of 2 m while the Ōrewa buoy recorded significant wave heights up to 5 m.

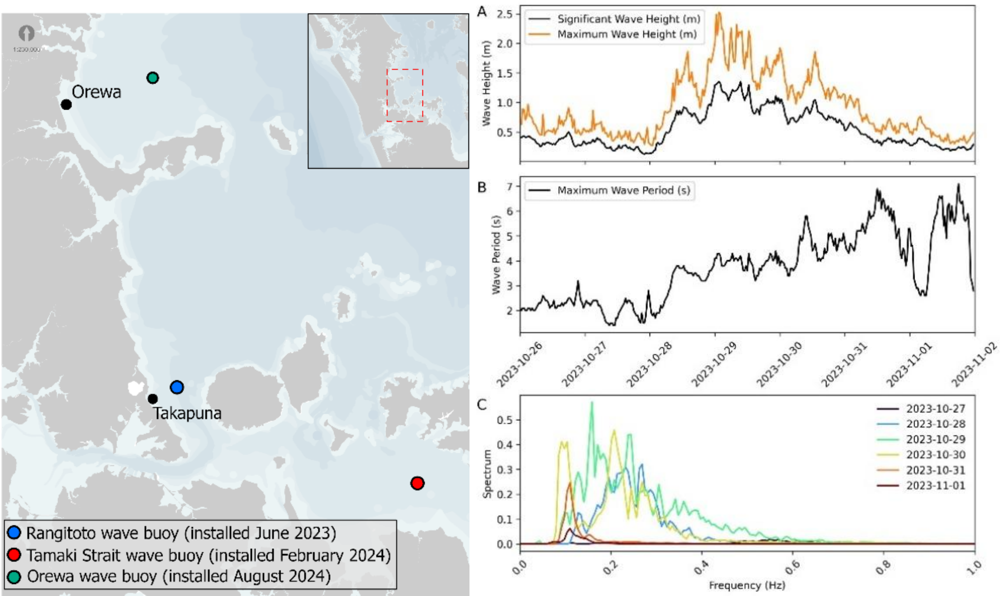

Figure 6.2: Map of east Auckland identifying Takapuna and Ōrewa Beach as well as the three wave buoys installed by Auckland Coastal Monitoring Unit. Wave parameters A) Significant and maximum wave height, and B) Wave period, and C) wave spectra recorded by the Rangitoto wave buoy during Cyclone Lola (26th October - 1st November 2023.

6.3 Ōrewa and Takapuna Beach storm response

Despite the proximity of Auckland's east coast beaches, their response to Cyclone Lola varied significantly. While some beaches experienced considerable erosion (e.g. Ōrewa), others remained stable or even exhibited accretion (e.g., Takapuna). Coastal camera imagery analysis indicates that Takapuna Beach initially underwent erosion, resulting in a temporary reduction in beach width. However, accretion followed during and after the storm, increasing beach width (Figure 6.3). The coastal camera imagery further reveals an accumulation of sediment on the upper beach post-storm, suggesting that wave-driven transport deposited sediment landward, enhancing both beach width and volume (Figure 6.4). Notably, infilling of the drainage area near the bottom of the coastal camera image taken on the 1st of November provides further evidence of post-storm sediment deposition.

In contrast, Ōrewa Beach experienced substantial erosion and beach narrowing, with sediment transported offshore during and after the storm (Figure 6.3). Coastal camera imagery clearly shows a lowering of the beach profile, exposing deeper rocks within the rock rampart – features that remained buried prior to the event (Figure 6.5). Analysis of the post-storm coastal monitoring camera imagery show that beach width at Ōrewa recovered relatively quickly from the erosion experienced as a result of Cyclone Lola. By the end of the year (Dec 2023) beach width had recovered to its pre-Cyclone Lola width. It is important to note that the coastal monitoring camera was installed at Ōrewa on the 25th October 2023, therefore minimal pre-storm imagery is available for this event although there is enough to illustrate the impact of Cyclone Lola on Ōrewa Beach (Figure 6.3; Figure 6.5).

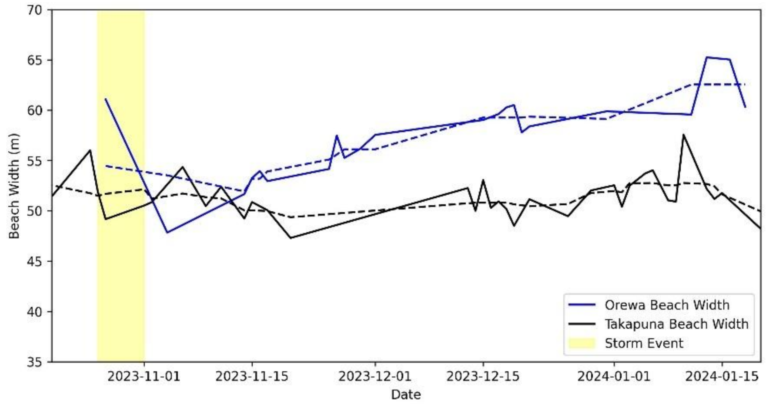

Figure 6.3: Change in beach width at Ōrewa (blue) and Takapuna (orange) beach before and after Cyclone Lola. Please note the coastal monitoring camera was installed at Ōrewa in late October so minimal pre storm beach width data is available.

Figure 6.4: Coastal monitoring camera imagery at Takapuna Beach showing before (21st October 2023) and after (1st November 2023) Cyclone Lola.

Figure 6.5: Coastal monitoring camera imagery at Ōrewa Beach showing before (28th October 2023) and after (1st November 2023) Cyclone Lola.

The absence of live wave buoy data and detailed bathymetric surveys limits our ability to fully investigate the drivers of beach response along Auckland's east coast. However, the finding that beach response to storms is not uniform, despite the proximity of these beaches, suggests that factors such as sediment supply play a critical role in shaping coastal dynamics. Coastal erosion during a high-energy event is expected as elevated water levels (e.g. storm surge) allow high-energy waves to reach further up the beach profile entraining and transporting sediment off and/or along the beach. In contrast, beach accretion during storm events is less common, in most cases post-storm accretion is reported during the post-storm recovery phase. Research suggests that extreme storm events can result in long-term net accretion of the beach by facilitating sediment transport between headlands or mobilising previously inactive sediment, adding to the nearshore sediment budget (Harley et al., 2022). At Takapuna Beach, accretion during Cyclone Lola suggests that substantial sediment may have been stored offshore and subsequently transported onshore by the storm waves. However, without pre- and post-storm bathymetric data, this hypothesis cannot be tested.

To better understand the mechanisms driving the contrasting responses of Ōrewa and Takapuna to storm events, continuous wave buoy data capturing site-specific wave conditions, alongside regular bathymetric surveys to assess offshore sediment storage, would be invaluable. These data would provide a more comprehensive understanding of the physical processes influencing beach response and recovery.

6.4 Storm monitoring

The coastal monitoring cameras installed at Ōrewa and Takapuna Beach in 2023 have significantly enhanced our understanding of beach response to high-energy events by providing high-frequency, continuous monitoring before, during, and after storms. The results highlight that not all beaches in Auckland, including those along the east coast, respond in the same way to storm events.

To improve our understanding of storm-driven beach change in Auckland and support site-specific coastal management decisions, it is essential to monitor individual beaches during storm events.

Auckland's CPM programme conducts quarterly beach profile surveys to capture seasonal and long-term trends at key sites. Additionally, pre- and post-storm surveys are undertaken when possible. However, logistical and safety constraints often make it impractical to conduct surveys before and after every storm, leaving significant gaps in data and limiting our ability to assess storm impacts.

Coastal monitoring cameras play a critical role in storm monitoring, as they are cost-effective and provide remote, high-frequency data on beach response and post-storm recovery. Auckland's CPM programme aims to expand the regional coverage of these cameras, prioritising installation at beaches that are particularly vulnerable to storm impacts or difficult to access at short notice.

At the time of Cyclone Lola, only a single wave buoy, located off Rangitoto, was operational, limiting direct wave observations during the event. Consequently, hindcast data remains the primary source for assessing wave conditions. However, with the recent deployment of three wave buoys along Auckland's east coast, future high-energy events will be better characterized, allowing for more detailed spatial analysis of wave conditions and their influence on coastal change.

7 References

Aris, A., Shneiderman, B., Plaisant, C., Shmueli, G., and Jank, W. (2005). Representing unevenly-spaced time series data for visualization and interactive exploration. In IFIP Conference on Human-Computer Interaction (pp. 835-846). Berlin, Heidelberg: Springer Berlin Heidelberg.

Auckland Council. (2016). LAN-67608 – Muriwai Beach Dune Restoration Planting Plan. Auckland Council.

Auckland Council. (2023). Decision on application by McCallum Bros Limited for in-shore sand extraction at Pakiri Beach (BUN60352951).

Blue, B., and Kench, P. S. (2017). Multi-decadal shoreline change and beach connectivity in a high-energy sand system. New Zealand journal of marine and freshwater research, 51 (3), 406-426.

Boyle, J. J. (2016). Beach change in the Auckland region: current state and trends. Auckland Council technical report, TR2016/048

Boyle, J. J. (2014). An Investigation into Coastal Change at Whites Beach, Auckland, New Zealand. MSc Thesis, University of Auckland.

Brander, R. W., and Short, A. D. (2000). Morphodynamics of a large-scale rip current system at Muriwai Beach, New Zealand. Marine Geology, 165 (1-4), 27-39.

Baverstock, K. (2003). Urban Beach Dune Restoration Project. Auckland Council.

Bryan, K. R., Kench, P. S., and Hart, D. E. (2008). Multi-decadal coastal change in New Zealand: Evidence, mechanisms and implications. New Zealand Geographer, 64 (2), 117-128.

Carpenter, N. and Klinac, P. (2015). Adapting shorelines – a reflection of managed realignment at Muriwai. Coastal News, The New Zealand Coastal Society.

Carpenter, N., McNeil, M., Soltau, C. and Tuck, M. (2025). The transforming coastline of Tamaki Makaurau in the wake of a triple dip La Nina cycle. In Shoreline Strategies: Embracing coastal transformation in Aotearoa New Zealand. New Zealand Coastal Society.

Dahm, J. (2002). Coastal Hazard Management Strategy: Muriwai. Report prepared for Auckland Regional Council and Rodney District Council. Coastline Consultants Ltd, Hamilton.

Dahm, J. (2013). Dune Management at Piha: Review and Proposed Management Plan. Report prepared for Auckland Regional Council. Eco Nomos Ltd.

Dickson, M., Ryan, E. J., and Ford, M. (2022). 80 Years of Shoreline Change in Northland, New Zealand. In Australasian Coasts & Ports 2021: Te Oranga Takutai, Adapt and Thrive. New Zealand Coastal Society.

Dickson, M. D., Ryan, E. J., Ford, M. R., Tuck, M. E., (2024). New Zealand's Coastal Change Dataset [dataset], Figshare, https://doi.org/10.17608/k6.auckland.27105955.v1

Dodet, G., Castelle, B., Masselink, G., Scott, T., Davidson, M., Floc'h, F., Jackson, D. and Suanez, S. (2019). Beach recovery from extreme storm activity during the 2013-14 winter along the Atlantic coast of Europe. Earth Surface Processes and Landforms, 44 (1), 393-401.

Dougherty, A. J. (2011). Evolution of Prograded Coastal Barriers in Northern New Zealand. PhD Thesis, University of Auckland.

Emery, K. O. (1961). A Simple Method of Measuring Beach Profiles. Limnology and Oceanography, 6 (1), 90-93.

Ford, M. R., and Dickson, M. E. (2018). Detecting ebb-tidal delta migration using Landsat imagery. Marine Geology, 405, 38-46.

Ford, M. (2024). Cyclone caused > 10m erosion of some North Island beaches. https://resiliencechallenge.nz/assessing-the-erosional-impact-of-cyclone-gabrielle-on-north-island-coasts

Godoi, V. A., Bryan, K. R., and Gorman, R. M. (2016). Regional influence of climate patterns on the wave climate of the southwestern Pacific: The New Zealand region. Journal of Geophysical Research: Oceans, 121 (6), 4056-4076.

Gorman, R. M., Bryan, K. R. and Laing, A. K. (2003). Wave hindcast for the New Zealand region: Deep-water wave climate. New Zealand Journal of Marine and Freshwater Research, 37 (3), 589-612. Doi: 10.1080/00288330.2003.9517191

Harley, M. D., Masselink, G., Ruiz de Alegría-Arzaburu, A., Valiente, N. G., and Scott, T. (2022). Single extreme storm sequence can offset decades of shoreline retreat projected to result from sea-level rise. Communications Earth & Environment, 3(1), 112.

Himmelstoss, E., Henderson R. E., Kratzmann, M. G., and Farris A. S. Digital Shoreline Analysis System (DSAS) Version 5.1 User guide. Report no. 2021-1091, US Geological Survey, 2021.

Hart, D. E., and Bryan, K. R. (2008). New Zealand coastal system boundaries, connections and management. New Zealand Geographer, 64 (2), 129-143.

Kench, P. (2008). Beach monitoring in the Auckland region: Beach profile analysis. Prepared by Auckland Uniservices Limited for Auckland Regional Council. Regional Technical Report 2008/015. 71 pages.

King, D. N. T., Nichol, S. L., and Hume, T. M. (2006). Rapid onshore sand flux in a high energy environment littoral cell: Piha Beach, New Zealand. Journal of Coastal Research, 22, 1360-1369.

Luijendijk, A., Hagenaars, G., Ranasinghe, R., Baart, F., Donchyts, G., and Aarninkhof, S. (2018). The state of the world's beaches. *Scientific reports*, *8* (1), 6641.

Oceanum. (2025). Wave hindcast dataset for New Zealand waters using SWAN spectral wave model at 1 km resolution. Oceanum Ltd. [Dataset]. Specification available from: https://hindcast-satellite-validation-4020-prod.app.oceanum.io/hindcast/oceanum_wave_nz_era5_v1_grid?show_description=true.

Phillips, M. S., Turner, I. L., Cox, R. J., Splinter, K. D., and Harley, M. D. (2015). Will the sand come back?: Observations and characteristics of beach recovery. In Australasian Coasts & Ports Conference 2015: 22nd Australasian Coastal and Ocean Engineering Conference and the 15th Australasian Port and Harbour Conference: (pp. 676-682). Auckland, New Zealand: Engineers Australia and IPENZ.

Schofield, J. C., (1985). Coastal change at Omaha and Great Barrier Island, New Zealand Journal of Geology and Geophysics, 28: 313-322.

Stephens, S., (2012). Development of an updated Coastal Marine Area boundary for the Auckland Region. NIWA.

Tuck, M., Dickson, M., Ryan, E., Ford, M., and Konlechner, T. (2024). A national scale coastal change dataset for Aotearoa New Zealand. *Data in brief*, *57*, 111104.

Yafar, B., and Miyamoto, M. (2024). Beach Oscillation Index code. The University of Auckland.

Appendix A: Beach envelope and historic beach profiles

Here you will find the beach envelope and historic beach profile record figures for all profiles that are **not** included in the main body of the report.

Piha

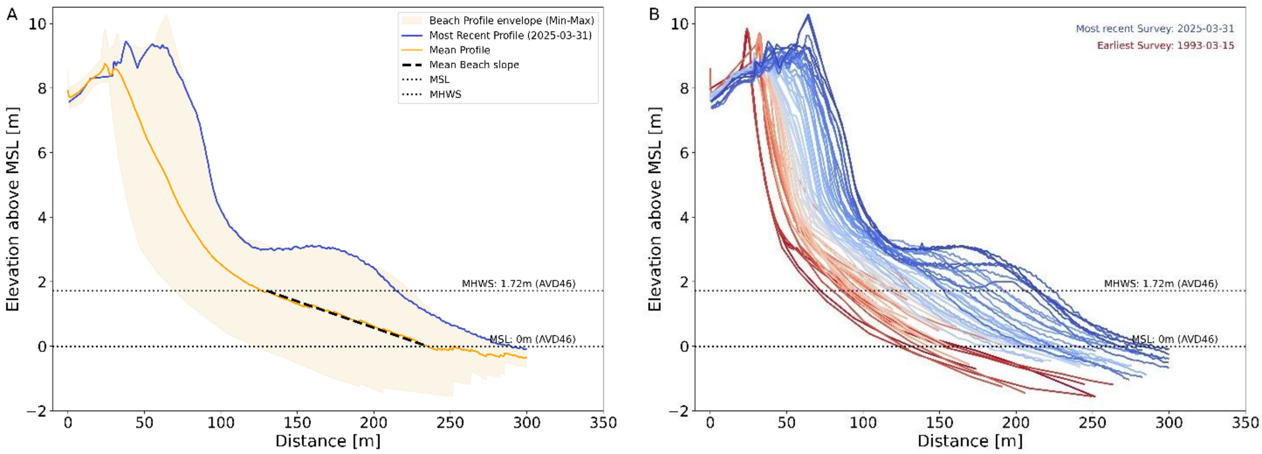

Figure A 1: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Piha beach.

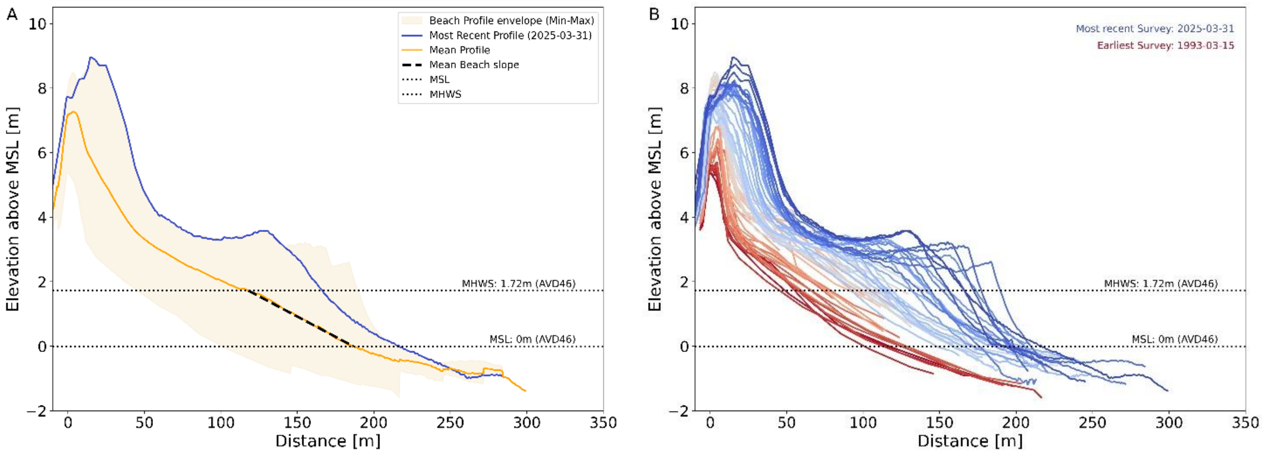

Figure A 2: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Piha beach.

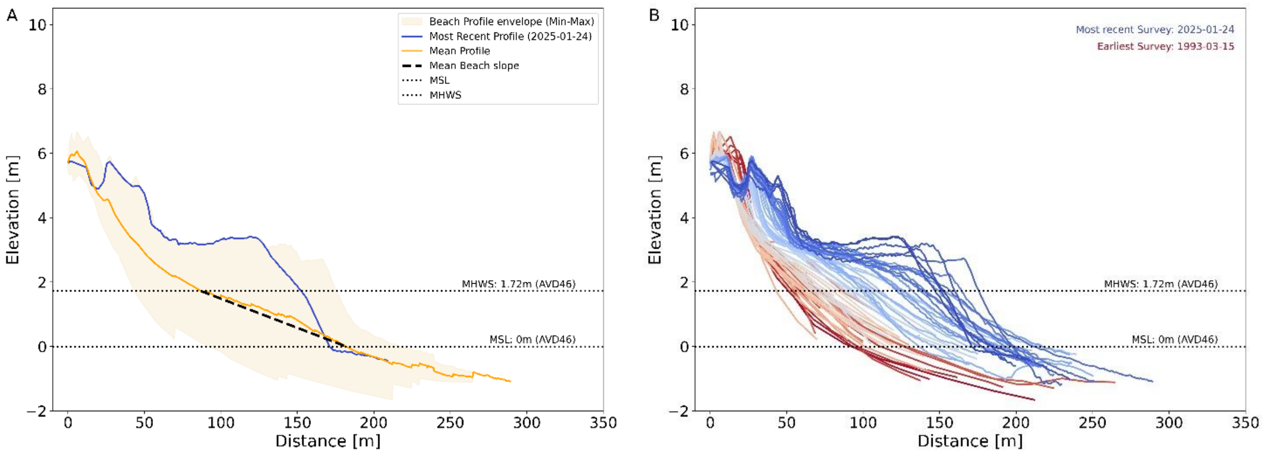

Figure A 3: Beach envelope (A), and historic beach profile record (B) for Profile 5 at Piha Beach.

Muriwai

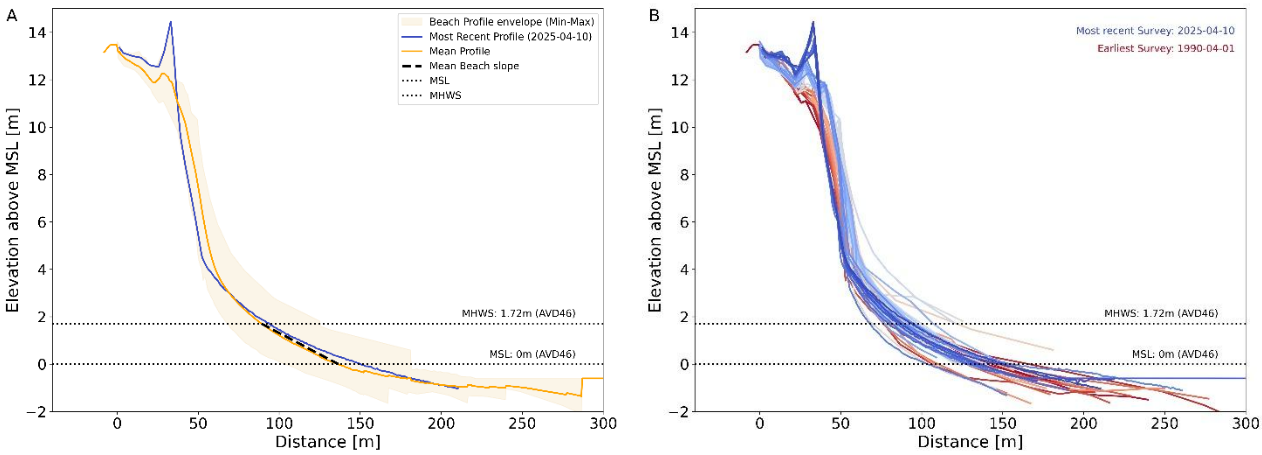

Figure A 4: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Muriwai Beach.

Pākiri

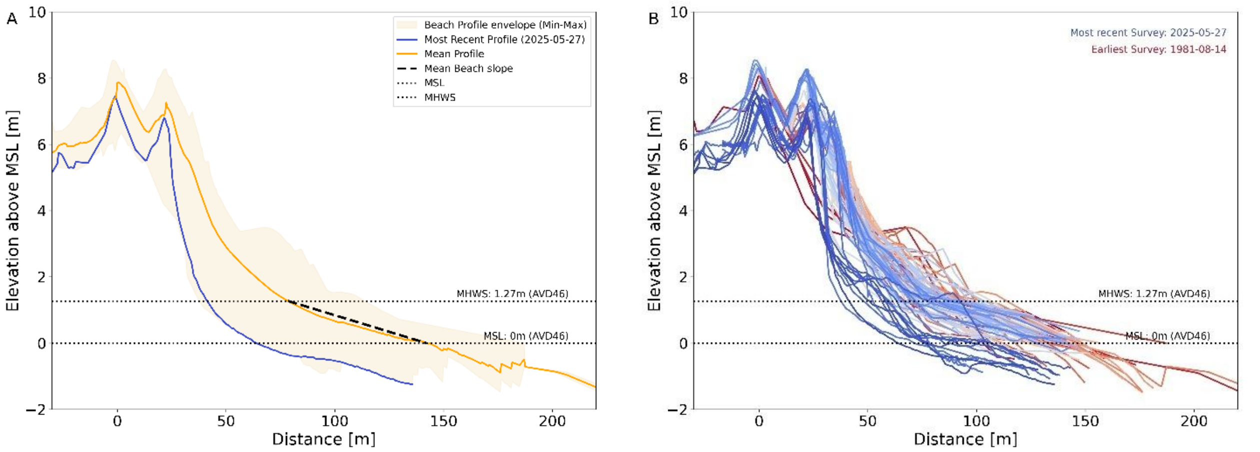

Figure A 5: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Pākiri Beach.

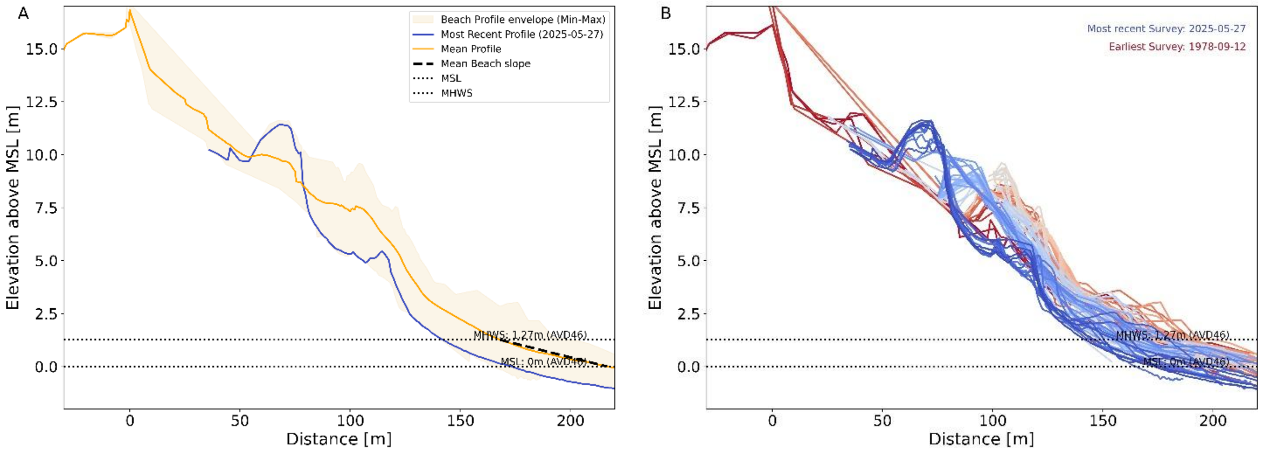

Figure A 6: Beach envelope (A), and historic beach profile record (B) for Profile 4 at Pākiri Beach.

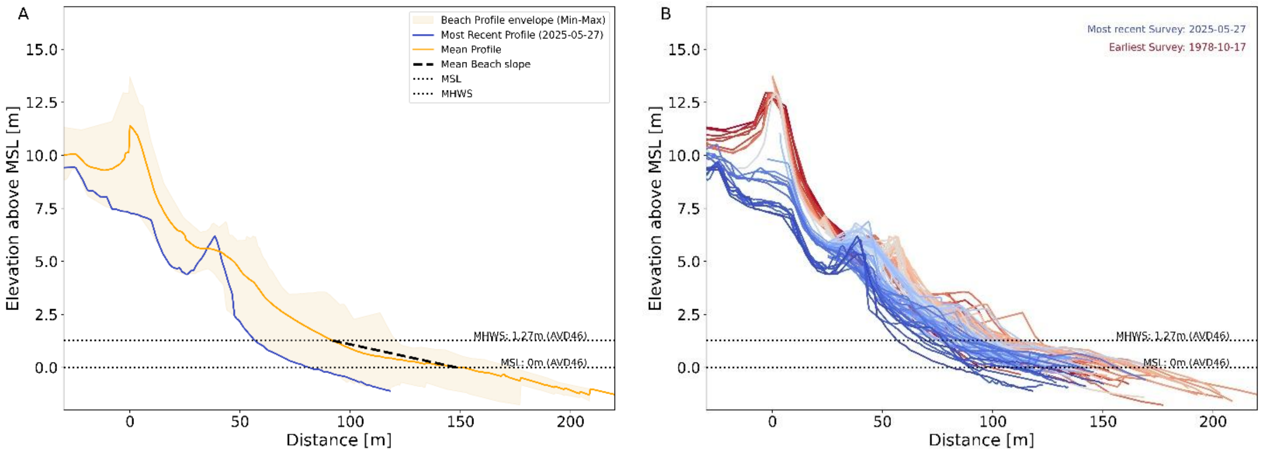

Figure A 7: Beach envelope (A), and historic beach profile record (B) for Profile 5 at Pākiri Beach.

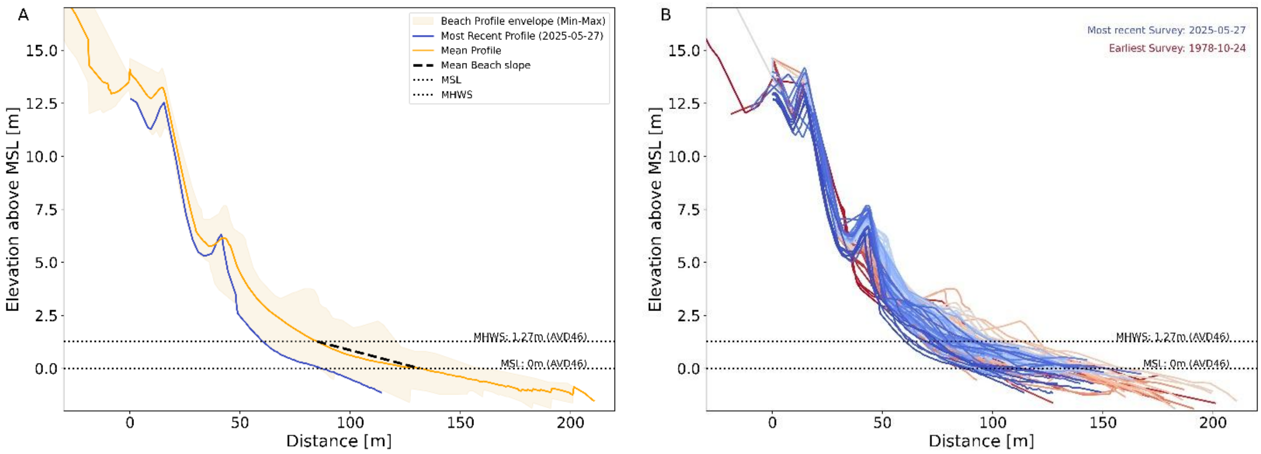

Figure A 8: Beach envelope (A), and historic beach profile record (B) for Profile 7 at Pākiri Beach.

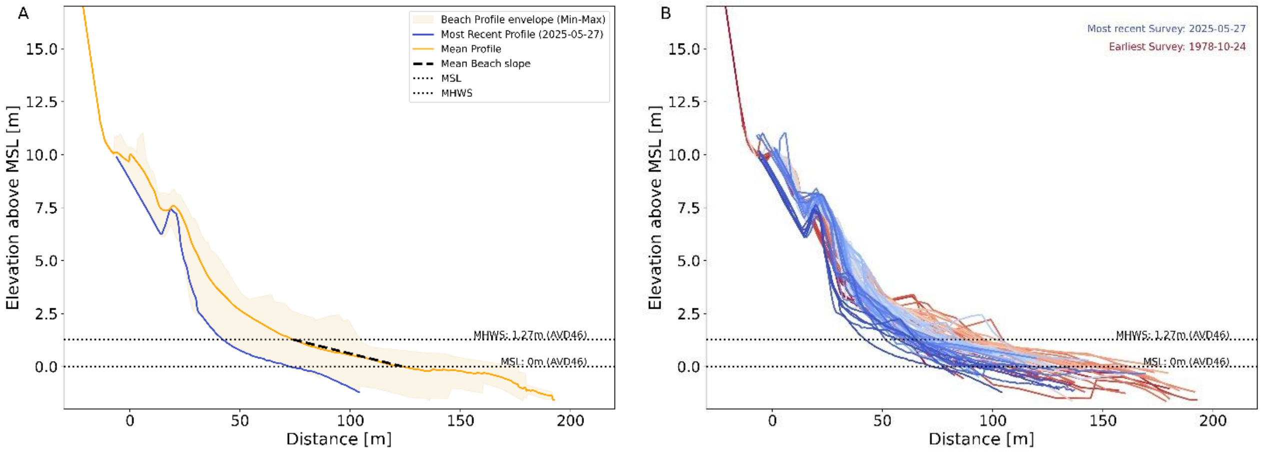

Figure A 9: Beach envelope (A), and historic beach profile record (B) for Profile 8 at Pākiri Beach.

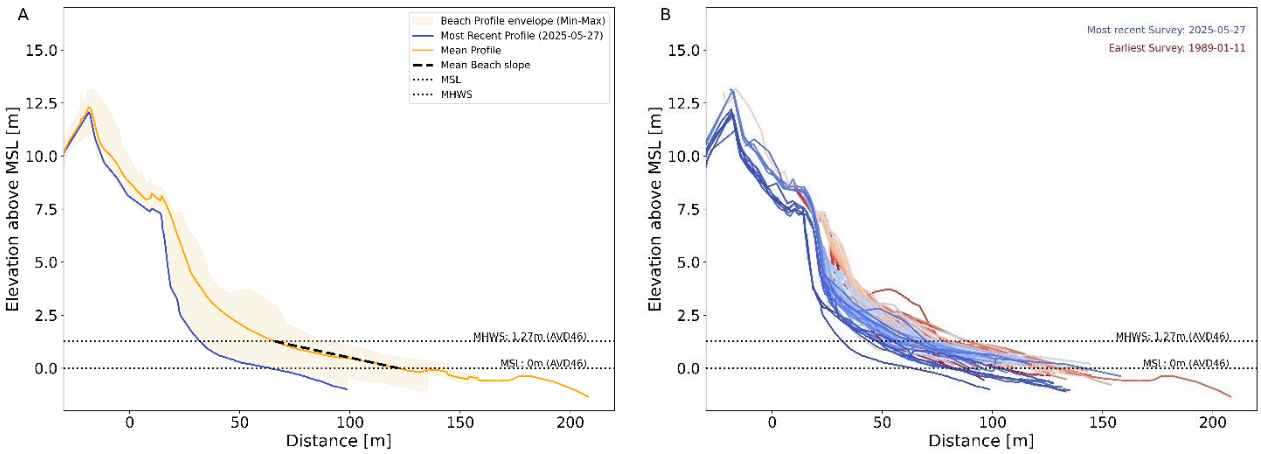

Figure A 10: Beach envelope (A), and historic beach profile record (B) for Profile 9 at Pākiri Beach.

Omaha

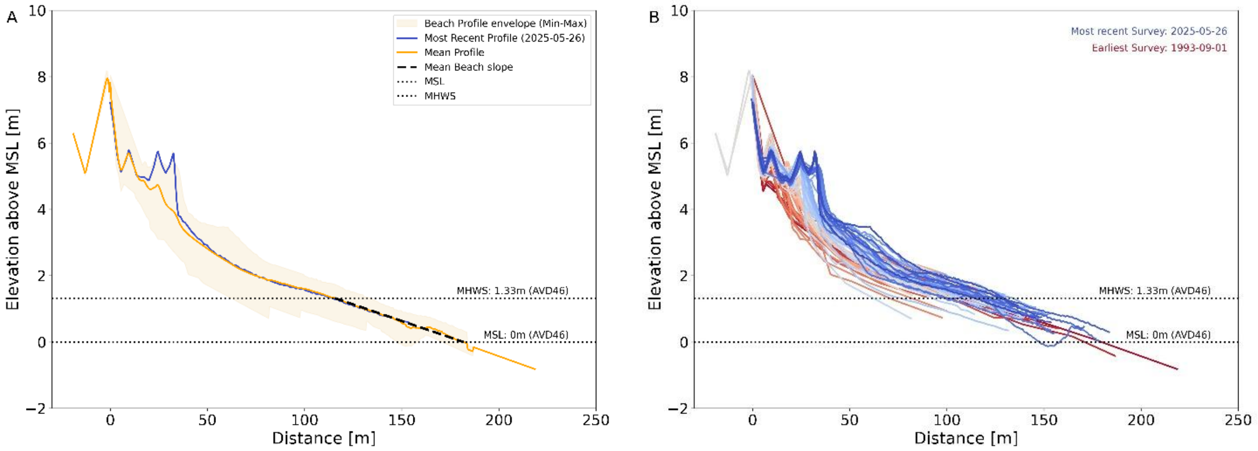

Figure A 11: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Omaha Beach.

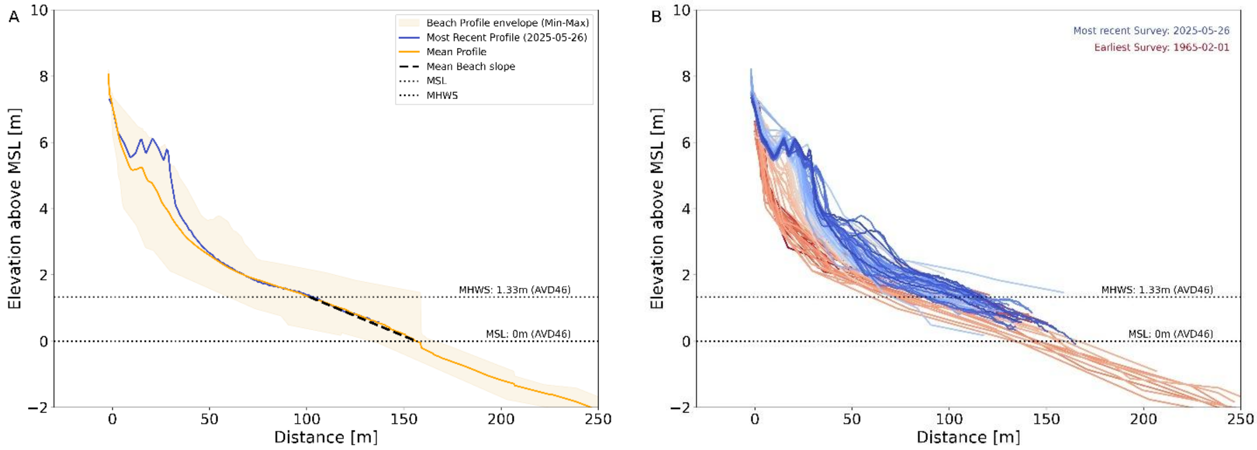

Figure A 12: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Omaha Beach.

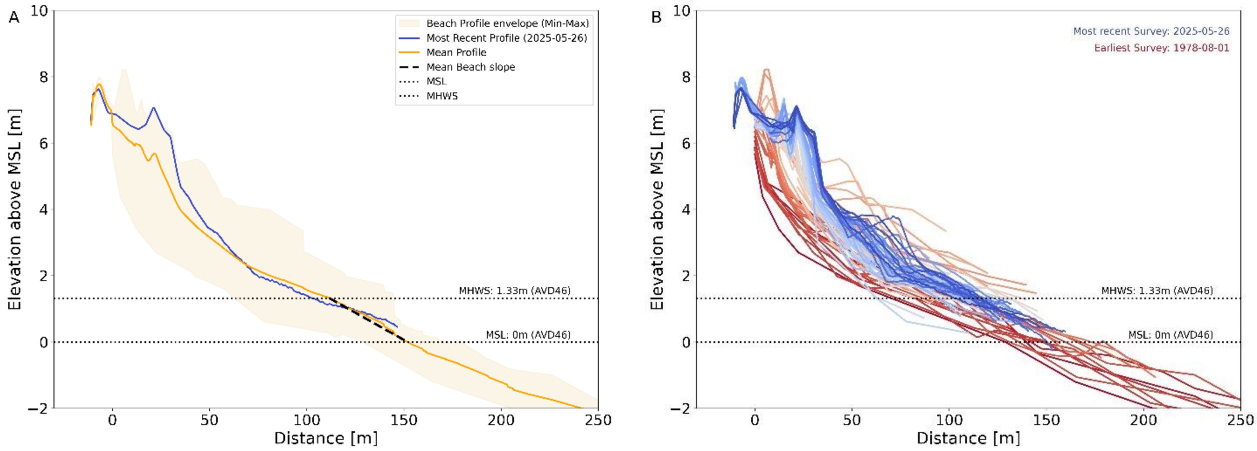

Figure A 13: Beach envelope (A), and historic beach profile record (B) for Profile 4 at Omaha beach.

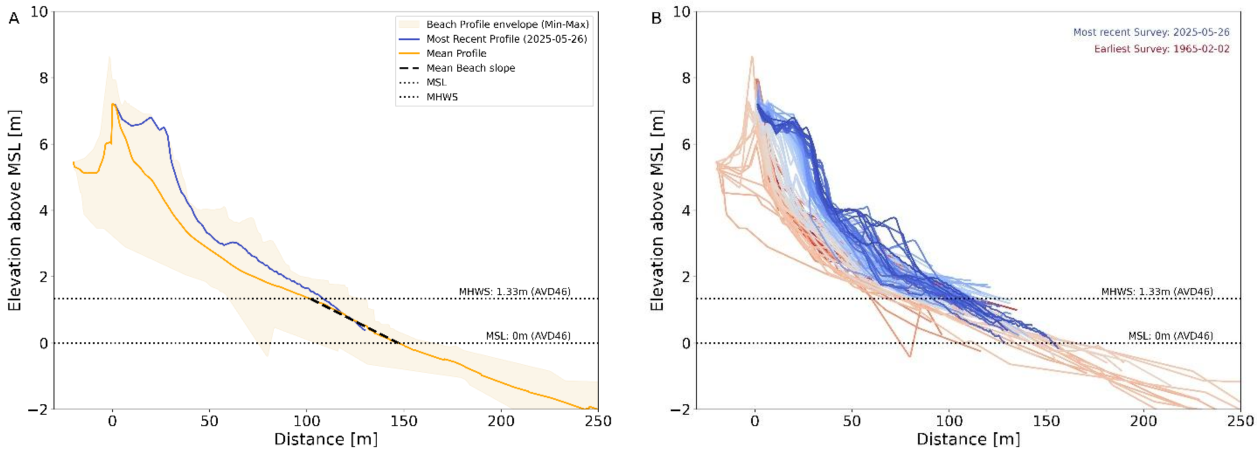

Figure A 14: Beach envelope (A), and historic beach profile record (B) for Profile 5 at Omaha Beach.

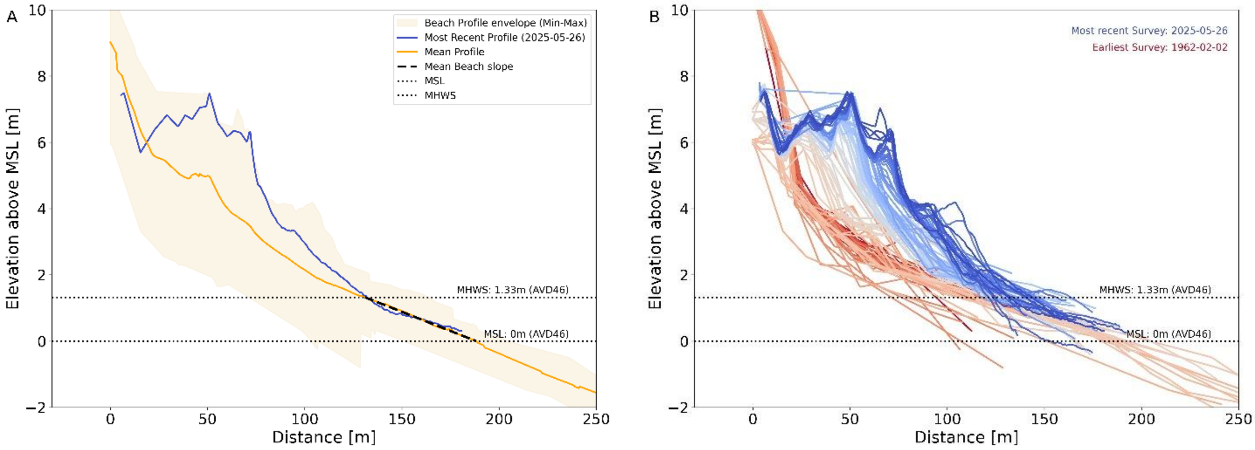

Figure A 15: Beach envelope (A), and historic beach profile record (B) for Profile 6 at Omaha Beach.

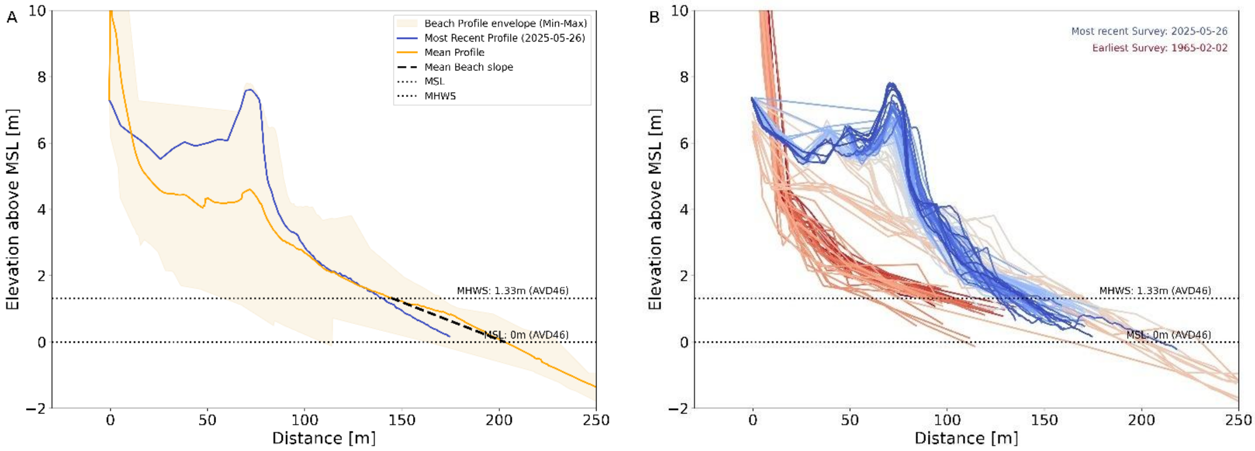

Figure A 16: Beach envelope (A), and historic beach profile record (B) for Profile 7 at Omaha Beach.

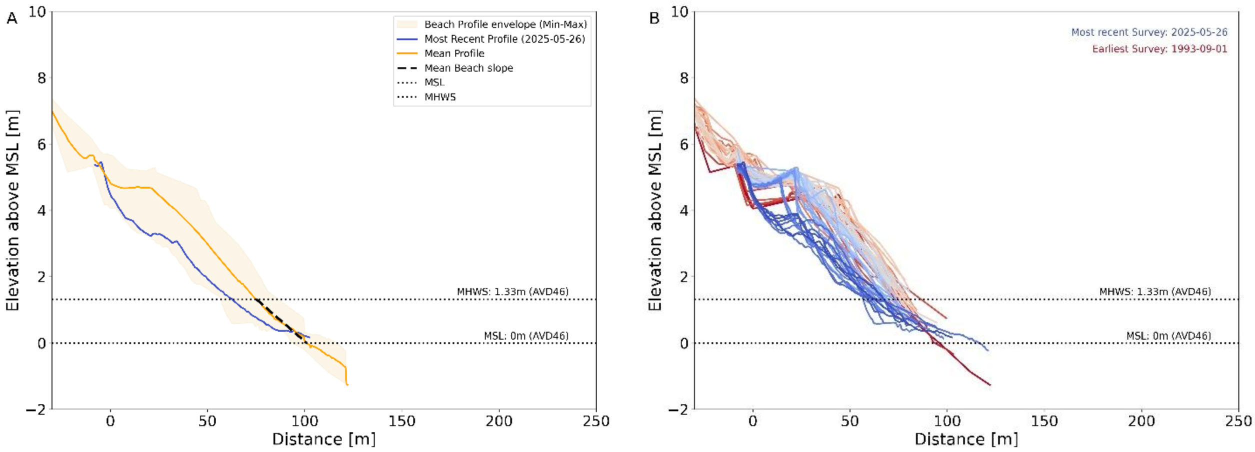

Figure A 17: Beach envelope (A), and historic beach profile record (B) for Profile 9 at Omaha Beach.

Takapuna

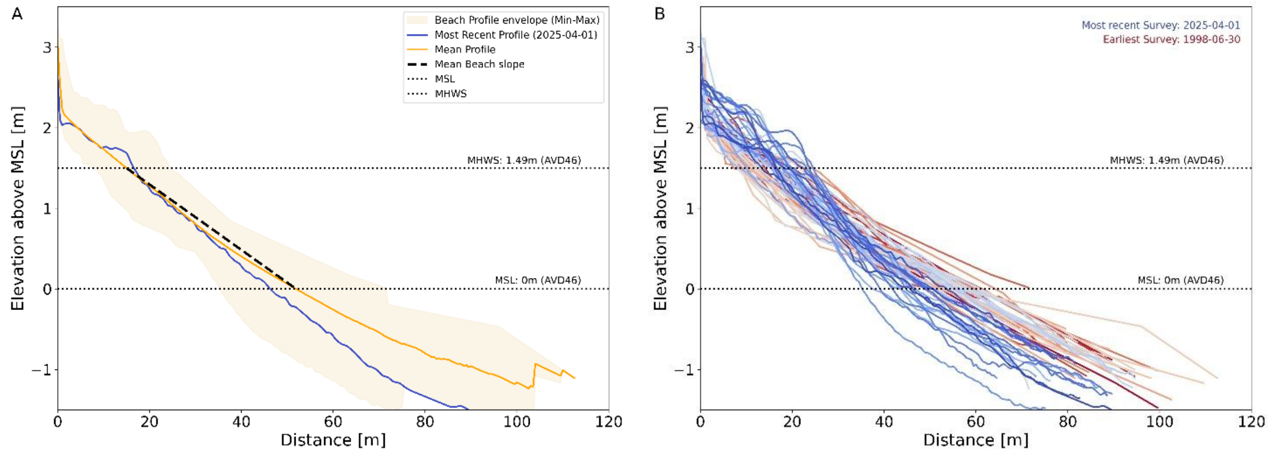

Figure A 18: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Takapuna Beach.

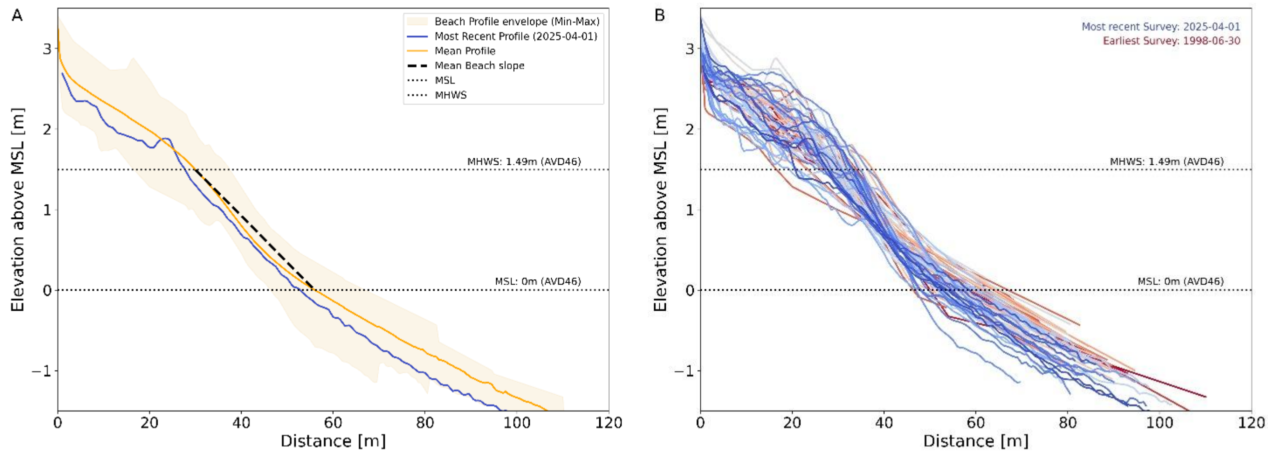

Figure A 19: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Takapuna Beach.

Milford

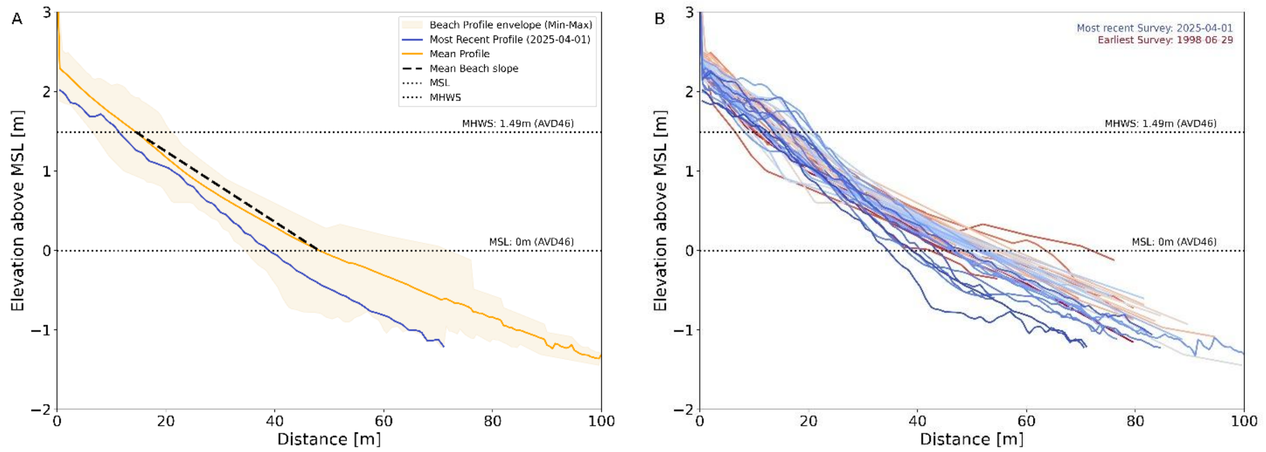

Figure A 20: Beach envelope (A), and historic beach profile record (B) for Profile 1 at Milford Beach.

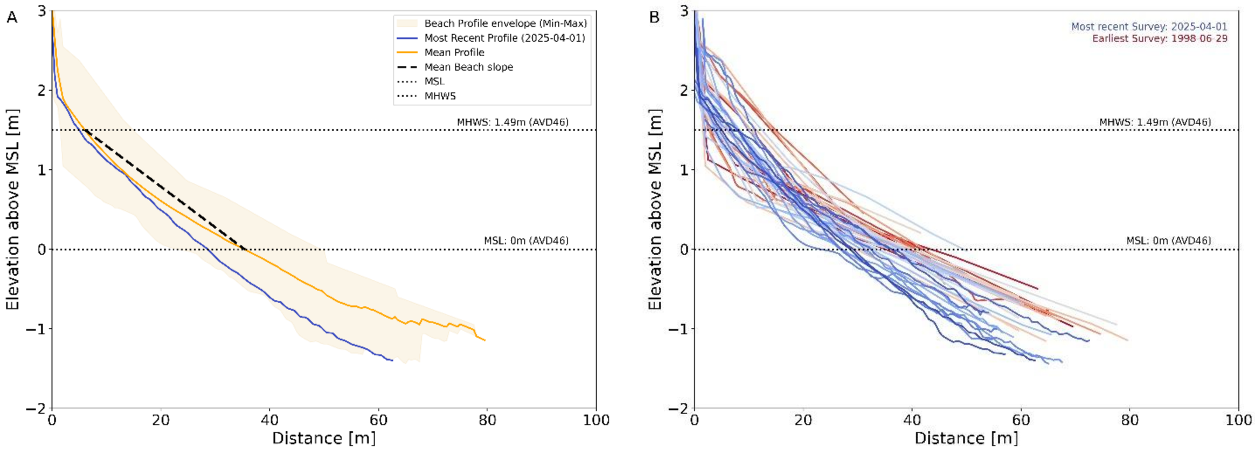

Figure A 21: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Milford Beach.

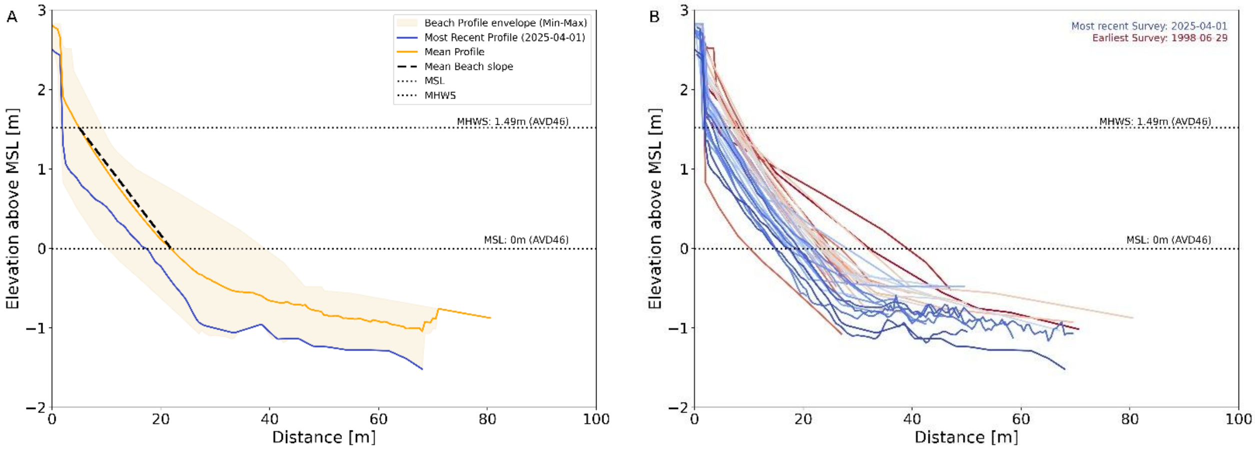

Figure A 22: Beach envelope (A), and historic beach profile record (B) for Profile 5 at Milford Beach.

Cheltenham

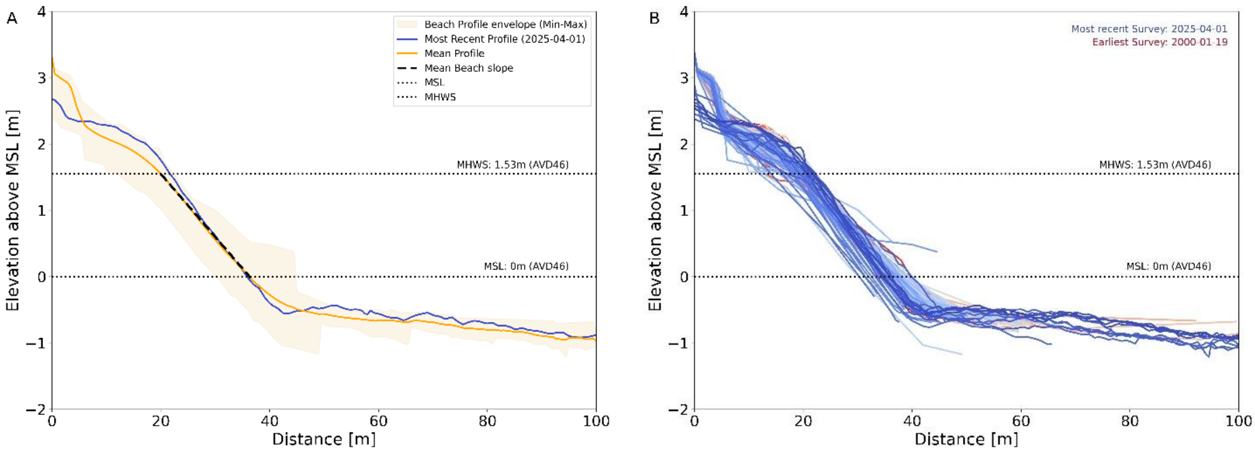

Figure A 23: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Cheltenham Beach.

Maraetai

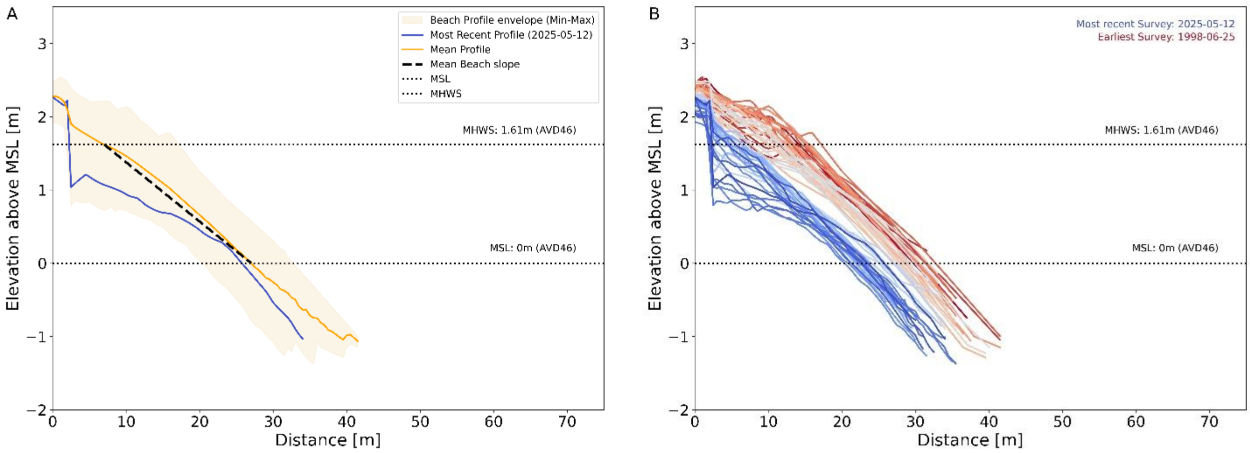

Figure A 24: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Maraetai Beach.

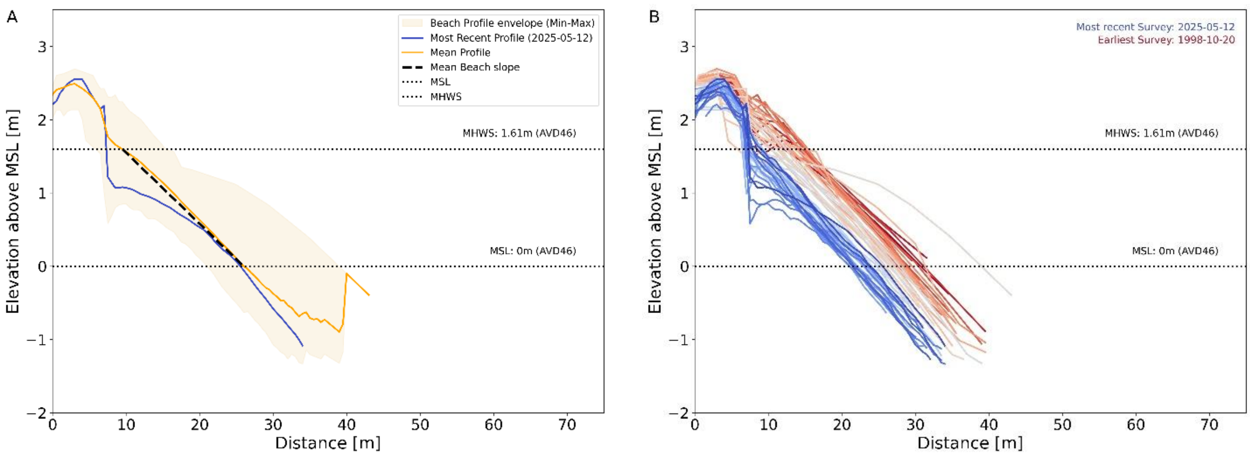

Figure A 25: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Maraetai Beach.

Kawakawa Bay

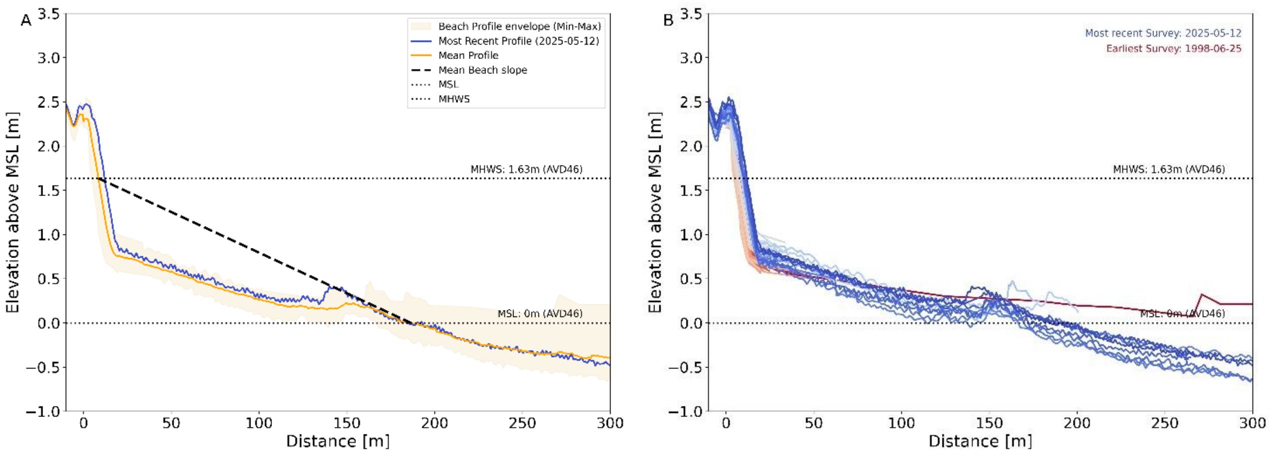

Figure A 26: Beach envelope (A), and historic beach profile record (B) for Profile 2 at Kawakawa Bay.

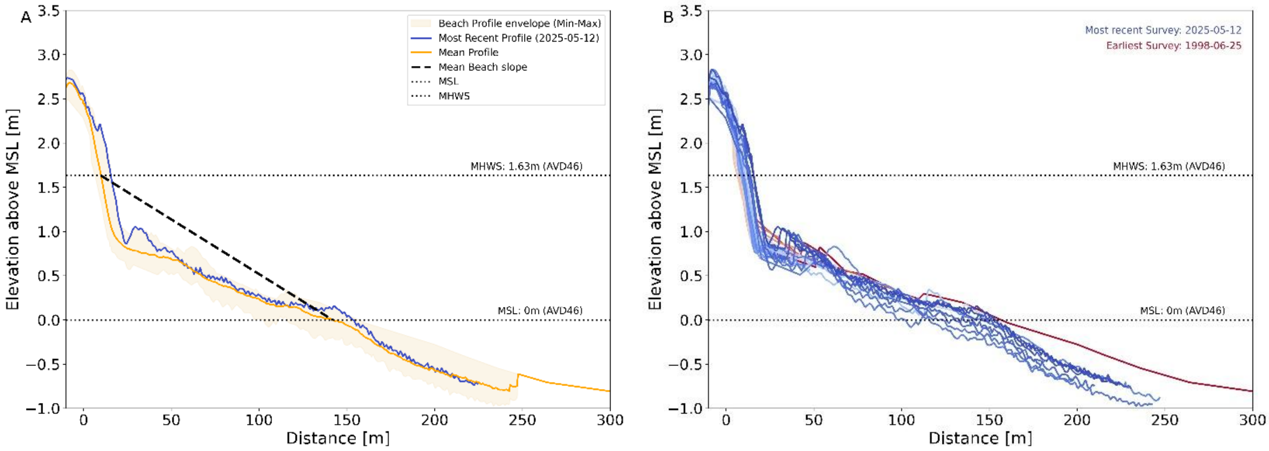

Figure A 27: Beach envelope (A), and historic beach profile record (B) for Profile 3 at Kawakawa Bay.

Appendix B: Foredune dynamics

Here you will find the individual foredune plots illustrating the change in the height and position of the foredune throughout the monitoring record for each beach profile.

Piha

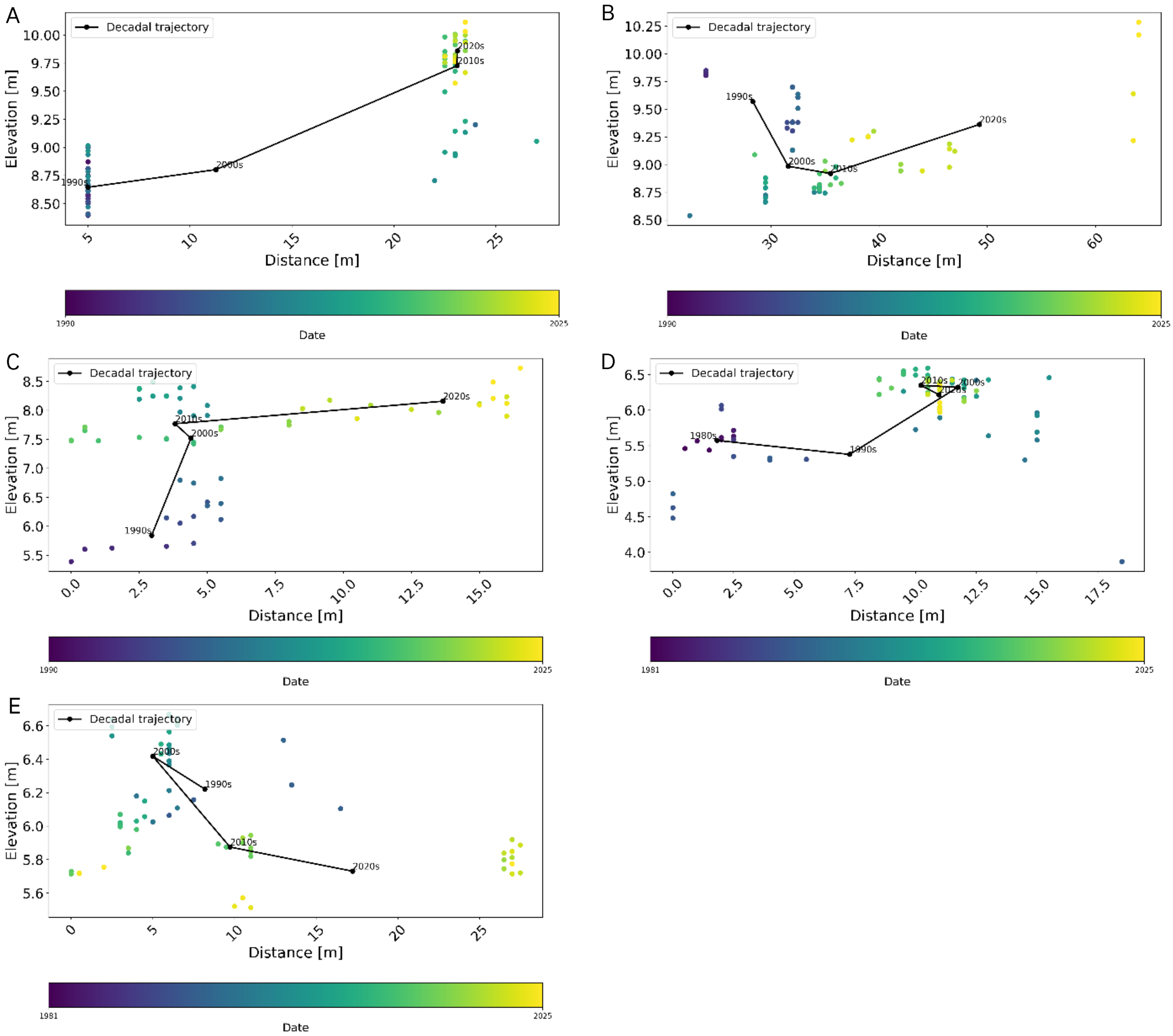

Figure B 1: Changes in foredune position at Profile 1 (A), 2 (B), 3 (C), 4 (D) and 5 (E) at Piha Beach. Please note the difference In the Y axis.

Muriwai

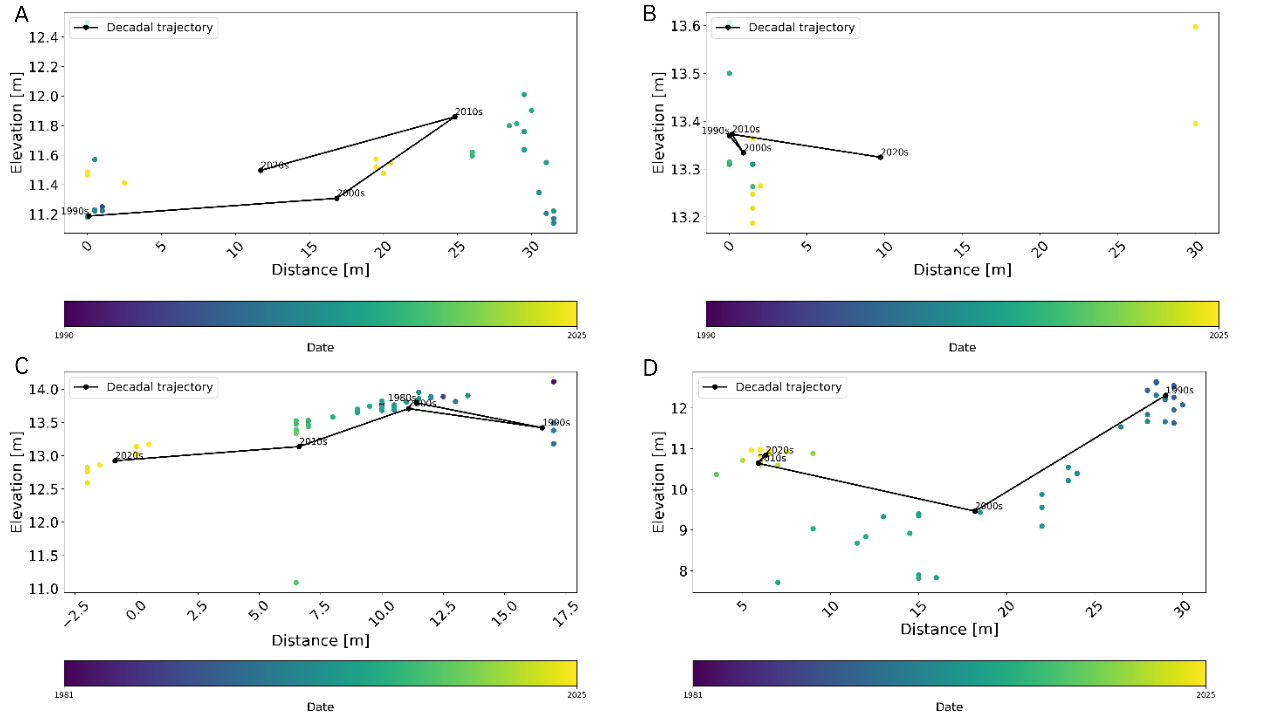

Figure B 2: Changes in foredune position at Profile 1 (A), 2 (B), 3 (C) and 4 (D) at Muriwai Beach. Please note the difference In the Y axis.

Pākiri

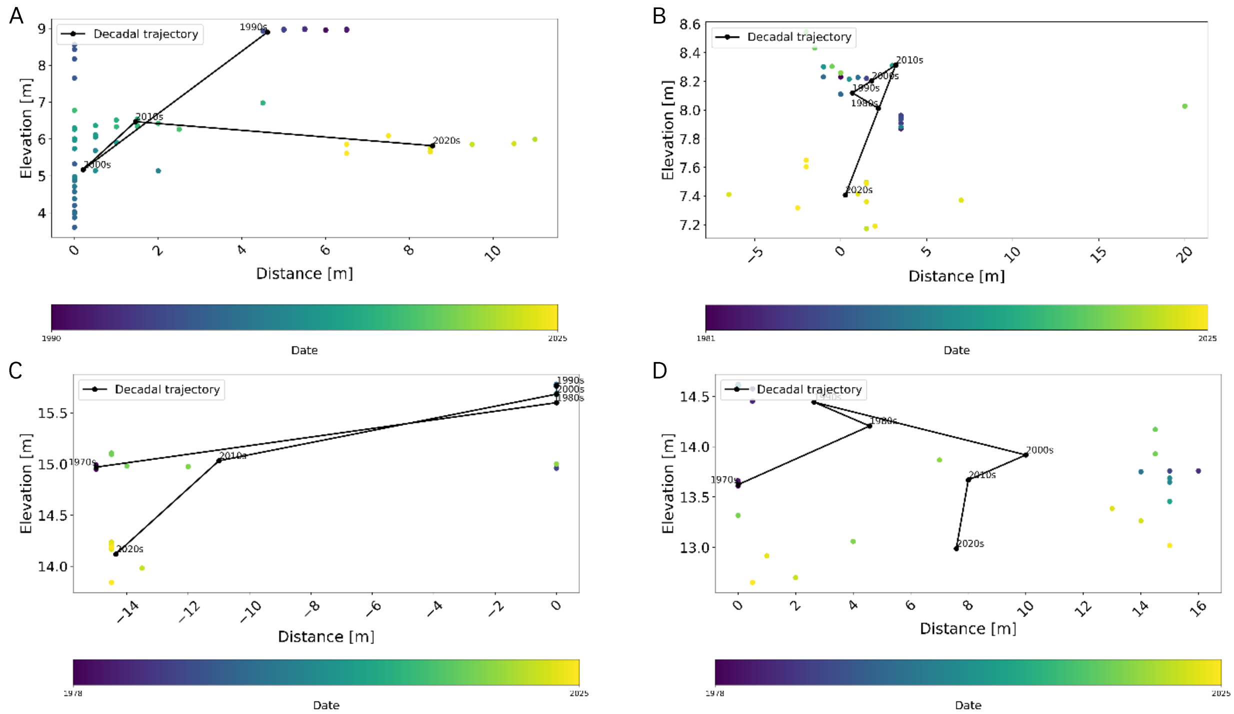

Figure B 3: Changes in foredune position at Profile 2A (A), 3 (B), 6 (C) and 7 (D) at Pākiri Beach. Please note the difference In the Y axis

Omaha

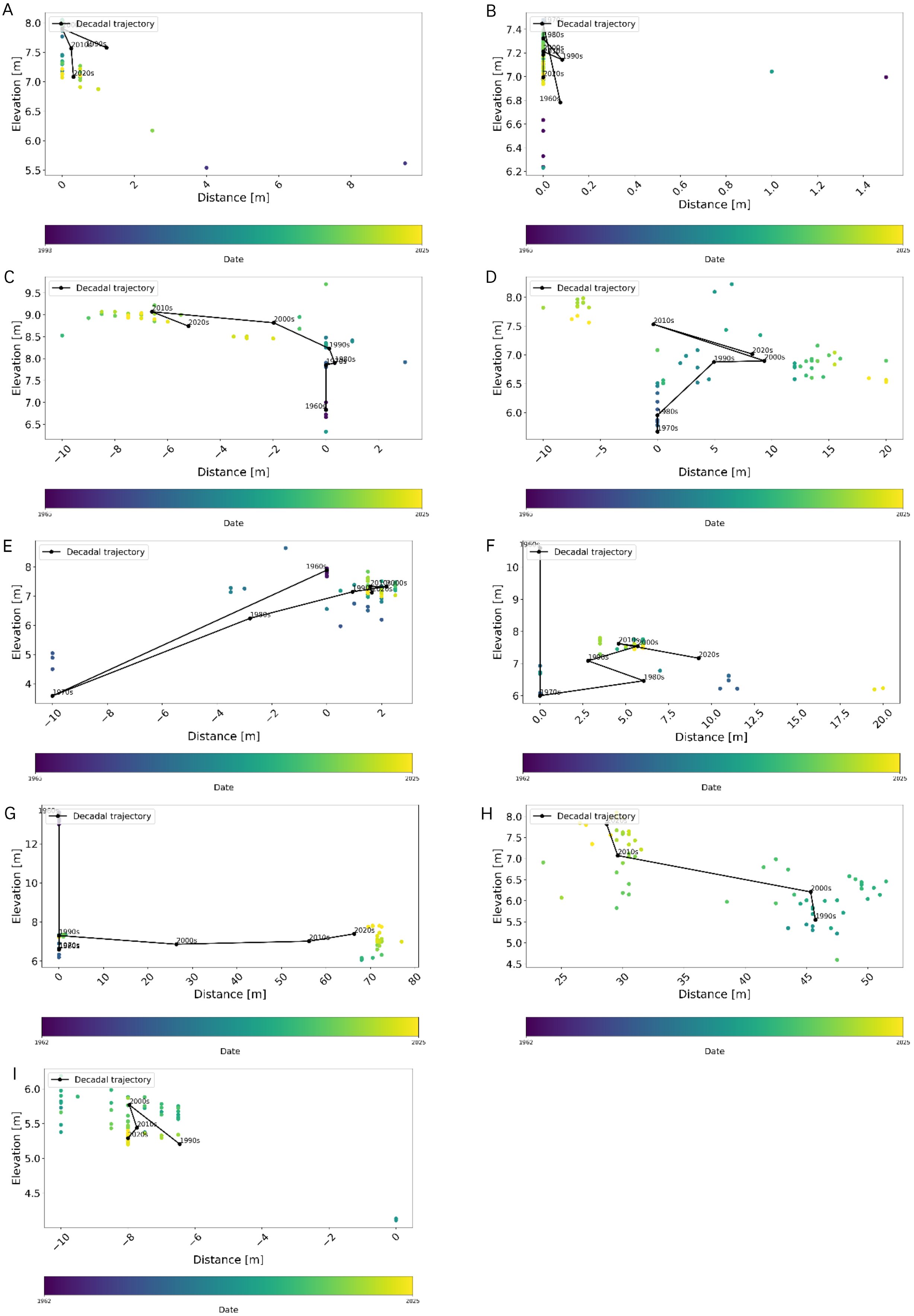

Figure B 4: Changes in foredune position at Profile 1 (A), 2 (B), 3 (C), 4 (D), 5 (E), 6 (F), 7 (G), 8 (H), 9 (I) at Omaha Beach.

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