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Braiding archaeology, geomorphology, and indigenous knowledge to improve the understanding of local-scale coastal change

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Abstract

Coastal landforms and associated archaeological records are at risk of erosion from a combination of rising sea levels and increasingly frequent high-intensity storms. Improved understanding of this risk can be gained by braiding archaeological and geomorphological methodologies with Indigenous knowledge[1]. In this paper, archaeological, geomorphological and *mātauranga* (a form of Indigenous knowledge) are used to analyse a prograded Holocene foredune barrier in northern Aotearoa/New Zealand. Anthropogenic deposits within dune stratigraphy are radiocarbon-dated and used as chronological markers to constrain coastal evolution, alongside geomorphological analyses of topographic data, historical aerial photographs and satellite imagery. These investigations revealed that the barrier is eroding at a rate of 0.45 m/y. A midden in the foredune, which has been radiocarbon dated to 224 to 270 B.P. (95 % Confidence), has been exposed by coastal erosion, confirming that the barrier is in the most eroded state it has been within the past ~300 years. Vertical stratigraphy reveals the presence of midden and paleosol deposits capped by dune sand deposits in the foredune, indicating that vertical accretion of the foredune continued over the last ~200 years, despite the barrier now being in an eroding state. *Mātauranga* played a vital role in this project, as it was the coastal *taiao* (environmental) monitoring unit of Patuharakeke (a Māori sub-tribe) that discovered the midden.

[1] In the context of Aotearoa / New Zealand it is termed *mātauranga*. We use *mātauranga* to indicate Indigenous knowledge in Aotearoa / New Zealand.

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The ecological *mātauranga* shared also played a vital role in this project, adding experiential evidence to empirical observations. The work of local Indigenous groups, like Patuharakeke, demonstrates the active use of *mātauranga*, woven with Western science methods to preserve or capture the knowledge contained within archaeological sites at risk of being lost to coastal erosion. In this study, we present a method for weaving *mātauranga*, geomorphological, and archaeological approaches to gain a deeper understanding of coastal landscape development.

Impact Statement:

The research presented is a collaboration between coastal scientists, Indigenous researchers, archaeologists, and the community from Aotearoa/New Zealand. The study integrates archaeology, geomorphology, and *mātauranga* (a type of Indigenous knowledge) to investigate a sandy coastal barrier system. The findings reveal the presence of archaeological sites that are culturally important to local Māori communities, located in exposed frontages of coastal dunes that have been eroding at 45 cm/year over the past 80 years. The inclusion of *mātauranga*, offering ecological and genealogical knowledge, was crucial to this study by providing information about the archaeological site at risk of being eroded away. The archaeological site was dated to be 200 years old, indicating that the coast hadn't been any further eroded than the current position in that time period (or otherwise the site would not exist). This study demonstrates how investigated and dated archaeological sites can provide temporal markers that enhance and extend in time our understanding of coastal landform development. This research demonstrates the effectiveness of integrating western science approaches and Indigenous approaches, offering a framework that can be adapted globally for coastal studies. This is crucial in the context of rising sea levels and increased storm activity, which threaten both natural and cultural heritage worldwide. The approach also underscores the importance of including Indigenous perspectives and knowledge systems in scientific research, which can lead to a more nuanced scientific understanding of geomorphic systems.

Key words:

Coastal change, archaeology, geomorphology, erosion, *mātauranga* Māori

Study highlights.

1. Approaches from archaeology, geomorphology and *mātauranga* are braided to improve understanding of a selected coastal barrier.

2. The coastal barrier is undergoing erosion that has exposed cultural sites within the dune that demonstrate the barrier is in the most eroded state it has been within the past 224 to 270 years.

3. The study highlights the importance of weaving different knowledge systems to improve understanding and preserve coastal landscapes.

Introduction

"There is a barrier of language and meaning between science and traditional knowledge, different ways of knowing, different ways of communicating." (Kimmerer 2013: Pg189)

Coastal barrier systems are influenced by coastal sediment budgets, relative sea-level changes, wind speed, storm-induced erosion, vegetation cover, and a variety of anthropogenic pressures (for example, FitzGerald and Buynevich, 2009; Little et al., 2017; Woodroffe, 2002; Woodroffe et al., 2011). Coastal sand barrier systems are valuable archives of climate and sea level, storm erosion, aggradation, and time-varying sand supply information (Otvos, 2020). Barrier systems evolve in three principal modes: 1) prograding, 2) transgressing/retrograding, and 3) aggrading (Galloway and Hobday, 1980). Prograded barriers record depositional history laterally and, therefore, retain the highest preservation potential of any coastal system developed within the Holocene (Caseldine and Turney, 2010; Dougherty et al., 2016; Little et al., 2017). Understanding the historical development of barrier systems is important for understanding how coastlines will respond to sea-level rise (SLR; Mariotti and Hein, 2022; Kennedy et al., 2023), providing insights into coastal hazard risk for communities (Hinkel et al., 2018; Rowland et al., 2014); and informing the preservation of archaeological and cultural heritage in the face of future SLR (Carmichael et al., 2018; Rowland, 2008; Rowland and Ulm, 2014).

Archaeological sites provide invaluable temporal and spatial information that illuminates the timing of anthropogenic effects on landforms (see Rivera-Collazo et al., 2021). Archaeological data have proven to be a valuable resource for geomorphological interpretation and have been incorporated

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into larger multidisciplinary studies to reconstruct the geomorphological evolution of landforms (Mason, 1993). For example, Caporizzon et al., (2021) utilised the position of Phoenician settlements and the remains of the La Martela Punic harbour, which were buried by fluvial sediments, to reconstruct the geomorphological evolution of the Northern Bay of Cádiz since the mid-Holocene. Other researchers have examined archaeological sites to evaluate present-day landforms and determine whether they have been affected by historic anthropogenic activities (Rivera-Collazo et al., 2015). Archaeological sites, assemblages, and artefacts have also been used as indicators of ancient sea levels, as discussed in recent reviews (Aucelli et al., 2016). Furthermore, Aucelli et al., (2016) used four geo-archaeological sites on the Sorrento Peninsula coast (Italy), where the submerged ruins of Roman buildings enabled the reconstruction of ancient positions of both past sea level and coastlines. Other studies have used archaeological sites as spatiotemporal reference points to provide radiocarbon data for coastal change research. For example, coastal landforms often contain evidence of human occupation, and radiometric dating of this evidence can contribute to the reconstruction of palaeo-coastlines and sea levels (Mason, 1993; Nichol et al., 2002).

A common element between geomorphological and archaeological investigations is the need to obtain chronological constraints. It is common in coastal geomorphology, for instance, to combine morphostratigraphic techniques such as ground penetrating radar, coring, and airborne LiDAR (Light Detection and Ranging) with radiometric methods, such as optically stimulated luminescence dating, to describe barrier development over millennial to interdecadal time scales (e.g., Oliver et al., 2017). Similarly, in archaeological investigations, for example, radiocarbon dating of well-developed palaeosols in contrast to thin humic layers within coastal barrier sequences has been useful for constraining the timing of dune accretion and mobility over several thousand years (Bampton et al., 2017; Gorczyńska et al., 2023; Sommerville et al., 2007). However, few studies have attempted to utilise oral histories of Indigenous communities alongside geomorphological and archaeological methods (Roberts et al., 2023; Westell et al., 2023).

The Western scientific community often disregards Indigenous knowledge because of the perception that it is mythical and fantastical, and hence not reliable, lacking accuracy and precision (King and Goff, 2010). However, in Aotearoa/New Zealand, Indigenous knowledge - *mātauranga* - is not only an accurate archive of oral history, landscape evolution, and natural events but has also been shown to influence and improve contemporary research (Hikuroa, 2017; King et al., 2007; Mercier, 2018). Furthermore, many oral histories are empirically derived and tested through time, and hence scientific, but explained from a Māori worldview (Hikuroa, 2017).

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Early use of oral histories sometimes suffered from loss of contextual framework, misrepresentation of data, or a tendency to accept insights only if confirmed by science (e.g., Bedford, 1996; Davidson, 1967). Hence, archaeologists and Māori scholars have not always agreed to the use of oral histories as textual sources to confirm the accuracy of ethnographic descriptions (e.g., Anderson et al., 2014; Campbell, 2008; O'Regan, 2016). Critics caution that combining methods might cause conflicts between Western science (e.g., archaeology/geomorphology) and Māori scholars. One issue might be a failure to recognise the significance of *whakapapa* (genealogy) (Hikuroa, 2017; Marshall, 2021). *Whakapapa*, as emphasised by Royal (1992) and Roberts (2012), is a fundamental element that underpins tribal histories and imbues meaning into human actions and understanding within the Māori community. According to Tau (1999), *whakapapa* is used to encode events relative to their ancestors rather than assigning them to a specific point in time. Tau (1999) also pointed out that applying chronology to genealogical time is akin to historicising a past that is not linear. Instead, *whakapapa* is a narrative construct to map the natural world and its phenomena and serves as a mental framework for comprehending places. Tau (1999) emphasised the importance of layering Māori knowledge and referencing places, ancestors, and key figures as memory cues for retaining vital information. Wehi et al., (2020) also emphasise the importance of layering Māori knowledge and referencing places, ancestors, and key figures as memory cues for retaining vital information. Thus, *mātauranga* has a distinct ordering system that may lead to misunderstandings if stories and their elements are interpreted using a different knowledge system rather than within the context of ancestry and cultural experience (King and Goff, 2010). This differs from the geomorphological and archaeological perspectives of time, which consider the diachronic past, present, and future.

Research that seeks to braid Māori and Western scientific approaches requires active collaboration with Māori researchers and the ancestral community, who provide and contextualise oral history. In undertaking this kind of work, the "braided method" is a theoretical framework that enables the braiding of Indigenous and Western knowledge systems to examine the same physical environment, although from distinct ontological viewpoints (Tengö et al., 2014; Macfarlane et al., 2015). According to Atalay (2020), a braided knowledge approach should acknowledge and credit knowledge carriers, follow cultural protocols, and allow refusals.

In this paper, we aim to braid archaeological, geomorphological, and *mātauranga* methods and knowledge to investigate the late Holocene development, stabilisation, and migration of a selected coastal barrier system in northern Aotearoa/New Zealand. Few previous studies have attempted

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to combine these knowledge systems in Aotearoa/New Zealand (see King and Goff, 2010; McFadgen, 2007; McFadgen and Goff, 2007; McIvor et al., 2024, and in Australia see Roberts et al., 2023; Westell et al., 2023). We utilise archaeological data from midden[2] sites preserved in sand dunes, ecological information obtained from oral histories documented in *mātauranga*, and geomorphological analyses of barrier topography to examine barrier development from pre-contact Māori occupation to the modern day. Hence, our objectives are to (1) appropriately apply the braided approach in the context of sand barrier evolution, and (2) critically evaluate the extent to which the braided approach adds value rather than using a single approach in isolation.

Methodology

The paper's methodology embraces a pluralistic approach, braiding techniques from archaeology, geomorphology, and *mātauranga*. In Aotearoa/New Zealand, the migration of Polynesian voyagers and their settlements, as well as the development of the Māori culture and later the arrival of Western colonial powers, have left a lasting impact that has resulted in numerous archaeological sites along the coastline. The initial Māori settlement occurred at approximately 700 B.P. (Anderson, 2016a, 2016b; Bunbury et al., 2022; Walter et al., 2017). Archaeological sites are primarily located near the coast because of human reliance on coastal resources and transportation by *waka* (canoe) (Jones et al., 2023).

Patuharakeke is *tangata whenua* (local people) of the Poupouwhenua/Marsden Point area which includes Te Akau/Bream Bay (Figure 1). This is demonstrated through *ahi ka roa* (continuous occupation), *nohoanga* (dwelling place), customary practices, *kōrero* (story), *pūrākau* (tales), *tuku whenua* (gifted land), marriage, ancestry, *raupatu* (confiscated), customary *tohu* or signs (e.g., landmarks, *tuahu* and *kohatu* mauri on the land). The naming of water systems and land features is one way that *tangata whenua* demonstrate the depth and closeness of their long traditional relationship with the site and surrounding area. The harbour, and ranges and peaks that surround it, are named in *pepeha* (a set form of words) and tribal *whakataukī* (significant saying) and *waiata* (song). These provide further rich descriptors of the relationship of Patuharakeke with the Poupouwhenua/Marsden Point area and their historical ties to all resources within the area. In contemporary times, *Patuharakeke* is represented through entities such as the Patuharakeke Te Iwi Trust, and their Pou Taiao (Environmental) Unit. The Taiao Unit focuses on exercising

[2] [2]Mātaita or shell middens in Aotearoa include pre-and post-contact deposits and can include but are not limited to koiwi/human remains, artefacts/taonga, faunal remains, lithic material, and charcoal.

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kaitiakitanga (guardianship), revitalising and integrating *tikanga* (protocols) and *mātauranga-a-hapū* (community-specific *mātauranga*) practices into the restoration of the local environment. The key aspirations for Patuharakeke are the local *taitamariki* (children) who *whakapapa* to Patuharakeke. As the Taiao Unit journey through their *mahi* (work), they engage *taitamariki* in culturally informed educational programmes that encourage interest in the environment while passing down their *mātauranga* to ensure the next generation can support environmental regeneration through a mix of traditional and Western practices.

Te Akau is an east-facing open-ocean foredune beach situated on a prograded Holocene barrier system (Figure 1). Vegetation within the dune system today is dominated by *Pōhuehue* (*Muehlenbeckia complexa*), *Toetoe* (*Austroderia* spp), *Wīwī* (*Cyperaceae spp*) and Pampas (*Cortaderia selloana*) and characterised by a series of large hummocky dune ridges (average height of ~7m) that transition into a higher foredune complex in the seaward direction (~14m height). Recent storm events, such as the tropical Cyclones Hale and Gabrielle (January and February 2023, respectively), caused significant erosion to the foredune, further eroding the exposed midden (Figure 2). The ridges in the prograded Holocene barrier system generally become progressively younger towards the sea, overlaying transgressive estuarine deposits (Dougherty, 2011; Nichol, 2001). The elongated and prograded barrier sand ridges result from sediment supply (Nichol, 2001) and probably also a period of late Holocene sea-level fall (Dougherty, 2011; Dougherty and Dickson, 2012).

Furthermore, the research design incorporates oral traditions through knowledge exchange in a manner that respects *mātauranga*. The shared environmental *mātauranga* came from co-authors Juliane Chetham and Ari Carrington who are mandated representatives of Patuharakeke. The geomorphological coastal change, and LiDAR data are available through a GitHub (https://github.com/Thepastfromabove/Braiding-Archaeology) account. The *mātauranga* and archaeological data, such as oral history, C14 dates, faunal, charcoal, archaeological recordings, and 3-D scans will be managed by Patuharakeke as the information relates to the intricacies of the archaeological site which holds *kōrero (information)* related to the *iwi (extended kinship group)*.

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Archaeological approach

A midden exposed by storm erosion (and subsequently nearly completely eroded by storms in 2023) was discovered within the foredune at Te Akau Beach in 2020 by Ari Carrington of the Patuharakeke Pou Taiao Unit. The stratigraphy of the dune comprises seven distinct units/layers (Figure 3). The excavation of the midden layer (Layer 3) was carried out using column sampling, following the protocol established by Casteel (1970). Two columns, each measuring 20 × 20cm, were placed along the length of Layer 3, with a spacing of approximately 2m between them. At the juncture of Layer 3 and Layer 2, there is a fire scoop[3]. The second column sampling was strategically positioned to analyse both the fire scoop and the underlying midden material. The first column comprised four 10cm spits, while the second column had three spits. Each spit was collected in a 1-litre sample, resulting in a total of 7 litres for the entire midden, which was then bulk-sampled. Straightening the exposed section for stratigraphic drawing, 3 litres of additional material was collected as a labelled surface sample. After column sampling, the collected material was sorted using a 2.8mm sieve, which separated various components, including faunal remains, shells, sediment, rocks, charcoal, and artefacts. An assemblage of shells, fish, birds, and marine mammals was analysed by CFG Heritage (consultants), employing the methodology outlined by Campbell (2016) to analyse fish and bird assemblages, and Parkinson (1999) for shell species and habitat identification. Marine mammal bone analysis was undertaken by Matthew Campbell using the University of Auckland Archaeological Laboratories reference collection. Due to the small size of the assemblage, it was analysed as a single assemblage rather than a spit assemblage.

To establish an age chronology for the midden, charcoal samples were collected from the buried soil (paleosol) and coastal midden. The identification of the charcoal species was carried out by R. Wallace from the Anthropology Department at the University of Auckland. The charcoal used for radiocarbon (C14) dating included Hebe spp., *mānuka* (*Leptospermum scoparium*, tea tree), *kānuka* (*Kunzea ericoides*, tea tree), and *tōtara* (*Podocarpus totara*). Four terrestrial C14 dating samples were taken from the midden (Layer 3, Q07/1495), and one from the buried paleosol (Layer 5). Charcoal was analysed at the species level, and a short-lived species was used for the C14 dating process (Tables 3 and 4). Materials suitable for dating were sent to the University of

[3] A firescoop is essentially a hearth without a substantial presence of firestones. This type of hearth is characterised by a shallow depression used for holding a fire, primarily distinguished by its lack of abundant stones typically used to retain heat.

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Waikato Radiocarbon Laboratory for AMS radiocarbon dating. OxCal v4.4 (Bronk, 2018) was used to determine the age of start, end and duration of each Phase. The OxCal software was used to calibrate the C14 dates, employing the SHCal20 curve for the Southern Hemisphere (Hogg et al., 2020). A Bayesian Sequence Analysis was developed and is shown in Figure 3 and modelled boundary ages are shown in Table 2. High convergence values (>95.4%) generated by the MCMC algorithms indicate that the model is robust (Brock, 1995). The 1860 boundary end is an archaeological statement that the material does not contain colonial/postcolonial materials.

Geomorphological approach

A historical coastal change analysis was performed using the methodology outlined in Jones et al., (2024) to quantify historical erosion and accretion trends. From 1942 to 2023, 17 coastline positions were captured using aerial photography and satellite imagery (Dickson et al., 2022). Vectorised lines in the aerial and satellite imagery represented the coastlines. The edge of vegetation (EOV) was used to define the dune toe, as an indicator for the coastline (Jones et al., 2024). The Digital Shoreline Analysis System (DSAS; United States Geological Survey) was used to assess coastal changes (Himmelstoss et al., 2021). Weighted linear regression (WLR) and net shoreline movement (NSM) were calculated using the EOV. The WLR was utilised to determine the annual average rate of coastal change. WLR modifies traditional linear regression by assigning weights to coastline data points based on their reliability or significance. The NSM was used to quantify the overall coastline position change over time, reflecting erosion or accretion patterns along the coast. We utilised the centroid of the midden as a reference point to analyse the recovery and erosion of the beach over time.

To acquire topographic elevation data for the dune system, the Northland Regional Council and Land Information New Zealand supplied a LiDAR point cloud. The ground points were classified into a digital elevation model (DEM) using Empirical Bayesian Kriging with a horizontal resolution of 1 m. Elevation profiles were obtained from the DEM to further examine the prograded-barrier coastal ridge system.

High-resolution three-dimensional models of the foredune and archaeological sites were captured before (3 Oct 2022) and after (23 Feb 2023) an ex-tropical cyclone (Gabrielle) that occurred on the 13th to 14th of February 2023. The models were captured using an Apple iPad Pro 11" LiDAR sensor (Polycam app). The scans of the site before erosion served as a baseline for the site's initial condition, whereas the scans after the cyclone illustrated the extent of the damage caused by the storm.

Mātauranga approach

The conceptual framework Awa Whiria (MacFarlane et al., 2015; Wilkinson et al., 2020) was employed to establish relationships between the different datasets. According to Wilkinson et al., (2020), this framework posits that discrete strands of knowledge may be interwoven, similar to the intricate pattern of a braided river. These strands may diverge, converge, and meander along their paths, but ultimately flow in the same direction, working towards a common goal. Knowledge holders or experts are responsible for safeguarding the knowledge stream and adjusting its path, suggesting appropriate or inappropriate connections. The metaphorical reference to "knowledge *kete*" or baskets, derived from the Māori *whakataukī* "*nā tō rourou, nā taku rourou, ka ora ai te iwi*" ("with your food basket and my food basket, the people will thrive"), symbolises the braiding of Western science and Indigenous knowledge through a Māori worldview, emphasising respect for the integrity and sovereignty of each stream, and the value to be gained by drawing from them both (Wilkinson et al., 2020). Furthermore, this relates to another reference whereby Tāne (deity of forests) brings “*ngā kete e toru o te mātauranga*” (three baskets of knowledge) the origin of knowledge, from the realms of the deities for humans to use.

It is important to note the selection of the site and the fact that a midden was exposed due to coastal erosion, was ascertained from local knowledge, and is a form of *mātauranga*. Patuharakeke actively monitor coastal areas in their *rohe* (territory) as part of their role as *kaitiaki* (guardians) and actively *manaaki* (assist) with archaeologists. Working together, archaeologists and *kaitiaki* attempt to retrieve and care for the information in coastal archaeological sites before they are taken by *Tangaroa atua* (ocean deity). In practical terms, and the context of Te Akau Beach, key sections of written and oral information from cultural assessments were identified and noted when they pertained to coastal information (following the method outlined in Macfarlane et al., 2015). These cultural assessments were provided by Patuharakeke, a tribal nation who are *ahi kā* (trace their ancestry back to primary ancestors who lived on the land and have continuously occupied these lands) for the area, and hence *mana whenua* (hold jurisdiction over the area), and contained *mātauranga* relevant to the research. As the research focused on the coastal evolution of a barrier system, relevant *mātauranga* was identified in oral and written information. For example, observations related to the coastal barrier system, specifically vegetation cover, how people interact with that system, any natural events observed, and potential anthropogenic pressures. The connections between these elements were then discussed among the authors,

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including how they interconnect with archaeology and geomorphology. To ensure transparent dissemination of information, recorded notes were stored in a cloud drive accessible only to the authors. The selected text was then presented to members of the Patuharakeke Te Iwi Pou Taiao unit to ensure that the text was correctly understood and utilised. This meeting followed a *hui* (meeting) and *wananga* (discussion forum), which took place on 12 December 2023 at the Patuharakeke Te Iwi Pou Taiao unit office. Through this process, it was determined how and where certain strands connected and which did not, ultimately contributing to a deeper understanding of the coastal environment in the past. This information is displayed in Table 1, showing how the verified data from the *wananga* (discussion forum) relates to the archaeological and geomorphological datasets to enhance the interpretive power of the analysis to better elucidate coastal changes in the coastal barrier system.

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Results

Archaeological findings

The foredune in which the midden lies reaches ~7.5m above mean sea level (amsl) (**Error! Reference source not found.**, see **Error! Reference source not found.** for layer descriptions). The midden (layer 3) is composed of a single layer ~50 cm thick and occurs near the top of the dune section at ~7m (amsl) (**Error! Reference source not found.**). At the juncture of Layer 3 and Layer 2, there is a fire scoop. Layer 3 is capped by dune sand A (layer 2) ~0.5m thick, and below dune sand B (layer 4) ~1.7m thick. Below this is a paleosol (layer 5) ~0.3m thick, and below this is dune sand C (layer 6), which is >5.3m thick (measured to excavation extent).

The midden was primarily composed of *hūai* (cockle, *Austrovenus stutchburyi*), *pipi* (*Paphies australis*), and *tio* (oysters, *Ostrea* spp.) (Tables 2 and 3). Of the 76 fish bones identified, 59 were vertebrae and 17 were cranial. There are similar numbers of vertebrae and cranial bones in fish; therefore, the high number of vertebrae relative to the cranial indicates that fish were being processed at the site. Although only 76 bones were identified, the fauna was quite diverse, with 10 species of fish identified. Given the low total number of identified specimens (NISP) score (76), no statistical analysis was performed. Three bird bones were found, one a small fragment, while the other two were from birds of the size of a gull or *tūī* but could not be identified. Some bone fragments of marine mammals, mostly unfused vertebral plates, were found. These are large (~15 cm long) and most likely originate from juvenile whales.

Charcoal identification in the midden (layer 3) deposit was a mosaic of *kanuka* (44%), *manuka* (22%), and *pohutukawa* (18%) (**Error! Reference source not found.**). Charcoal analysis suggests the utilisation of vegetation to produce fire, which may have been employed for cooking or smoking fish and shellfish (Wallace and Holdaway, 2017). The use of fire by individuals is inferred from the presence of charcoal (and fire-cracked rock) among the shells and faunal material in the midden. Below this layer, a dune sand layer (4) lies atop a paleosol layer (5) that contains bracken, suggesting the presence of herbaceous and small scrub species in the area. However, further analyses to identify specific species would require larger sample sizes. The discovery of predominantly herbaceous material rich in charcoal along the entire length of the foredune, beyond the extent of the midden (3), indicates that a significant quantity of fire accumulated in a continuous layer of charcoal within the foredune.

The radiocarbon ages obtained from layers 3 and 5 imply a depositional history related to human activity for approximately 580 years (**Error! Reference source not found.**). The middle layer (3) is nearly 300 years old with a date range of 220 to 270 B.P. (95% Probability), and the lowermost palaeosol layer (5) was deposited 505 to 540 B.P. (95% Probability). The paleosol layer is laterally extensive in the subsurface architecture of the dune structure, extending well beyond the midden layer, and is visible in sections along the length of the foredune at Te Akau.

Geomorphological findings

The Te Akau coastal barrier exhibits a distinct arrangement of ridges and swales, as evidenced by the topographic cross-section moving inland from the sea (Figure 3). The dune crest is ~7.5m above the dune toe, with a steep face of ~33°, close to the angle of repose of dune sand (Shand et al., 2015). The cross-sectional view of the foredune (Figure 3) reveals a notable scarp after cyclone Gabrielle, around 1.5m high, suggesting that the storm had cut back into the foredune. Landward of the foredune, a series of dune ridges, reaching approximately 13m in height (asml) extends 200-300 m inland. Based on the topographic data these dunes are typically 12 m wide and characterised as narrow dune ridges. Low (~5m amsl) and wide (~100m) beach ridges are present further inland, forming an undulating terrain shaped by falling sea levels in the late Holocene (Dougherty, 2011; Dougherty and Dickson, 2012). The approximately 6.5 m difference in elevation between the higher dune ridges near the foredune and lower beach ridges further inland may indicate a change in coastal evolution at some point in time.

A radiocarbon date of 5750 B.P. obtained on the outer barrier by Osborne (1983) (Figure 2) indicates that beach ridge formation was active during the mid-Holocene period. Osborne conducted a bulk C14 date on eight shell valves from the beach sand and yielded an age of 5750 + 140 years B.P. (NZ-6376A). The locations of this date (5750 B.P.) and the midden date (224 to 270 B.P. (95% Probability) presented herein are separated by approximately 900m, implying a minimum barrier progradation rate of ~0.16m per year during the mid to late Holocene. A scarcity of detailed chronological information means that little can be said about the history of barrier development, including the relative importance of drivers such as sea level change and sediment supply (Nichol, 2002). However, it is notable that an abrupt change in barrier morphological development has occurred at some point between beach ridge formation in the mid-Holocene (indicated by the radiocarbon date of 5750 B.P.), and the development of high foredunes in more recent centuries (indicated by the midden and paleosol radiocarbon dates of 224 to 270 B.P. and 506 to 538 B.P. (95% Probability), respectively). The midden and paleosol dates suggest that

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vertical accretion was occurring in the high seaward foredunes between at least 506 to 538 -224 to 270 B.P. Nearly 0.74m of dune sand separates the midden and paleosol, indicating a vertical accretion rate of 0.0027 m/y and above the midden lies 1.5m of dune sand, indicating a vertical accretion rate of 0.0006 m/y. It is unlikely that vertical accretion is continuous, but rather the result of multiple cycles representative of the change envelope of Te Akau.

Historical coastal change analysis has revealed erosion and accretion patterns along the Te Akau coastline. In the central and northern regions of Te Akau, particularly near Whangārei Harbour, the coastline is accreting (prograding seaward), with rates ranging from 0.46-3.46 m/yr (Figure 4). However, there is also erosion, particularly in the sections where the midden has been exposed. The rate of erosion in these areas reaches -0.45 m/yr, leading to slumping of the foredune face that contains the midden layer. The presence of the 200-year-old midden shows that coastal erosion has not advanced landward beyond this position in the past 200 years, as the midden remained intact (pre–Cyclone Gabrielle) dating back to 224 to 270 B.P. Historic coastline positions reveal that the coast has retreated approximately 20 m between 1942 and 2023, with ~10m of this erosion occurring during Cyclone Gabrielle in February 2023 (Figure 6). The midden (Layer 3) sampled before the storm was severely impacted, where most of the shell material was removed leaving only a remnant thin black layer of where the midden was (Figure 7).

Mātauranga Māori

In total 10 quotes from the *mātauranga* oral and written history were selected for inclusion in this paper (**Error! Reference source not found.**). Selected quotes are provided in the text of this section alongside relevant information from archaeological and geomorphological datasets. The following passage presents mātauranga that delves into the coastal environment of Te Akau:

"Patuharakeke have many wahi tapu [sacred sites] including ancient urupa [burial grounds] that still contain the remains of important and illustrious forebears. Patuharekeke are kaitiaki [guardians] of these urupā [burial grounds]. These are mainly on the coastal fringes, and some have been either eroded away or subsumed already by encroaching mangrove mudflats and in some cases dense overgrowth." (Chetham et al., 2020:45).

The text emphasises two key factors: the location of historical burial grounds along coastal margins, and the threats to significant cultural heritage sites posed by coastal erosion and mangrove growth, as recounted in oral traditions. Moreover, this passage highlights the broader

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geomorphological context, indicating the destruction of burial sites resulting from coastal erosion in these areas. The next passage highlights the range of past human activities at Te Akau.

"Poupouwhenua Block is depicted in Figure 5 below. This location was an extremely particularly important tauranga waka[4] and was utilised often by various war parties stopping there to prepare for battles further south. Preparations included training and discussions of tactical warfare. The number of war parties varied between small groups of 20 to 50 to some numbering in the thousands (Clarke, 2001:2). Up until industrial development in the 1960's it was utilised by Patuharakeke and whanaunga [relations] tribes as a seasonal nohoanga [occupation site] where a rich harvest of kaimoana [seafood] could be gathered and processed. In earlier times would have likely to have involved entire tribes particularly in times of peace." (Chetham et al., 2020: 14)

"Families would live mainly on the coast for a rich harvest of kaimoana. Food gathering would involve entire tribes at times and operations such as netting or fishing both inland and out to sea." (Chetham et al., 2020: 48)

The details in these histories align with the archaeological evidence uncovered in this study, offering insights into the daily lives of past individuals within the coastal environment.

"a rich tapestry of signifiers of traditional relationships with the Northport area. This includes the relationship of Whangarei Terenga Paraoa [the gathering place of whales] as a bountiful and rich food basket or 'pataka' that hosted seasonal migrations of descendants from in and around the [kinship] related inland hapu [grouping of families] to harvest kaimoana. According to Patuharakeke elders, prior to the construction of the refinery, a substantial mussel bed covered the takutai [seafloor] adjacent to the site, ranging from the edge of the channel into shallow water and running from Mair Bank along to the Port Jetty. "When an easterly gale blew you could just roll carpets of mussels into your sack." (Living Memories Hui, Rangiora, Takahiwai 1998)" (Chetham et al., 2020: 45)

This evidence details the significant abundance of *kaimoana*, which is supported by archaeological findings.

"Pīngao (sand sedge, Descmoschoenus spiralis) used specifically to make piper nets was gathered in Te Akau and Rauiri areas." (Chetham et al., 2020: 45).

[4] *dedicated canoe landing places*

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This knowledge of coastal vegetation present in the past pertains to the geomorphological strand, as *pīngao* only grows in coastal dune areas, predominantly the foredune (Bergin, 1997).

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Discussion

This study presents an analysis of a prograded coastal barrier system in Aotearoa/New Zealand as an example of how braiding the methods of archaeology, geomorphology and Indigenous knowledge can provide more detailed information about historical coastal change compared to using just one method alone.

Archaeological and *mātauranga* braid

Coastal barriers in Aotearoa have been frequented by Māori for hundreds of years, as they are ideal locations for fishing and shellfish gathering (Campbell et al., 2004). An archaeological investigation of Omaha Sandspit (Figure 1) identified 249 middens along the length of the barrier, dating between approximately 550-250 B.P., indicating a long period of occupation and utilisation of the area (Campbell et al., 2004). Based on the known archaeological evidence and similarities in barrier geomorphology, is likely that Te Akau/Bream Bay barrier has a comparable settlement history to Omaha Sandspit. Archaeological evidence from Te Akau shows that seasonal temporary encampments, where widespread shellfish processing activities occurred, were common from approximately 450 B.P. onwards (Bickler et al., 2007; Campbell, 2005; 2006; Phillips and Harlow, 2001; Prince 2003). Archaeological sites in Te Akau contain an abundance of *hūai* (*Austrovenus stutchburyi*, cockle) and the sandy spit at Patangarahi/Snake Bank, located 1.5km inside Whangarei Harbour, is a rich source of accessible *hūai*. Similarly, the coastline at Te Akau also contains significant quantities of *pipi* (*Paphies australis*) and *tuatua* (*Paphies subtriangulata*), which can still be found in the intertidal and subtidal zones along the beach (Williams et al., 2009). Results from this research, reported through *Patuharakeke mātauranga*, confirm that the area served as a dwelling place where people camped, gathered, and caught *kaimoana*. Further, it is reported that at Te Akau the deceased were interred, and spaces were dedicated for canoe landing. The *mātauranga* suggests continuous use of the area, which is likely to have impacted the archaeological record and geomorphological systems, which is discussed further below.

Archaeological findings from this research indicate continuous human utilisation of the Te Akau coastal area between 550-150 B.P., consistent with the Patuharakeke *mātauranga* (Table 5). The midden studied in this paper is one of several known middens situated on the southern bank of the Whangārei Harbour. Archaeological evidence and *mātauranga* suggest that marine resources

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are exploited seasonally for food procurement, storage, and trading. Other archaeological findings in the area have revealed middens within the immediate vicinity of Te Akau, ranging from 450-150 B.P. (Jones et al., 2019). These middens provide evidence of shellfish harvesting across the strand plain, where dune ridges provide locations for preparing, processing, cooking, and drying marine resources.

The primary components of the midden are *hūai*, *pipi*, and *tio* (oysters). Notably, mussel shells (mentioned in the *mātauranga*) were absent in the middens investigated in this study, whereas oysters, which require a hard substrate to attach to and hence must have been brought to the site from elsewhere, were present. The small fish assemblage was dominated by *aua* (yellow-eyed mullet, *Aldrichetta forsteri*) and *hature* (mackerel, *Trachurus* spp.), which was most likely harvested using nets (Campbell et al., 2022). *Tamure* (snapper, *Chrysophrys auratus*) is typically abundant in upper North Island middens, but is uncommon in this assemblage, along with other larger species that are often caught on baited hooks (Campbell et al., 2022). Despite the small size of the assemblage (76 identified specimens, the number of identified specimens (NISP), it seems to represent a specialised fishery.

Mātauranga suggests that the faunal and charcoal remains in the midden could be related to the cooking and drying of fish and shellfish, or to swidden horticulture, where patches of coastal vegetation were cleared for this purpose. This activity may have led to the formation of a continuous paleosol with an abundance of charcoal within the matrix. The paleosol charcoal preserved within the eroded foredune at Te Akau is found throughout the length of the foredune (extending laterally in the exposed foredune beyond the midden area). It is dated at 506 to 538 B.P. and includes herbaceous charred remains that suggest a fire that was likely fuelled by vegetation and ignited either by natural or human activity.

The archaeological findings of the paper are linked to the *mātauranga*, which suggests that families spent significant time on the coast catching a rich harvest of *kaimoana*. Food gatherings involved numerous tribes at times, and operations such as netting or fishing were conducted both inland and on the coast. The faunal material in the archaeological deposits aligns with *mātauranga*, providing a broader understanding of how and where people interacted in the coastal zone and greater confidence in our findings. The middens at Te Akau are situated within a larger cultural landscape, and archaeological evidence suggests that humans used the area seasonally. This aligns with Patuharakeke *mātauranga*, the reliable empirical knowledge gathered and tested through generations, and their associated expertise, as confirmed in Table 5. The potential loss

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of pre-human coastal vegetation may have led to a dynamic dune system, as seen at Mangawhai, south of Te Akau (Enright and Anderson, 1988). We consider this in more detail below.

Archaeological and geomorphological braid

Late Holocene sea level in Aotearoa was once thought to be relatively stable (Gibb, 1986), but in northern New Zealand, it is now considered that a sea level highstand probably reached a maximum of 1-2 m amsl around 4k B.P., before gradually declining toward the present level (Clement, 2011; Clement et al., 2016; Dougherty and Dickson, 2012; Hayward et al., 2010a, 2010b, 2010c). The scarcity of detailed chronological information for beach and dune ridges at Te Akau prevents a detailed assessment of the likely link between Holocene sea-level change and barrier development (Nichol, 2001) but a radiocarbon age from Osborne (1983) and the midden chronology obtained in this study provide some rough constraint that we present in **Error! Reference source not found.**. Beach ridge progradation was active in the mid-Holocene (radiocarbon age of 5750 B.P. [Osborne 1983]), which is somewhat earlier than the initiation of chenier barrier progradation inferred from the Firth of Thames (Figure 1) around 4k B.P. (Dougherty and Dickson, 2012; Woodroffe et al., 1983). It is possible that a high rate of sediment supply at Te Akau promoted earlier barrier progradation, but further dating of the beach ridges would be required to assess that prospect. Regardless, it is apparent that barrier progradation continued between the mid-Holocene until sometime before 224 to 270 B.P., at a rate of at least 0.16 m/yr. This progradation was supported by a falling sea level in the mid-late Holocene, and it seems likely that progradation slowed as the sea level approached the current level and stabilised.

The large foredune ridge is a conspicuous feature of the Te Akau dune system. Anthropogenic impacts are likely an important component of the development of this ridge. The presence of midden and paleosol deposits capped by dune sand deposits suggests vertical accretion of the foredune has continued over the last 200 years, despite the barrier now being in a laterally eroding state. Fires might have removed coastal vegetation, remobilising sand that was formerly trapped in vegetated beach and dune ridges. The primary components of charcoal found in the midden are small scrub species, while palaeosol layer 5 is virtually entirely bracken. The accumulation of charcoal deposits across Aotearoa during the pre-contact Māori settlement period coincided with evidence of soil instability or forest replacement by herbaceous communities (McGlone, 1983). Humans in the past have used fire for various purposes, including land clearing for access, hunting, horticulture, and slash-and-burn agriculture (McGlone, 1983). Repeated burning is

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necessary to accomplish these objectives, as it prevents forest succession and results in permanent vegetation changes (Enright and Anderson, 1988).

Enright and Anderson's 1988 barrier evolution model from Mangawhai, located ~30km south of Te Akau, is useful in understanding dune development at Te Akau (Figure 7). According to their model, a large fire occurred around 800 years ago, clearing a mixed forest that included *totara*, *kanuka*, *titoki*, lacebark and maire. This forest grew on sandy soils, on a coastal hill about 20m high and 300m from the sea. The fire's destruction of coastal vegetation initiated a period of instability. Enright and Anderson (1988) noted that after the fire, there was a volcanic ashfall, known as *Kaharoa*, dated to between 650-670 years B.P. The *Kaharoa* ash was found in remnant swales at Mangawhai suggesting that the coastal area underwent significant deflation and erosion following the fire, where paleosols formed on top of the ashfall deposits. Between the *Kaharoa* ashfall and the emergence of middens (around 650-400 years B.P.), the topography changed considerably. A deflation surface developed between the retreating foredune and the coastal hill, causing high dunes to form as sand accumulated from the deflating surface. From 400 years B.P. to the present, almost the entire foredune system has disappeared, with high dunes and scarp formation replacing it.

Applying this model to Te Akau (Figure 7), we see a similar pattern. An extensive fire (the date possibly 800 B.P. if we follow the Enright and Anderson [1988] model) cleared a pre-contact mixed forest containing species like *totara*, *kanuka*, *titoki*, lacebark and maire. Unlike Mangawhai, Te Akau shows no evidence of the *Kaharoa* ashfall. Instead, signs of the fire were quickly re-deposited into depressions like dune swales, forming paleosols. A paleosol in this study was dated to about 506 to 538 B.P., and middens at Te Akau were dated to around 224 to 279 B.P. Between the formation of the paleosol and the midden deposition, Te Akau experienced significant topographical changes, similar to Mangawhai. The retreating foredune caused high dunes to form as sand accumulated from the deflation surface. The coastal erosion that has occurred over the past 80 years (as evidenced by the coastline change analysis) and associated foredune instability might have erased parts of the earlier landscape, removing any evidence of paleosols that were deposited further seaward of the midden analysed.

Mātauranga and geomorphology braid

Patuharakeke *mātauranga* record that *pīngao* was present in the coastal vegetation at Te Akau. *Pīngao* is an endemic sand-binding plant widespread on foredunes in both the North and South Islands of Aotearoa before European contact (Bergin, 1997). *Pīngao* is said to be *Ngā Tukemata*

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o Tāne (the eyebrows of Tāne), given as a peace offering to *Tangaroa atua*, however, "Tangaroa rejected this gift and threw them to the shore. There they sprouted and grow today as *pīngao*, symbolizing the boundary between the realms of *Tāne* and *Tangaroa*" (Wassilief n.d., pg1). The *mātauranga* notes *pīngao* was used for fish nets and is one of the four natural fibres that Māori extensively use for braiding (McKendry, 2020). This is an important observation as this species has not been detected in the charcoal from the midden deposit (3) and is not typically found in archaeological contexts in Aotearoa, possibly due to preservation issues. *Pīngao* has a significant role in shaping coastal dune morphology by stabilising sandy areas and creating a continuous, hummocky alongshore landscape (Konlechner et al., 2015). Currently, *pīngao* is scarce on the dunes at Te Akau, where restoration of the species is a key aspect of Patuharakeke's coastal *taiao* work.

While archaeological records do not identify any pre-contact *urupā* (burial sites) along the Te Akau coastline, *mātauranga* indicates that such sites are present, suggesting that they may be at risk from coastal erosion. *Patuharakeke mātauranga* also records that *tohorā* (whales) and human remains were historically buried in dunes to allow for natural decay, with the bones later retrieved. Given that the paper shows erosion in the central portions of Te Akau, this knowledge can be used to focus monitoring done by the *taiao* unit and support efforts to ensure that any exposure of *urupā* or *tohorā* remains is promptly addressed. By weaving this *mātauranga* with coastal change data that show hotspots of local coastal erosion, coastal management can be tailored to protect culturally significant sites at risk from coastal changes.

Loose strands - compatibility and incompatibility of Western and Indigenous knowledge

This study has attempted to braid archaeological, geomorphological and *mātauranga Māori* methodologies to enhance our comprehension of coastal behaviour during the late Holocene (**Error! Reference source not found.**). The core research focus of each knowledge system occasionally diverges. An illustration of this is the mention of *taniwha*, which, although not directly relevant to the overarching question of accretionary dune development, contributes to a deeper understanding of how people perceived and interacted with aspects of past landscapes, and what was potentially viewed as a hazard (Hikuroa, 2020). The *mātauranga* of Patuharakeke highlights the presence of two *taniwha* (powerful creatures), *Te Rakepatupaiarehe* and *Pokapuwaiorehua*, near Whangārei Harbour. Stories of *taniwha* that cause destructive surges that threaten the lives of individuals close to the water are prevalent throughout coastal Aotearoa (for example: King and

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Goff, 2010; King et al., 2020; McFadgen, 2007). As King and Goff (2010) state, *taniwha*-related *mātauranga* suggests a long-standing recognition of the potential for treacherous conditions along a region's coastline. These *taniwha mātauranga* were developed to explain environmental hazards and have origins in traditional ways of interpreting natural phenomena as signs of something more than mere biophysical processes. Through their codification, they serve as effective disaster risk reduction mechanisms (Hikuroa, 2020). The existence of *taniwha* raises future research avenues and directly connects how people perceive and interact with past coastal spaces. This is an example of how various techniques are applied to different forms of knowledge braids. This application produces a wide array of information. However, tension arises when trying to incorporate this diverse information into a cohesive conclusion. This tension stems from the challenge of appropriately synthesising the varied data into a unified understanding or result. It's about finding the right balance and making sense of all the different pieces of information gathered from the research. What is important from a research view can also potentially conflict with community aspirations.

Wilkinson et al., (2020) highlight that Māori groups have unique values, priorities and interests in research situated in their frame of reference. For example, according to Tau (1999), blending Māori knowledge with references to places, ancestors, and key figures as memory cues can help retain crucial information. For Patuharakeke, who are responsible for their *mātauranga* and the stewardship of their *rohe*, their aims include preserving ancestral knowledge and practices and restoring cultural landscapes and *taonga* species. Middens, discussed in this paper, reveal past fishing and harvesting practices and types of wood used in coastal areas. Charcoal's plant composition offers clues for selecting plants to restore cultural landscapes. This proactive approach aligns with Patuharakeke's goal to preserve and restore vital cultural elements. The primary focus of the research in this paper aligned with the aspirations of Patuharakeke.

However, this is not always the case as Western science and Indigenous knowledge have different frames of reference. However, by pursuing a common aspiration that led to weaving these diverse knowledge systems, we argue interpretive power of the past is enhanced. The paper argues that these differences in knowledge production can facilitate co-creation and collaboration, benefiting both scientists and Indigenous communities. It benefits science as without this collaborative approach, research results can end up in the hands of the community, requiring them to interpret the findings without adequate support from the researchers. Open discussions and relationship-building throughout research projects can help address this issue,

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providing flexibility and enabling new research directions that might not strictly follow the original objectives but can yield valuable insights.

Conclusion

This paper braids archaeological and geomorphological evidence with *mātauranga* Māori to try to improve understanding of coastal change within a sand barrier across decadal to millennial time scales. The main findings of this study are: 1) Te Akau has experienced erosion of the foredune in the last 80 years, as indicated by the coastal change data and the exposed cultural sites; dating of which suggests the coast is presently in the most eroded state in at least the last 200 years; 2) The results of this research support *hapū* in the revitalisation and preservation of knowledge and goals for the restoration of cultural landscapes and *taonga* species; and 3) This case study of weaving Western and Indigenous knowledge was relatively successful, and we argue that this type of research is crucial for a more detailed understanding of coastal change in local contexts. These findings aid the development of more effective coastal management strategies that can help mitigate the consequences of erosion and other coastal hazards in the context of sea level rise.

Conflicts of Interest: The authors (s) declare no conflict of interest.

The authors declare no conflicts of interest.

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Author Contribution statement

The lead author, I (Benjamin D. Jones) conducted the majority of the research, including data collection, analysis, and manuscript writing. This work is part of his Ph.D. thesis by publication. Co-authors contributed to the study's design, provided feedback, and approved the final manuscript.

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Conflict of Interest statement

The authors declare no conflict of interest.

Data Availability statement

The *mātauranga* data, which is integral to our research, is held and facilitated by Patuharakeke (including authors J. Chetham and A. Carrington). This includes the knowledge and insights gained from the coastal taiao (environmental) monitoring unit that discovered the midden. As this

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data is of cultural significance, it is not publicly available but was used with the permission and guidance of Patuharakeke.

The archaeological data used in our study, including the anthropogenic deposits within dune stratigraphy and their radiocarbon dating, is also not publicly available due to its sensitive nature and the need to preserve the integrity of the sites.

The geomorphological data, including topographic data, historical aerial photographs, and satellite imagery, will be made publicly available. This data is be hosted on a GitHub repository (https://github.com/Thepastfromabove/Braiding-Archaeology). Please note that any use of this data should be properly cited and acknowledged.

We believe in open science and are committed to making our research as transparent and accessible as possible while respecting the cultural and archaeological sensitivities involved. We appreciate your understanding and cooperation.

Ethics Statement

The nonindigenous authors (Mark Dickson, Emma Ryan and Murray Ford), and especially the first author (Benjamin D Jones) who conducted the fieldwork, analysis, and co-lead the hui (meetings), sought the expertise of Indigenous researchers in *mātauranga* to ground and co-write the research (Associate Professor Daniel Hikuroa, Juliane Chetham and Ari Carrington). This experience has guided the first author, who is a non-indigenous researcher, to actively engage in culturally and socially responsible relationships and participate in student-teacher interchanges as a manuhiri (visitor) researcher. By doing so, all the authors respect the tino rangatiratanga (right of self-determination over *mātauranga* and cultural heritage) of Tangata whenua (local people), as affirmed by Te Tiriti o Waitangi (The Treaty of Waitangi).

Furthermore, the research design incorporates oral traditions through knowledge exchange in a manner that respects *mātauranga*. The shared environmental *mātauranga* came from co-authors Juliane Chetham and Ari Carrington who are mandated representatives of Patuharakeke, the mana whenua (recognised ancestral Indigenous nation) in the rohe (areas) of Te Akau and Te Poupouwhenua.

The oral traditions are from cultural assessments that were provided by Patuharakeke, a tribal nation who are ahi kā (trace their ancestry back to primary ancestors who lived on the land and have continuously occupied these lands) for the area, and hence mana whenua (jurisdiction over the area) and which contained *Mātauranga* relevant to the research. To ensure transparent dissemination of information, recorded notes were stored in a cloud drive accessible only to the authors. The selected text was then presented to members of the Patuharakeke Te Iwi Pou Taiao unit to ensure that the text was correctly understood and utilised. This meeting followed a hui (meeting) and wananga (discussion forum), which took place on 12 December 2023 at the Patuharakeke Te Iwi Pou Taiao unit office.

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Figure 1

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Figure 2

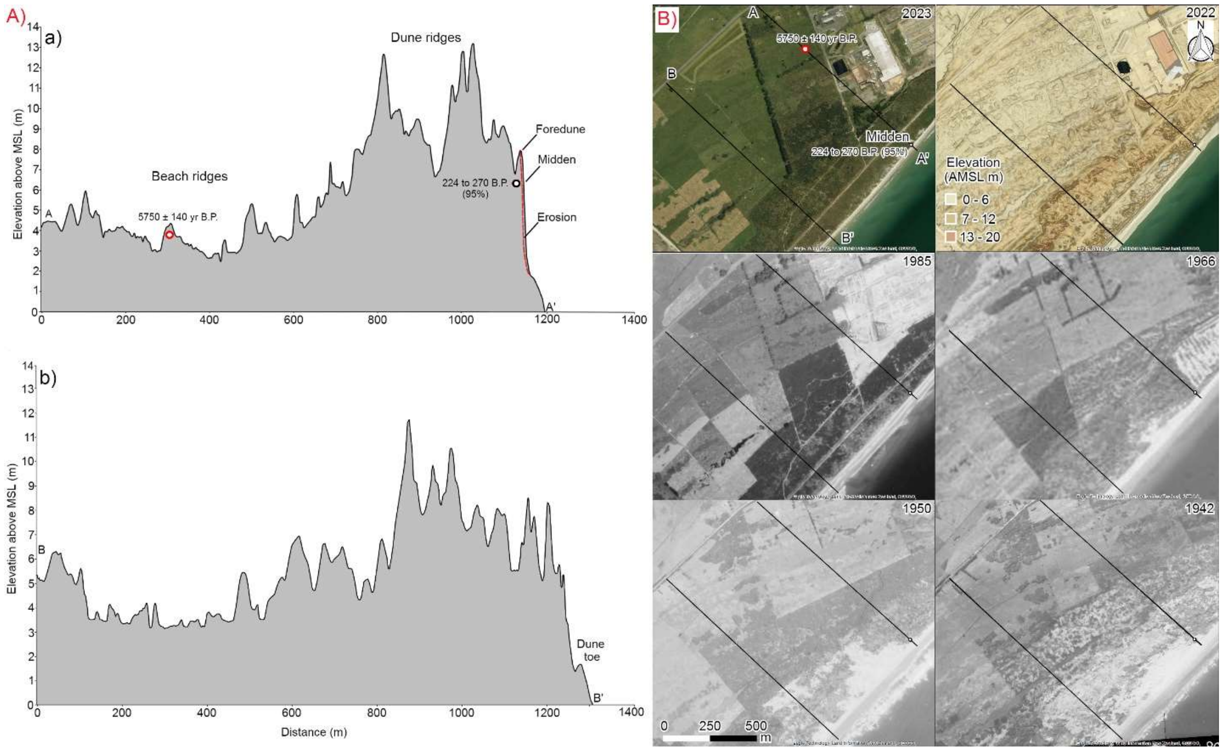

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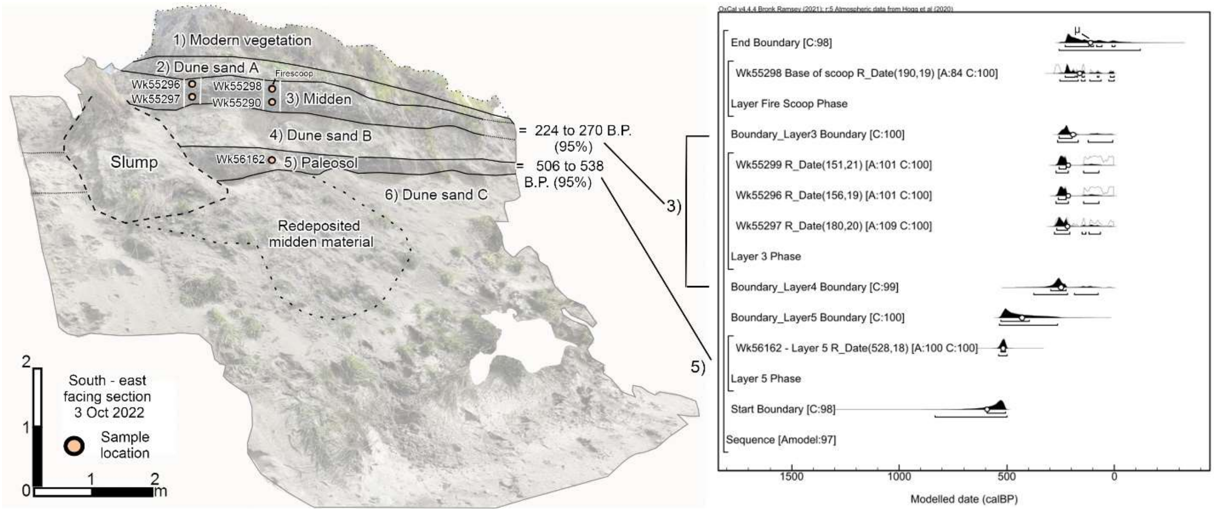
Figure 3



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1137 Figure 4

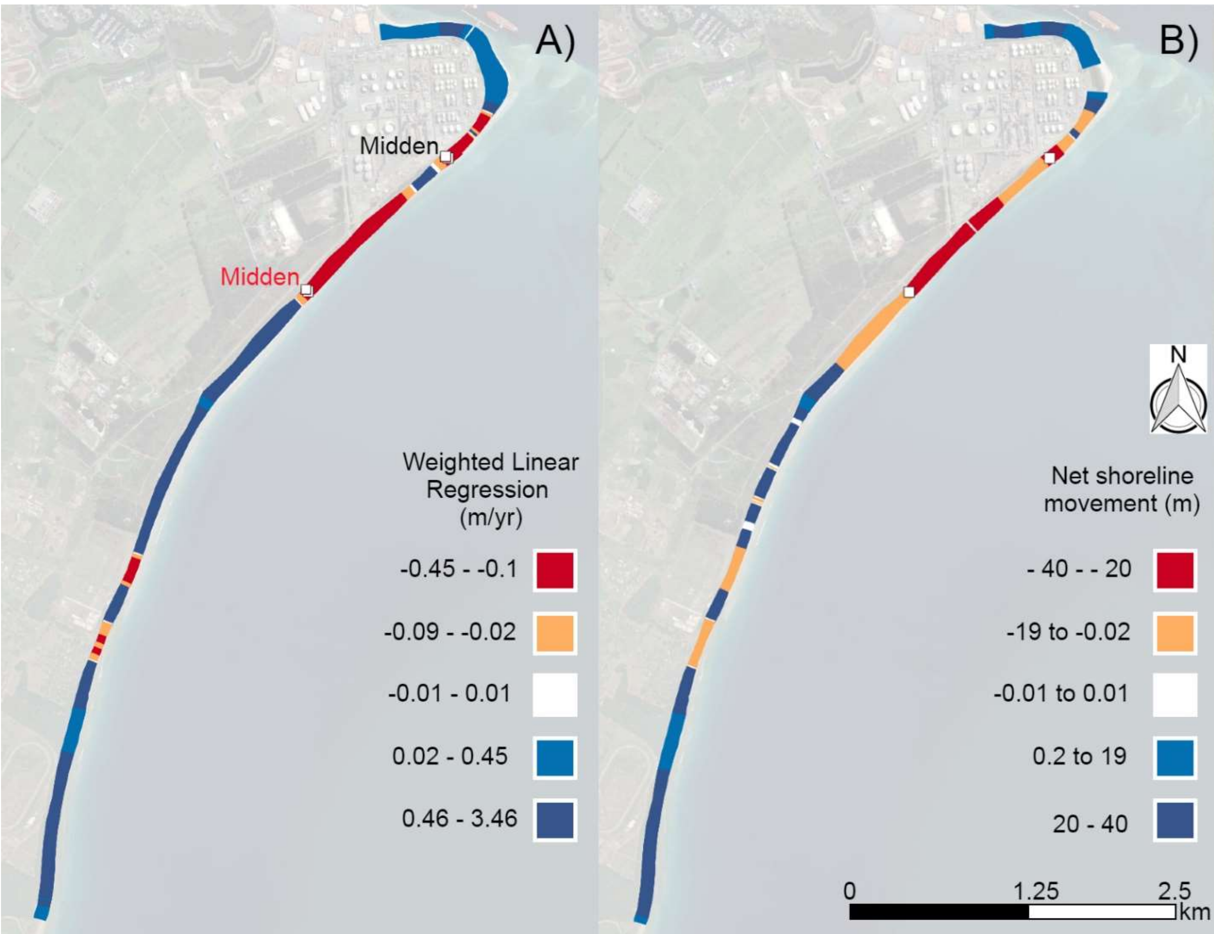
1138 

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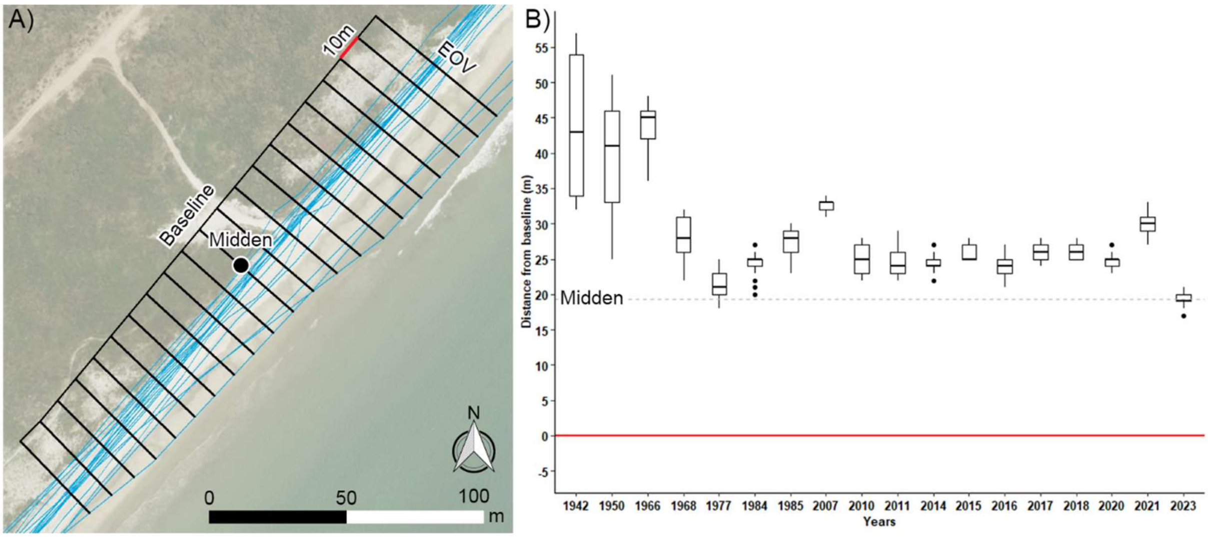
Figure 5



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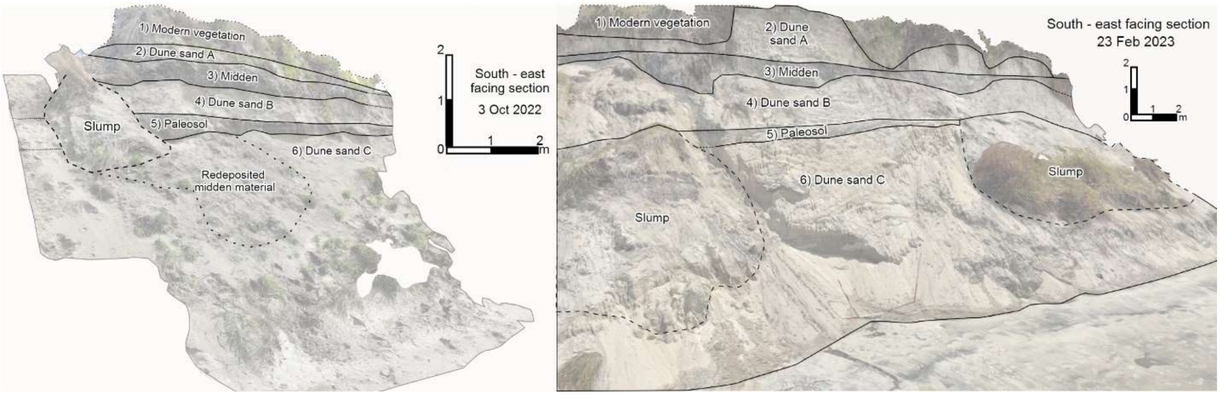
1143 Figure 6

1144 

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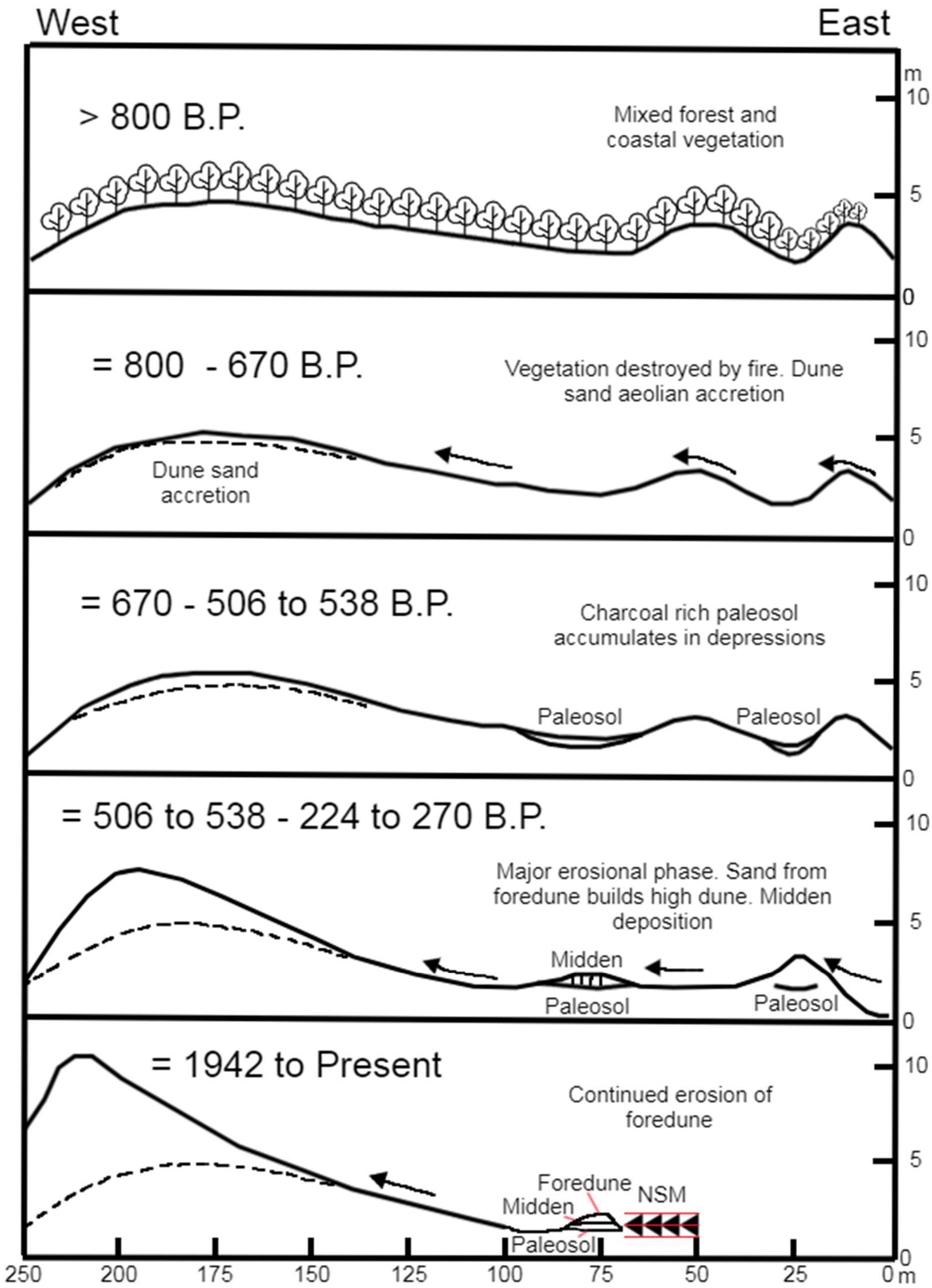
1146 Figure 7



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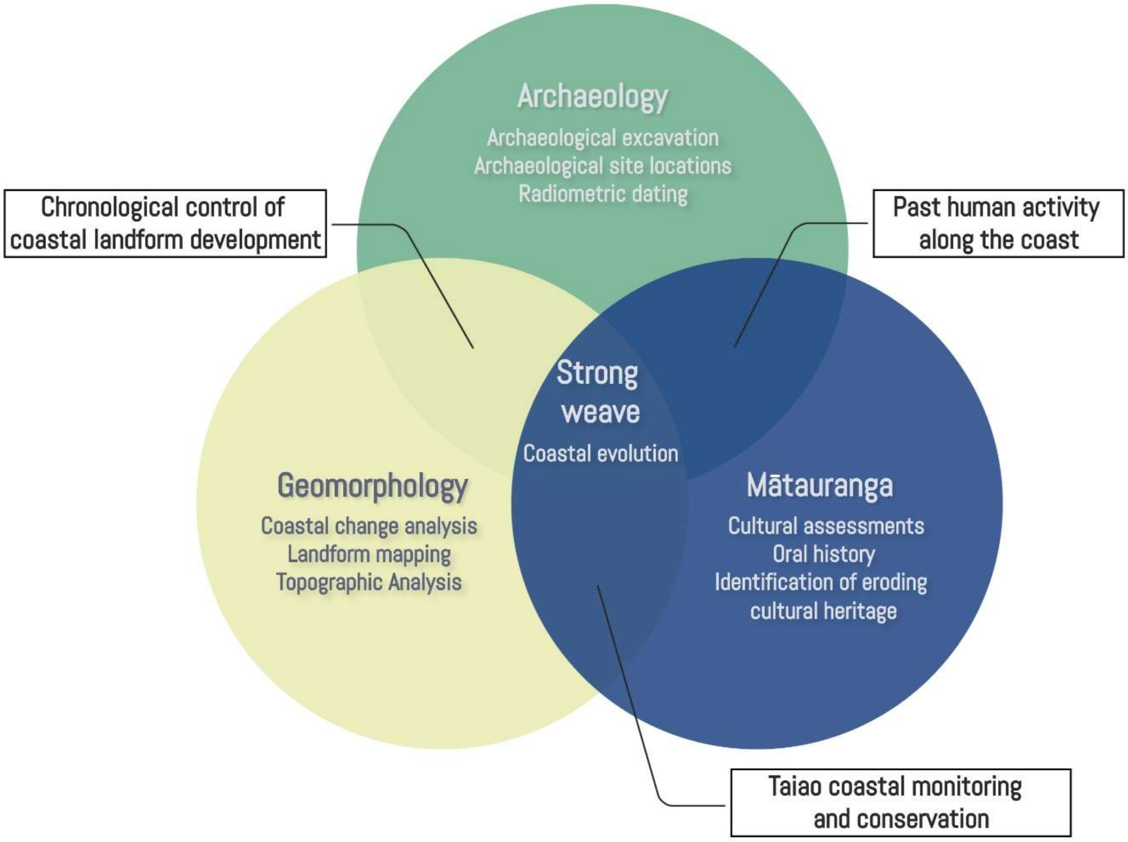
1149 Figure 8



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1152 Graphical Abstract

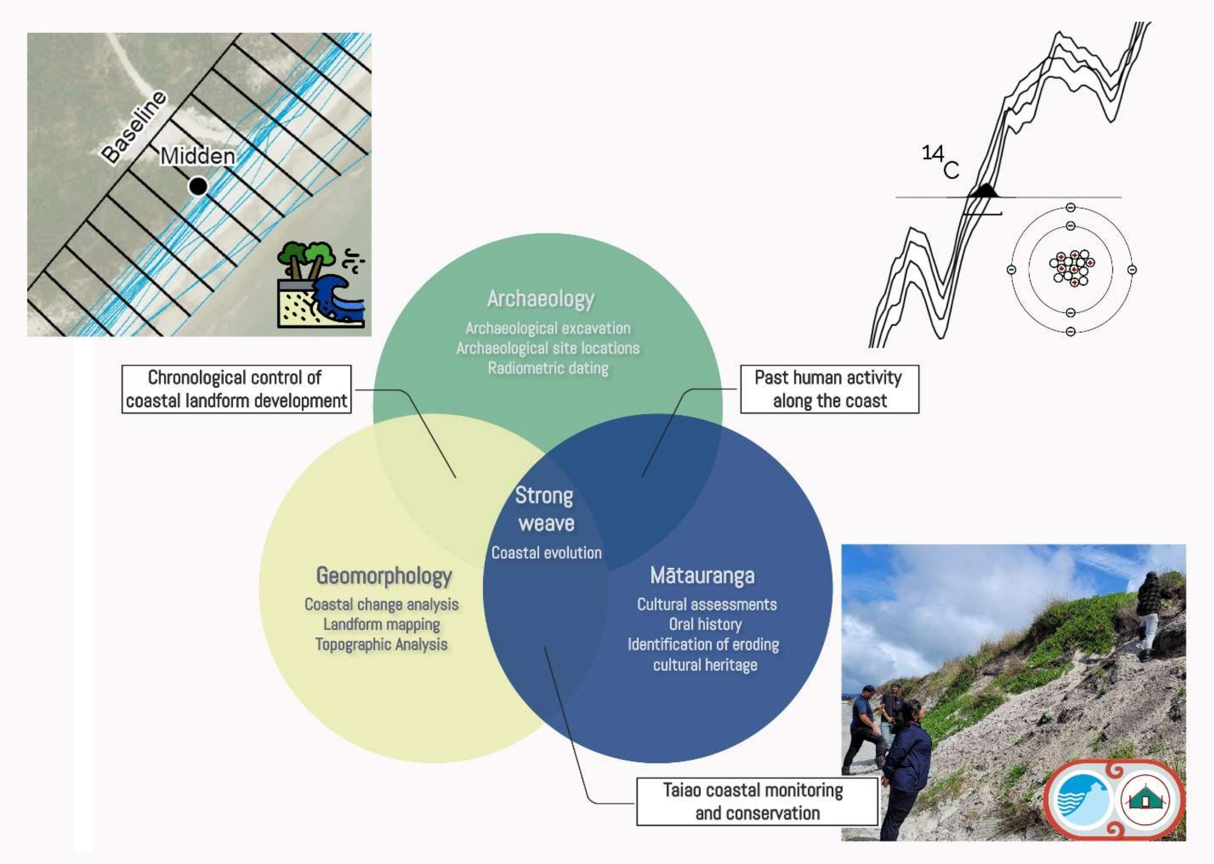

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Table 1

Theme	Mātauranga
Coastal change	“On the southern side of the harbour the Takahiwai and Pukekauri, Kukunui and Piroa (Brynderwyn) ranges circle the landscape, and the seascape is dominated by the tahuna or sand banks that are known not only for their significance as markers, but as mahinga mātaitai/kaimoana gathering places. These include Poupouwhenua/Mair and Marsden Bank, Patangarahi/ Snake Bank, Calliope Bank, McDonald Bank, and Tahuna Patupo (a historical Kuaka gathering spot).” Pg16
Coastal use	“a rich tapestry of signifiers of traditional relationships with the Northport area. This includes the relationship of Whangarei Terenga Paraoa as a bountiful and rich food basket or ‘Pataka’ that hosted seasonal migrations of descendants from in and around the harbour and related inland hapu to harvest kaimoana. According to Patuharakeke elders, prior to the construction of the Refinery, a substantial mussel bed covered the takutai adjacent to the site, ranging from the edge of the channel into shallow water and running from Mair Bank along to the Port Jetty. “When an easterly gale blew you could just roll carpets of mussels into your sack.” (Living Memories Hui, Rangiora, Takahiwai 1998).” Pg45
Coastal change	“Patuharakeke have many wahi tapu including ancient urupa that still contain the remains of important and illustrious forebears. Patuharekeke are kaitiaki of these urupa. These are mainly on the coastal fringes, and some have been either eroded away or subsumed already by encroaching mangrove mudflats and in some case dense overgrowth.” Pg45
Coastal use / change	“Te Akau Block is depicted in Figure 5 below. This location was an extremely particularly important Tauranga waka and was utilised often by various war parties stopping 15 there to prepare for battles further south. Preparations included training and discussions of tactical warfare. The number of war parties varied between small groups of 20 to 50 to some numbering in the thousands (Clarke, 2001:2). Up until industrial development in the 1960’s it was utilised by Patuharakeke and whanaunga tribes as a seasonal nohoanga where a rich harvest of kaimoana could be gathered and processed. In earlier times would have likely to have involved entire tribes particularly in times of peace.” Pg 14
Coastal vegetation	“Pīngao used specifically to make piper nets was gathered in Te Akau and Rauiri areas.”
Coastal behaviour	“Dunes are a repository for Tohorā (whale) bones” pg47.
Coastal use	“Families would live mainly on the coast for a rich harvest of kaimoana. Food gathering would involve entire tribes at times and operations such as netting or fishing both inland and out to sea.” Pg 48
Coastal hazards	“Te Rakepatupaiarehe and Pokapuwaiorehua.”.pg18 “With respect to the above-mentioned taniwha, it was also related at that same hui that a tupuna (circa 1950) had had a prophecy about the future construction of Marsden wharf. The exact wording of the prophecy is not generally known or recorded now, however its meaning related to the knowledge that the taniwha in that location was of a cautionary nature. Also, the location of the wharf had to be shifted because the piles kept disappearing or sinking. It is also recalled that three people lost their lives in the construction of the wharf.” pg18.

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Coastal hazards	"With respect to the above-mentioned taniwha, it was also related at that same hui that a tupuna (circa 1950) had had a prophecy about the future construction of Marsden wharf. The exact wording of the prophecy is not generally known or recorded now, however its meaning related to the knowledge that the taniwha in that location was of a cautionary nature. Also, the location of the wharf had to be shifted because the piles kept disappearing or sinking. It is also recalled that three people lost their lives in the construction of the wharf." pg18.

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Table 2

Species	Latin Name	Weight (g)	NISP	MNI
Cockle	Acanthocardia paucicostata	381	587	0
Dosina	Dosinia	35	31	260
Pipi	Paphies australis	118	68	18
Oyster	Ostrea spp.	0	37	36
Cats Eye	Turbo cats' eye	1	1	21
Whelk	Buccinum undatum	0.1	0	1
Gastropods Sp.	Gastropoda	0.1	10	0

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Table 3

Table 3. Fish by the number of identified specimens (NISP)	**Table 3. Fish by the number of identified specimens (NISP)**	**Table 3. Fish by the number of identified specimens (NISP)**
Taxon	Latin Name	NISP
Barracouta	Thyrsites atun	2
Blue mackerel	Scomber australasicus	1
Gurnard	Chelidonichthys kumu	11
Kahawai	Arripis trutta	2
Kingfish	Seriola lalandi	1
Mackerel	Trachurus sp.	22
Snapper	Chrysophrys auratus	2
Trevally	Pseudocaranx georgianus	5
Yellow-eyed mullet	Aldrichetta forsteri	23
Unidentified fish sp.		7

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Table 4

Taxon	Latin Name	Vegetation Category	NISP
Hebe	Veronica speciosa	Small Shrubs	1
Coprosma	Coprosma repens	Small Shrubs	6
Fivefinger	Pseudopanax arboreus	Small Shrubs	5
Olearia	Olearia	Small Shrubs	2
Lancewood	Pseudopanax crassifolius	Small Shrubs	1
Mingimingi	Coprosma propinqua	Small Shrubs	1
Ribbonwood	Plagianthus regius	Small Shrubs	1
Ngaio	Myoporum laetum	Small Shrubs	4
Manuka	Leptospermum scoparium	Scrub spp.	33
Kanuka	Kunzea ericoides	Scrub spp.	67
Pohutukawa	Metrosideros excelsa	Broadleaf tree	28

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Table 5

Dating sample	Description	Layer
1	Hebe twig 2mm diameter	3
2	Manuka twig 3mm diameter	3
3	Kanuka twig 4mm diameter	3
4	Manuka twigs 2mm diameter	3
5	Bracken 2mm diameter	5

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Table 6: Stratigraphy of the foredune

Layer	Description	Depth (m, measured from top of dune)
1	Vegetation composed of Pōhuehue, Toetoe, Wīwī and then exotic, pampas, grass	0
2	Beach yellow sand well sorted	0.42
3	Midden layer	0.77
4	Beach yellow sand well sorted	1.65
5	Paleosol composed of a black sand layer	2.6

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