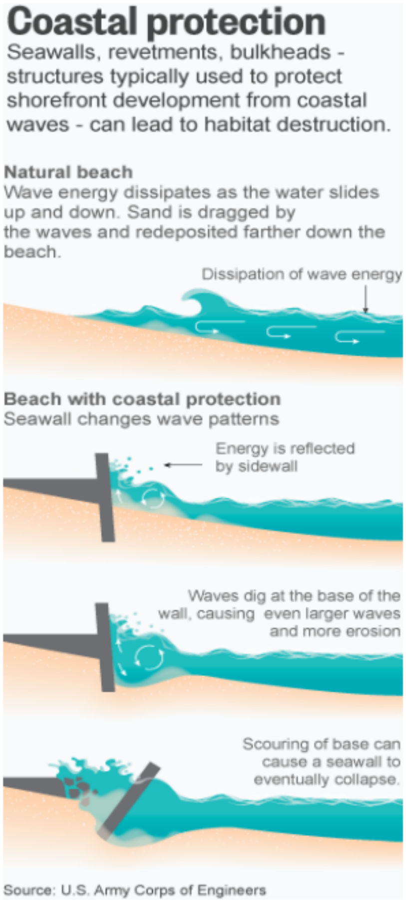
Reversal of Human-induced Dune Erosion Processes - Ōmaro Spit - attachments.

Attachment A: REUTERS - USACE Short-term Folly of Seawalls

The Short-term Folly of Seawall Construction: Reuters News, with graphic supplied by US Army Corps of Engineers



The graphic at left summarises the futility of installing coastal 'armouring' when attempting to defeat coastal erosion problems (i.e. seawalls, revetments, bulkheads etc.). International consensus increasingly reveals these fixed coastal structures provide only limited or ephemeral succour while also being demonstrably extraneous due to their short lifespan (20-40 years on average). They are also vastly expense (up to US$12,000/lineal metre of beach – that's US$12million/km) while similarly having a record of enormously increased costs with each subsequently required rebuild (Jenks *et al*, IPCC 4AR 2007). Added to all these preceding adverse factors, coastal 'armouring' **DOES NOT** even remedy the true root cause of coastal erosion. So what actually does cause or prompt that problematic erosion?

The harsh reality behind the summary at left is that dune margins in USA (and in NZ & internationally) are largely barren of functional salt-tolerant foredune vegetation; a simple and normalised fact that causes the problems demonstrated in the first image adjacent where **'Sand is dragged by the waves and redeposited farther down the beach'.**

Affordable community-engaged dune restoration work pioneered in NZ significantly improves that situation by returning the original native plants to dunes. This action changes beach drainage and function to naturally mitigate sediment loss by ensuring sand on the beach face and foredunes has significantly increased porosity – this critical and largely unrecognised functional factor minimises the removal of sand off the beach (de Lange and Jenks 2007, Müller 2011). So this natural, practical advantage then ensures all restored beach systems have increased resilience to sand losses during storms, thus ensuring more sand remains on beaches to thus avoid **any** requirement for seawall construction. And this proven protective action costs less than 1% of coastal 'armouring' while also being more naturally enduring and effective.

In fact, NZ beaches diligently restored with low-stature indigenous salt-tolerant vegetation (plants provided and perfected by harsh evolutionary processes) now actually **accumulate** further sand on coastlines, even during large oceanic storm events - storms that formerly induced significant coastal erosion. Two local beaches where this has been closely researched and monitored reveal **dune width increases** over 20 years **averaging +1.6m / year of lateral increase** (and **dune volume growth of between 1.2 and 1.7m^3 / lineal metre of beach / year).** This useful and natural resumption of progradation has occurred in conjunction with regular cyclonic storms and existing sea level rise. These results simply reflect the recorded progradation rate over the previous 7,000 years (during this sea level rise maximum or stillstand), and the era before these pivotal coastal plants were widely removed by human activity through preceding centuries.

This is the new **21st Century Paradigm** for coastal management – one that truly works in harmony with and actually enhances natural coastal processes rather than forlornly battling against them with futilely expensive extraneous structures. And significantly, this new paradigm is recognised by the IPCC as the most affordable and successful littoral management system known for reversing human-induced coastal erosion processes (Jenks *et al*, IPCC 4AR 2007).

News and graphic source: http://www.reuters.com/investigates/special-report/waters-edge-the-crisis-of-rising-sea-levels/

Attachment B: HISTORIC COASTAL SYSTEMS PERSPECTIVES

All global coastal margin dune ecosystems, such as the existing Matarangi beach–Ōmaro Spit example, were formed during the Holocene Epoch, beginning approximately 11,700 calendar years before present (BP). The Holocene onset itself was initiated *c.*19,000 years BP and accelerated *c.*15,000 years ago. A later abrupt natural warming *c.*11,700 BP, resulted in rapid melting of remaining global ice sheets. That warming also created the most recent large natural sea level rise, of about 120m above that of the Last Glacial Maximum. During that former large glaciation period (>19,000 years BP), the original Matarangi– Ōmaro 'beach' was then most likely situated far offshore from its present location – probably seaward of Cuvier Island and Aotea (Great Barrier island) near the 120m depth contour, shown on NIWA bathymetry maps). Large ancient sediment inputs derived from predominantly local Tertiary volcanic hinterland slope erosion supplied plagioclase feldsarenites (Marks & Nelson 1979) that were deposited as paleo-sediments by local river systems on those ancient beach ecosystems prior to the Holocene onset, far seaward of the current landforms, and long before the ocean achieved its current stillstand *c.*6,500 years BP.

Paleoecological data suggests those ancient coastlines and hence their natural coastal processes were originally dominated by the same four indigenous halophyte foredune plant species that still (barely) occasionally exist at Matarangi presently. These specialised indigenous plants evolved over many millennia (with the halophyte speciality first evolving about 450–470 million years ago – (Flowers et al 2010) to provide their beneficial and natural ecosystem services for dynamic control of beach / foredune erosion and natural accretionary processes. These specialist species persisted on A / NZ's 'golden fringe', that thin band of sand that progressively moved ever landward forced by the effects of sea level rises during the early Holocene epoch (Jenks 2018).

Natural processes became usefully dominant again when the existing sea levels reached their peak and coastlines reached their present locations; then the dynamic nature of coastal margins is now reflected in the typical 'ridge and swale' geomorphology of dunelands (Marks & Nelson 1979) where that archaic record is not obliterated by modern influences. Subsequently, NZ back-dune zones became dominated by older indigenous climax dune forests, with mid-dunes populated by shrubby species, increasingly salt-spray tolerant glycophytes (tolerating a maximum of 1.5% salt), while the most seaward foredune zones were exclusively occupied by the four indigenous halophyte (tolerating >3.5% salt) and sturdy low stature perennial herbaceous plants commonly threatened today (Jenks 2018).

These dynamic dunelands remained in this naturally stable or accretionary condition until people first arrived on these shores. All have left their indelible marks and impacts upon the local coastal physiography and formerly natural dune foundational processes, changing this once *natural landscape* into an increasingly degraded *cultural landscape*, one that increasingly reflects anthropological rather than natural influences. Hence the Holocene epoch is now commonly referred to as the Anthropocene due to the impacts of expanding human populations during the extended period of the Neolithic Epoch.

In human impact sequence, we are obliged to acknowledge the early natural landscape modifications of our original Polynesian settlers in *c.*14th century Aotearoa/New Zealand (A/NZ), on "*the last major temperate land mass in the world to be settled by humans"* (Irwin 2010). Among other impacts, their struggles for survival in this cooler southern land resulted in mass hunting of indigenous moa (all 4 genera in the order Dinornithiformes - plus other bird species) for their necessary sustenance and nutrition. Those pursuits resulted in the use of fire to flush moa into open areas for easier and more successful hunting. Regrettably, those fires often burned out of control and unintendedly removed much of Aotearoa's drier lowland and coastal back-dune forests. The adverse effects have been described thus: "*Late-Holocene pollen and charcoal records from New Zealand provide striking evidence for initial Polynesian arrival being strongly associated with widespread burning and loss of native forest. These forests had no previous history of fire and thus showed little resilience to the introduction of a new disturbance"* (McWethy et al 2009). These Polynesian settlers thus inadvertently created NZ's earliest and substantive ecosystem impacts: *"It is probable that Māori … also weakened the coastal vegetation, initially with their use of fire to encourage the growth of bracken fern, a major source of starch in their diet"* (McKelvey 1999).

The next and yet wider influence arose from later European settlements in this 'new' land. Omnivorous English wild pigs (boars and sows - *Sus scrofa*) were the first mammalian imports *"introduced to New Zealand by Captain James Cook, Captain Cooker pigs … have subsequently formed most of the country's wild* [feral] *pig population".* These animals were *"introduced by Cook on his first voyage to New Zealand, in 1769"* (Petrie 2012). James Cook then followed that damaging alien invasion by delivering and releasing the first damaging goats (*Capra aegagrus hircus*) to our shores in 1774. Those two separate deliberate introductions of the first destructive mammalian herbivore species in Aotearoa / NZ were both intended as 'living larders' for subsequent shipwrecked sailors in this land possessing globally unique vegetation diversities but were previously quite devoid of any grazing mammals, or their significant impacts.

These unfortunate influences were subsequently only significantly accelerated by the later 19th and 20th century European settlement period of Aotearoa/NZ. Populations rapidly expanded and these new people also required feeding, and so further herbivorous species were subsequently released: sheep, cattle, horses, donkeys, rabbits, hares, plus more goats and pigs etc. were all introduced apace. There was little time or desire for fence construction, especially in coastal locations where oceans conveniently formed a farm's seaward boundary (Edge 2020, pers. comm), and any remnant dense inland indigenous forests only limited access and slowed conversions so pastures could be expanded. So, the low, reasonably flat and warmer coastal dune plains became ideal grazing locations, this activity significantly aided by the then useful but unfortunate natural palatability of indigenous dune plants commonly and erroneously referred to as 'dune grasses'.

The many deleterious effects thus created were consequently rapidly amplified during this European settler period – these many impacts unequivocally quantified and recorded by extensive nationwide coastal surveys, the damning results presented to parliament by Dr. Leonard Cockayne. He prepared two separate *'Reports on the Dune-Areas of New Zealand'* (Cockayne 1909 & 1911), in his 1911 report he highlighted the "Geology, Botany, and Reclamation" of those now devastated dunelands. That 1911 report also usefully acknowledged precise botanical observations regarding the natural functional roles of our 4 principal and now variably threatened indigenous foredune plants, but at that early juncture their halophyte status and (simple) propagation practices remained quite elusive. But Cockayne did unambiguously report how the former dynamically stable coastal margins of A / NZ were being ubiquitously destroyed by a wide variety of human activities; *"it is not altogether easy to present a picture of the virgin dunes of New Zealand ...* [as] *there are few places where man, his fires, and his grazing animals have not* [already] *wrought great changes"* (Cockayne 1911). These many environmentally destructive activities altered the dominance and function of indigenous halophyte foredune plant species – so are the true root cause of all existing littoral erosion, in A/NZ and globally (Jenks 2018). These salient and obviously recorded facts are infrequently seldom recognised by many modern coastal scientists.

During this protracted period of European settlement, the nationwide cumulative area affected by these explicitly recorded destructive activities was quantified to be *"about 40,000ha in 1880; by 1909 the estimate had risen to over 120,000ha"* (McKelvey 1999)*;* so, the area of stable dunes destroyed by the harmful effects of simple grazing and even further burning effectively tripled in just 29 years of those rapidly expanding 19th century agrarian impacts. This latter "*120,000ha"* area amounts to an alarming 93% of New Zealand's total 129,000ha area of this nation's 1911 dunelands.

This was a young country, and for a second perplexing time, these most recent colonial settlers again plainly revealed extreme naivety regarding the true ecological and coastal instability impacts of their many early and increasingly deleterious actions. And extraordinarily, this destructive conduct was actively promoted by our early colonial governments - in 1881 the extensively moving sand dunes between Paekakariki and Wanganui were *"a consequence of coastal Crown land being leased for cattle and sheep grazing. Crown lands leased for grazing included many of the worst problems"* (Cockayne 1911).

Those natural dune ridges at Matarangi defined by Marks & Nelson (1979) as a "series of dune ridges on the ocean side" are a natural morphological response to the regularised accretion of sand in a dynamic coastal environment, especially where sand often comes ashore in dynamic pulses (usually during storm / calm weather cycles) and where that often aeolian sediment was trapped and stabilised by indigenous functional halophyte foredune plants. Unless modified by heavy machinery, these geomorphological records of natural dune function remain as physical reminders of earlier natural littoral processes resulting from recurring 'Cut and Fill' cycles.

That naturally induced physiography phenomenon is now more frequently observed on our east coast dunefields, like those also clearly seen on *c.*4,800ha of dunes from Mauao to Pāpāmoa. Such regular morphological responses on west coast dunefields did exist but are now rarely observed as the former natural dune ridges and swales were subsequently and convincingly overwhelmed and buried by vast volumes of loose sand artificially released by those ubiquitous colonial settler impacts (as credibly recorded by Cockayne, just 2 paragraphs above), and that 'released' sand was then exposed to severe and persistent westerly winds, for example, on the massive *c.*90,000ha Manawatu / Whanganui dunefield. Such unnatural aeolian sand deposits are recorded as far as 18km inland, at Rangiotu (Jenks 2018).

Clear written records remain of this artificially induced and forced dune instability that led to immense landward losses of beach and foredune sand volumes, plus those induced losses then created many of those earlier and remaining pervasive coastal erosion problems. But due to inexperience with indigenous foredune plant propagation, the colonial government became obliged to hastily contemplate and then adopt Cockayne's recommendations to use alien plants for the then necessary control of those immense insidious human-induced impacts (McKelvey 1999). And that's when the following plants began to be utilised: European marram grass; Scots, maritime and radiata pines; Californian lupin; South African iceplant and boxthorn; Mediterranean buckthorn etc.

However, all the alien species utilised by colonial governments to 'solve' those nation-wide dune erosion problems in 19th and 20th century A/NZ proved to be quite useless - all these foreign plants are salt sensitive – they do not and cannot contribute to the undeniably fundamental sand accretion functions on beaches – these alien plants are all destroyed by any contact with natural seawater containing 3.5% salt.

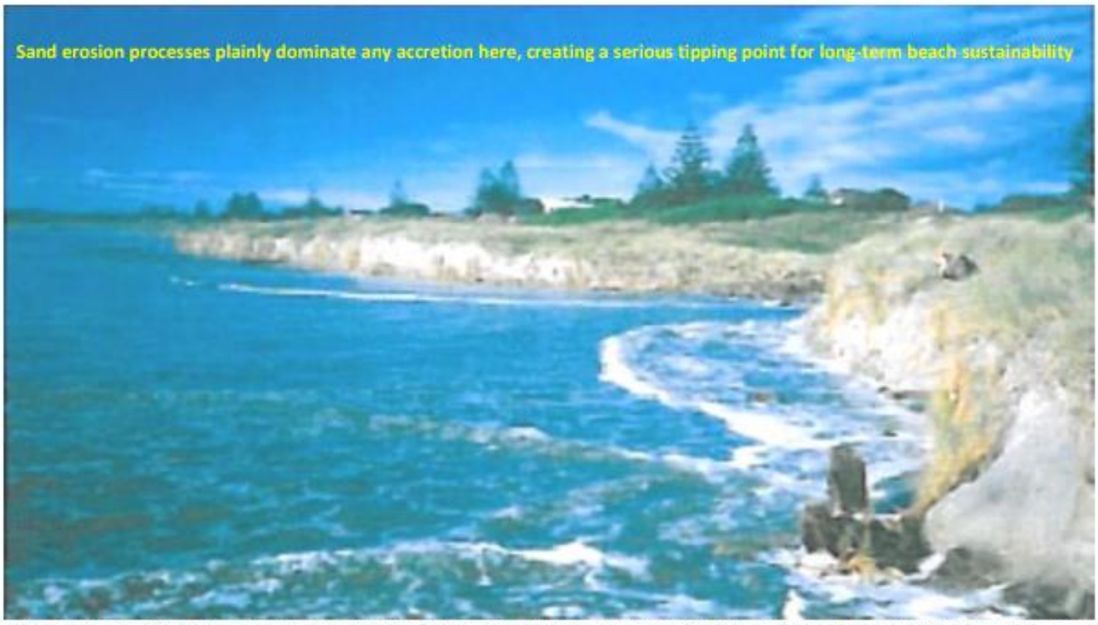
Local anecdotal information quite unsurprisingly suggests that similar unwitting ecological impacts occurred at Matarangi, much the same as at any other A/NZ location. Remnants of marram, pine forests, Arctotis, S.A iceplant, Gazania, kikuyu etc still persist on Matarangi dunes. Not one of those foreign plant species can naturally assist normal coastal processes, so where they remain or dominate, coastal erosion follows like night follows day. Some compelling examples are revealed in photos 3–6 in the main report.

Attachment C: Mount Manganui - TAY ST BEACH accretion

The image above reveals the old 2001 beach erosion scarp, when erosion was marching inland. **That problem is reliably replaced by >40m** of horizontal dune expansion. This fresh sand accumulated by simple low-cost restoration aided by the natural proliferation of superior native salt-tolerant and sand-trapping short-stature herbaceous dune plants (spinifex and pingao). This natural accretion response follows decades of beach and dune erosion here - prompted by reckless utilisation of plants now known to be sensitive of salt-water contact (i.e., the previously utilised alien plants marram & kikuyu). Simple astute restoration of the full 22km length of the Tauranga coastal zone is now complete, hence sand accumulating over these former erosion sites now exceeds 650,000m^3 since restoration first commenced in 1995 (**Jenks 2018***). In addition, the high-tide beach is now naturally wider, aiding both biodiversity habitats and amenity values, this action occurring in conjunction with increasing dune widths.
***Jenks 2018 - open the following link for further peer-reviewed research data:** Restoring the natural functional capacity of coastal dune ecosystems

Attachment D below: Mount Maunganui - Banks AVE 2020 Reversing human-induced erosion – as shown in the three photos below – all at the same location:

Mount Maunganui - Banks Avenue beach: Affordable, ethical reversal of human-induced erosion processes 1995 - 2020



Banks Ave beach and dune in 1995. Storm waves surge up this flat degraded beach system to simply be reflected by the vertical face of these eroding 'dunes'

These now extirpated dunes are typical of those found throughout the sandy coastal margins of Aotearoa/NZ (and globally). These dunes are now more correctly labelled mere mounds of loose sand clothed with remnant non-functional introduced plants like European marram & other salt-sensitive (non-halophyte) weed species) visibly inept at coping with storm erosion impacts. This exposes the reality of prolonged damaging human-induced impacts first reported to the NZ Parliament in 1911 by Dr L. Cockayne. Some indigenous salt-tolerant (halophyte) spinifex plants are present above, but these functional plants have insufficient coverage to effectively contribute to the truly natural coastal attribute of sand accretion, between and even during storms. The salt-sensitive weeds hastily recommended by Cockayne for NZ dunes (including marram) do not possess the typical characteristics required for that naturally evolved sand accumulation function possessed by our indigenous halophyte foredune plant species – see below.

Restoration of indigenous salt-tolerant foredune plants could not occur here until **1999**, when suitable sand volume returned to this beach through normal cross-shore exchange (diabathic) processes. Only then would beach stability conditions permit the narrow 5m-wide band of those essential indigenous plants to be tentatively installed.

Banks Avenue beach July 2008 – sand accretion <u>during</u> the North Island NZ 'Weather Bomb' (Ref NIWA NZ)

27 July 2008: The remarkable post-restoration effects of fresh sand accumulation during a severe winter storm – Banks Avenue beach, Mount Maunganui

- This is the same beach shown at top, but after diligent restoration of indigenous halophyte (salt-tolerant) foredune plants in **1999** (see the Norfolk Island pines).
- This functional dune is 20m wider than in the 1995 photo above and is now proving dramatically more resilient to wave erosion than that weed infested sand mound.
- This July 'weather bomb' generated onshore swells exceeding **7 metres**, with winds gusting over **111km/hour** (**WEBLINK:** niwa.co.nz/event/July_2008_Weather_Bomb)
- This accumulated sediment resembles snow rather than storm-tossed sand - note all sand is stabilised within the most seaward 10m of this restored foredune.
- The large volumes of accumulated sand are obviously both extremely soft and porous, another natural function of these indigenous foredune plants (Müller 2011).
- This photo also reveals the beach now remains unaffected by erosion, while the plants exhibit useful salt-tolerance and natural abilities to endure significant burial.

Banks Avenue beach 2020 – this restored beach just keeps further growing seawards from that narrow planting back in 1999

April 2020: The enduring fresh accretionary effects of calm weather induced sand deposition post-restoration – Banks Avenue beach, Mount Maunganui

- This is the same beach shown at top 21 years after the **1999** diligent restoration of indigenous halophyte foredune plants (see the background Norfolk Island pines).
- This functionally resilient dune is now greater than 40 m wider than the 1995 photo, a fresh sand accumulation rate approximating 48m^3/lineal m of beach.
- The high tide beach has also vastly expanded seaward – it now exceeds 50m in width, compared to the non-existent dry beach in the above 1995 photo.
- This fresh sand now has improved slope & porosity - aiding natural resilience to storm surge impacts (Müller 2011) & maintains the beach ecosystem in a positive state.
- Significant storm erosion seen in 1995 photo above no longer occurs here, though many ex-tropical cyclones have passed through here during the long post-restoration period (and see the 2008 storm shown above) - storms that still induce heavy losses on many other similarly exposed but still non-restored east-coast beach systems.
- This diligent restoration paradigm comprehensively addresses the "true root cause of erosion" (Jackson *et al.* 2012) by simply and ethically replacing the erroneously utilised surrogate introduced non-halophyte and non-functional plant species with naturally evolved indigenous functional halophyte foredune plant species.
- **No need for carbon intensive seawalls or 'managed retreat' here yet**, this community-involved restoration of indigenous dune plants has reversed erosion processes while enhancing amenity opportunities, faunal habitats and increased natural coastal biodiversity - **while actively sequestering carbon** – a true win-win-win scenario.

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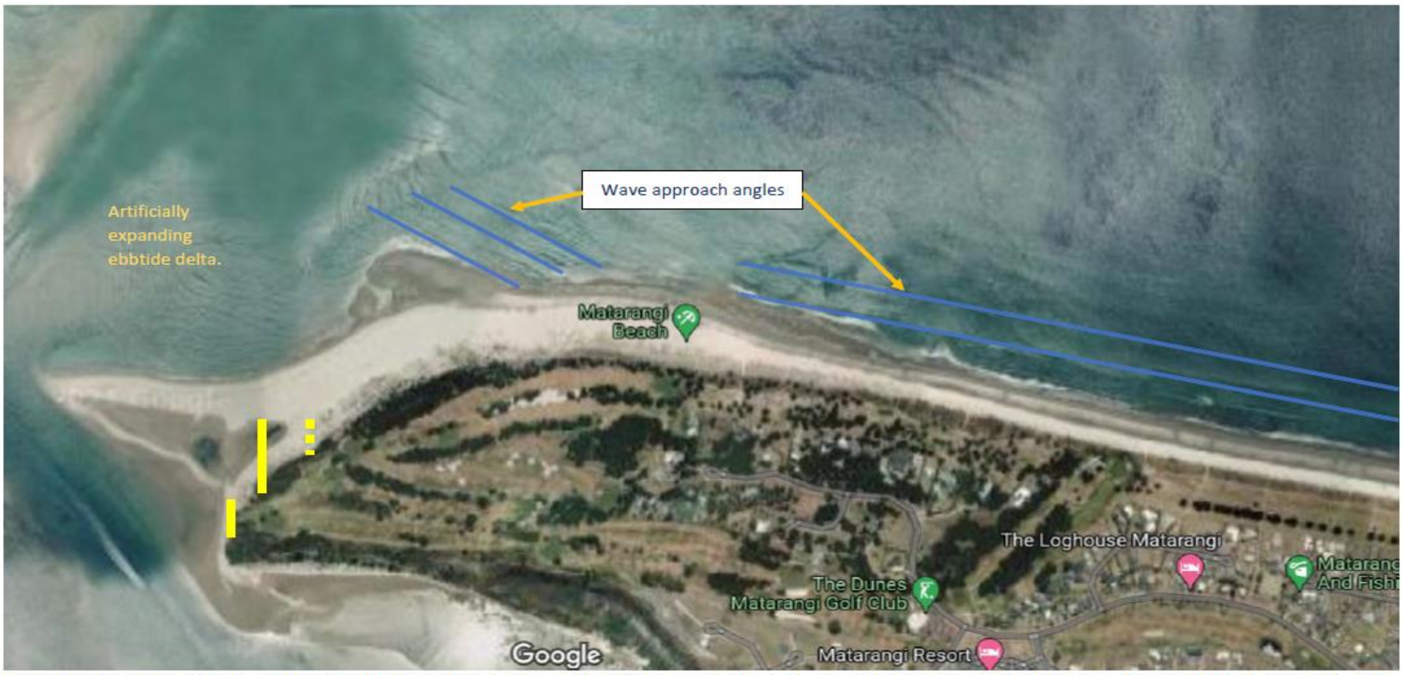
Attachment E below: Matarangi beach - Ōmaro spit erosion reversal and enduring protection.

Matarangi beach - Ōmaro spit erosion reversal and enduring protection.

The location of the two proposed sand pillow groynes (with a possible third) are shown below. Included also is the logic that supports this preferred placement.



Matarangi beach itself faces almost due North, with a slight eastern influence, as shown above. Storm swells reaching this beach are modified, reduced, and refracted by several offshore islands, including Aotea/Great Barrier, Repanga/Cuvier, and Ahuahu/ Great Mercury Islands.

As captured in the 'Google Maps' photo above, the approaching waves along the main Matarangi Beach are largely shore parallel, so having a slight NNE line. That is the common expectation for a long beach in this location. However, no beach acts in isolation, with Whangapoua Beach also receiving shore parallel waves, even though that beach has a differing alignment – more NE than Matarangi's NNE. So, the aerial photo above reflects the factual and changing wave approach angles concisely, with waves near the western end of Ōmaro spit being refracted by a combination of beach-parallel sub-tidal offshore sand bars while also responding to the influence of the Whangapoua harbour entrance ebbtide delta. These waves run up the channel at a more damaging acute angle to the Ōmaro Spit beach. The influence upon this completely non-vegetated beach is to increasingly erode the unprotected frangible dunes and so transport those eroded sand particles in an inland direction towards the Whangapoua harbour channel and beyond.

That combination of unalterable factors mean the La Niña influenced storm waves presently impacting on the already degraded and defenceless Ōmaro spit are striking that beach at an acute angle of incidence approaching 50-60 degrees. The consequent beach response to that sharp angle of attack forces those storm waves to progressively lift and push sand along the beach as each wave strikes, pushing further sand volumes along the beach and then around the spit and into the harbour channel. The response action of that channel is then to pump that fresh excess sand out to sea with each ebb tide, adding most of this unnaturally relocated sand mass originating from the Ōmaro spit out to the harbour entrance ebbtide delta, the results of which are easily observed above.

The physical reality of that present process can also be observed onshore in the photo below, taken during the beach survey visit on 14 September 2021.

The progressive lowering of beach levels is readily observed here. This lowering is being forced by the relocation of the high tide beach sand that is slowly being moved into the far distance. This eroding beach is now unnaturally overwhelmed by ocean storm surges with an acute angle of attack, this shown by the increasing height of the eroded dune scarp as this view looks towards the Whangapoua Channel and estuary. This induced lowering of beach slope encourages movement into the harbour. This image clearly reveals this now forced transport of sand along this beach system and towards that estuary. The only affordable and proven method presently available to reduce this sand relocation is to place sand retaining soft groynes by the distal end of spit, near the dead trees shown in the distance of this adjacent image.

This presently unrelenting erosion process can be also readily observed below, photo taken on the same day, but looking back towards the Northeast:

The above image reveals the impact of sand being stripped off the former high tide beach by waves impacting at 50–60-degree angles, and progressively relocating that sand into the estuarine channels.

A new drone photo (16 October 2021 - kindly supplied by Ray Fanning) also reveals similar effects of this intensified unnatural sand relocation process, but now after some expected fresh sand has returned from offshore bars. Carefully observe the angle of attack of the incoming waves (nearer to 80 degrees on this day), and the consequent poor high tide sand recovery in the bottom right corner of this photo. For superior sand trapping results, groynes function best when placed perpendicular to incoming waves – see further explanation of this sediment restraining process in the main plan report. The proposed location of one of the soft groynes (peer reviewed by Geofabrics NZ Engineer and approved on site by their contractor, Ray Blackler) is shown in yellow superimposed below. Other groynes to the north of that shown could also be considered if suitable funding allows.

As these erosion processes are unstoppable presently (with existing conditions), it is imperative that both the sand nourishment operation (push-ups) AND groyne construction occur simultaneously, or as close in time together as possible. If a preference were possible, groyne construction would slightly precede sand nourishment.

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