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Abstracts

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Mataikona Road Coastal Resiliency Study

Mataikona Road, a critical 13 km mostly gravel route, is the sole access to three coastal settlements as well as farming and forestry properties. It faces severe challenges due to climate change, with storm events and sea erosion causing significant maintenance issues. The road's small ratepayer base and low traffic volume complicate the justification for ongoing repairs, especially when such efforts are likely only /short-term solutions. Recently Cyclone Gabrielle exacerbated the situation, washing out sections of the road and necessitating a temporary diversion onto private land. This has highlighted the unsustainable nature of the current maintenance approach and the urgent need for a long-term solution to ensure continued access to Mataikona.

The community, along with Masterton District Council and Waka Kotahi, has explored various options to address these issues. Stantec facilitated a long listing workshop in July 2022 and generated a list of potential interventions, which were narrowed down using a multi-criteria analysis (MCA). The MCA considered economic, social, environmental, and cultural well-being factors. However, the most effective solutions were deemed unaffordable, while affordable options did not fully address the problems.

The outputs of the MCA, mana whenua rankings and economics assessments were presented at a further stakeholder workshop and community meeting in September 2022. This led to the preference of a hybrid option, combining elements of road realignment, increased maintenance, and selective strengthening. This option was further refined into three sub-options (A, B, C), with option B addressing critical and high risks, offering the best balance of cost and effectiveness.

Discussions with Waka Kotahi suggested funding through low-cost, low-risk improvements in discrete packages. This approach allowed for immediate remediations but carries the risk of incomplete work.

Some of the key takeaways from the study included:

- An initial drone survey was crucial in assessing the remote area with a multidisciplinary team, as well as when engaging with the community.
- Early engagement with Mana Whenua and the community identified the key drivers and constraints for the study.
- What initially was considered a coastal hazard assessment, ended up including a large geotechnical hazard component.
- Dynamic Adaptation Pathway planning can be crucial in order to create an Investment Prioritisation Plan. This allowed for funding mechanisms to be identified which ideally package works which sit within the low-cost, low-risk Waka Kotahi funding threshold.

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Applying the Ecological Impact Assessment Guidelines to a critical infrastructure project in the marine environment.

The Hutt City wharfline is used for transporting fuel from the Seaview Wharf to terminals at Seaview. It is to be replaced by a submarine pipeline to meet legislative requirements and to provide a more resilient supply of fuel to the lower North Island in the event of an earthquake. The key purpose of the works is resilience, separating the use of the wharf from the pipeline. To support the application for resource consent an ecological impact assessment was required.

The Ecological Impact Assessment Guidelines for New Zealand (Roper-Lindsay et al., 2018) were adopted to guide the assessment approach. Derving ecological values for marine habitats required a combination of practiced and accepted methods for soft sediment habitats and professional judgement around hard substrates.

This case study had multiple construction methodologies to address, a variety of habitat types to assess, and a number of difficult temporal and spatial scales to consider. But given the critical nature and location of the project, the room to manoeuvre these challenges were limited. This presentation follows the consenting process from start to finish and highlights some of the challenges of applying modified EIANZ Guidelines and generally undertaking impact assessments in the marine environment.

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On the use of regression models to reconstruct time series of wave buoy data in Hawke's Bay

Wave buoy data is essential for oceanographic purposes such as port operations, marine transport, extreme value analysis (EVA) and validation of both wave models and satellite wave measurements. Due to the nature of the marine environment, these devices are constantly exposed to high seas, biofouling, moisture, etc, which can eventually lead to instrument failure.

At Hawke's Bay, the Port of Napier (PON) has been maintaining wave buoy deployments for nearly 20 years to assist their operations. This data is of parnamount importance for Hawke's Bay Regional council's (HBRC) coastal management. In particular, the frequent coastal flooding events that occur in this area require EVA to determine the events' Average Recurrence Interval. In 2022 the council started an ongoing buoy deployment that can be used as redundancy when the PON's buoys fail. However, the existing data for this deployment is still too short for EVA and HBRC's buoy location is further onshore compared to PON's deployment ,i.e, the wave measurements are different at each spot.

This research explores the use of different regression models to estimate the sea state condition at the HBRC's wave buoy location based on the PON's wave buoy data, and to reconstruct a 20-year time series of wave parameter at the HBRC's buoy site. Validation results show good agreement between the estimated and measured values, as well as similar ARIs for the extreme events of both datasets.

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Production and trial of artificial rock pools at Lyttelton Port Company

Over the last decade there has been considerable progress and growing interest in the field of marine ecological engineering (eco-engineering) in the attempt to promote more sustainable marine built environments. Marine eco-engineering solutions, despite not representing a substitute for natural systems, have provided encouraging results so far, but biodiversity benefits have been shown to be context-dependent and applications have been limited to a few geographical hotspots.

Here we share insights from one of the first marine eco-engineering applications in Aotearoa New Zealand: a small-scale trial of artificial tidal pools at Lyttelton Port, in Whakaraupō / Lyttelton Harbour. While there are several proprietary tidal pool designs available, these are typically very expensive and require sophisticated casting facilities. In contrast, the tidal pools in use at Lyttelton Port are based on a relatively simple design which allowed the construction of the pools in-house using recycled materials and a bit of Kiwi ingenuity (including the use of a range of perishable elements to produce fine-scale surface texturing). This shows that there are ways to make marine eco-engineering relatively affordable and low-tech.

In addition to details of the fabrication process, we will present preliminary results from the monitoring program measuring the growth of benthic organisms within and outside the pools, which provides one of the first assessments of the performances of marine eco-engineering features in Aotearoa New Zealand.

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Adaptive tools for coastal infrastructure adaptation in an uncertain climate

Multiple interacting hazards in coastal areas pose increasing risks for infrastructure and to infrastructure providers in New Zealand and around the world. Coastal infrastructure systems are exposed to erosion, landslip, storm surge, heavy rain, overland and river flows, rising groundwater and tidal effects, and relative sea-level rise from climate change and the effects of land subsidence, as well as the compound impacts of these hazards. But there is uncertainty around the frequency, magnitude and timing of hazards impacts in the face of deeply uncertain physical and social responses to climate change.

Utilities also face compounded risk from droughts and heat driven water demand. How do utilities decide where, when and what to invest in?

We outline an approach for integrated and adaptive water and wastewater investment decision-making, that ensures resilience against uncertain future climate scenarios while ensuring levels of service are maintained. The approach combines workshops, systems mapping, dynamic adaptive pathways planning (DAPP), exploratory modelling, robust decision-making (RDM) and real options analysis to assess and stress-test adaptation options for specific water infrastructure assets. The seven analytical methods can be applied within the Ministry for the Environment's (2024) ten-step planning cycle for making decisions on infrastructure adaptation under a wide range of climate change and demand scenarios.

Exploratory modelling is used to investigate the viability and lifetime of actions within alternative adaptive pathways (in a DAPP) and how the different pathways play out under different scenarios. An RDM framework is used to interrogate model outputs and rule out unsuccessful actions and pathways in an iterative process. Economic analysis is undertaken to assess the costs of the robust pathways, and the costs of delaying actions. Finally, results are validated with the infrastructure provider, culminating in the identification of one or more robust pathways for each infrastructure asset. This approach has been applied to wastewater adaptation planning for two New Zealand case studies.

This guidance can be used to inform adaptation of infrastructure systems in Australasia. The guidance is compatible with New Zealand Ministry for the Environment Coastal Hazards and Climate Change Guidance for Local Government (2024) and the Water Services Association of Australia Climate Change Adaptation Guidelines (2016).

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Tsunami-tide interaction in Foveaux Strait and Bluff Harbour

Tsunamis pose a constant threat to coastal areas, and understanding their impact is crucial for disaster preparedness and mitigation, especially in regions with significant maritime activities. Accurate assessment of tsunami impacts is essential for safeguarding lives, infrastructure design and protection, and economic activities in these vulnerable zones.

This study investigates the impact of tsunamis in the Foveaux Strait and Bluff Harbour, using data from New Zealand's National Tsunami Hazard Model (NTHM 2021) and the 2018 Probabilistic Tsunami Hazard Assessment for Australia (PTHA18). Employing the SCHISM code on an unstructured grid, we incorporated tidal effects to simulate the dynamic interaction between tsunami waves and tides.

Each scenario was modeled across four tidal phases to evaluate variations in wave height and maximum currents. Our analysis focused on sensitive areas, including port infrastructures and harbour inlets.

Results indicate that wave height is minimally influenced by tidal phase, while currents exhibit significant variations. This suggests that while traditional statistical approaches based on static water levels may provide a reasonable estimate for the total wave height at the coast, they may underestimate the range of possible current amplitudes. The findings underscore the necessity for dynamic models in accurately assessing tsunami impacts on maritime infrastructure and may provide valuable data to enhance machine learning models for predicting and mitigating tsunami effects.

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Increased exposure of marae to coastal flooding with sea level rise and adaptation learnings of Ngāi Tamawhariua and Maketū Iwi Collective

Sea level rise driven by anthropogenic climate change is disproportionately affecting Indigenous communities globally. In Aotearoa New Zealand, Māori communities and cultural infrastructure are often located at the coast, including marae. Marae are critical to Māori culture and identity, past, present, and future. Here, we assess the national exposure of marae buildings (e.g., wharenui, wharekai, ablution blocks and kaumatua housing) and land parcels to coastal flooding with sea level rise. By 2150, under the shared socio-economic pathway 5-8.5, 50 and 53 coastal marae are exposed to a 100-year and 1000-year annual recurrence interval extreme sea level event respectively. Furthermore, 16% of coastal marae land parcels have more than 75% of their land area exposed under ARI 1000. This highlights that many coastal marae are vulnerable to flooding with sea level rise and will be unable to operate if some of their buildings and land parcels are impacted, including as civil defence centres. We share two empowering stories from the Maketū Iwi Collective and Ngāi Tamawhariua in the Bay of Plenty whose marae and papakāinga are at risk of coastal and river flooding. Important aspects on their adaptation journeys include identifying internal expertise, including rangatahi in the process, maintaining decision-making autonomy, the power of community climate adaptation funding, collaboration with scientists and in particular connections to research programmes, and mana whenua sharing experiences in implementing their adaptation plans.

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Deep learning in the shallows: An automated approach to mapping variability of hāpua morphodynamics in Aotearoa New Zealand.

The Canterbury Bight is an eroding coastline and contains 11 of the 29 identified hāpua, or coastal river mouth lagoons, in Aotearoa New Zealand. Hāpua are freshwater river mouths that are parallel to the coastline with a dynamic gravel or mixed sand and gravel barrier intermittently separating them from the marine environment. Field work at these lagoons can challenging, which means hāpua studies tend to focus on individual sites and therefore occur in isolation from one another. To address this concern, I have created a novel remote sensing method using the high-resolution and near daily frequency Planet imagery to assess changes in hāpua processes and morphologies. Neural networks have been used to automate the creation of lagoon and barrier masks at a system wide scale. With increasing pressures of water abstraction coupled with climate change, it is vital to benchmark current conditions so that sustainable management decisions can be made.

In this talk I will explore the process of deep learning integration within coastal zones and the potentials of scalability. I will also discuss case study results from hāpua situated within the Canterbury Bight to quantify their response to river flow fluctuations and tidal events.

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Evaluating EcoReef: An Economical Approach to Mitigate Coastal Erosion in Cape Palliser

Cape Palliser Road is a vital link to the Ngawi community and an important section of the South Wairarapa District Council's (SWDC's) transport network. The road is vulnerable in several locations to coastal erosion and washouts which pose risk to users and lead to closures. The road corridor itself provides the only access for the local Cape Palliser community and it's visitors, which emphasises it's criticality. Multiple repairs have been required in recent years and has required in excess of $2.4m in emergency work expenditure on this short section of rural road.

Previously, rock revetments have been used to manage erosion risk along the corridor. Large armourstone rock for these structures was sourced from quarries near Tinui, Linton and Ohakune and transported to Cape Palliser Road. The high costs associated with the sourcing and transporting of the rock have led the SWDC to investigate alternative options. One such option that has been trialled in two sections of the coast is EcoReef cellular retaining walls. These comprise interlocking hexagonal concrete blocks filled with locally won materials to create a modular retaining wall structure.

EcoReef offers potential cost and carbon savings compared to rock revetments and other coastal erosion measures. The primary carbon savings relate to reduced haulage distance and volume as the blocks are filled with locally sourced materials. In the pilot sites blocks have been filled with river-run gravels and coarse sand sourced from Cape Palliser. There is also notable cost savings as the concrete units are less expensive and quicker to install than a comparable rock revetment. This solution has also been used for dropout repair and bridge abutment protection in Cape Palliser.

Anecdotal evidence from the SWDC Roading team suggests that the wall has performed well since its installation in February 2023. Consents from the regional council require SWDC to monitor the effectiveness of the wall and monitor any impact on the coast. Our inspection of the two EcoReef pilot sites in Cape Palliser forms the basis of the consent reporting.

Our presentation will provide an overview of the observations on the wall's condition and performance over the year since it has been installed. We will provide our thoughts on the likely longevity of this erosion risk management approach and some design considerations for future similar structures based on our observations.

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Carparks to Cockles-Plastic Pollution Pathways in Te Taitokerau (Northland)

Global plastic pollution affects diverse ecosystems. Regional plastic pollution from land-derived urban runoff is understudied in Aotearoa, New Zealand. In Te Taitokerau (Northland), collaboration among Northland Regional Council, iwi, hapū, and researchers focused on plastic entering the aquatic environment. Several methodologies were applied, macroplastic (>5 mm) quarterly surveys of stormwater drains using LittaTraps™, and beach litter surveys facilitated by the Litter Intelligence App. Microplastic (<5 mm) assessments of beach sediments, marine trawls, and three species of shellfish (*Paphies australis*, *Austrovenus stutchburyi*, and *Macomona liliana*).
An estimated 9.4 million plastic items are captured annually from the 51 LittaTraps™ surveyed in Northland, with cigarette butts and hard/soft plastic fragments the most common pollutant. Six high-risk land uses were identified 'Fast food', 'Retail', 'Hospital', 'Playgrounds/skateparks', 'Car parks', and 'Transport, postal and warehousing'. Hard and soft plastic fragments, and food wrappers were predominant in beach litter surveys. Microplastics, mainly polyethylene terephthalate, polyethylene, and polypropylene, were widespread, including shellfish. Microplastic polymers reflected plastic items found in macroplastic surveys. Comparison with marine trawls and Aotearoa and South Pacific fishes revealed similar presence of microplastic polymers, morphotypes, and colours. This research demonstrates plastic's ubiquitous nature in Aotearoa, highlighting widespread impact and necessitating the implementation of mitigation strategies.
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Modelling dynamic inundation from waves

Coastal inundation is typically assessed using the 'static' components of coastal water level, including sea level rise, tides, and storm surge. The influence of waves on causing coastal flooding is usually limited to wave setup, which is the time-averaged increase in mean water level caused by breaking waves.

Static inundation is a robust and spatially scalable method for understanding areas potentially exposed to coastal inundation at national and regional scales. However, some coastal land and infrastructure will be exposed to direct wave impacts with small increases in sea level rise, causing impacts and disruption before flooding from static inundation is realised. This presentation outlines two projects that model dynamic coastal inundation from waves, with methods suitable for the local scale (e.g. 5 km^2) and the coastal compartment scale (300 km^2).

The first example considers wave driven inundation of a coastal swimming pool complex in Newcastle, Australia. The site is located on a rock platform, with waves crashing across the complex at present day, causing a danger to bathers, and a challenge for climate change adaptation. A combination of numerical modelling and field measurements were used to assess coastal inundation exposure from extreme and typical wave conditions, at present day and with future sea level rise. The XBeach non-hydrostatic (XBNH) model was capable of simulating wave interaction with the nearshore, rock platform, and pool complex. Model outputs were evaluated using video cameras to detect the wave overtopping on an elevated building platform, and modelled water levels were compared to pressure sensor data captured during a large swell event in 2023. An efficient quasi-3D XBNH model was utilised to simulate a matrix of over 200 wave and sea level scenarios to understand coastal inundation exposure.

The second example is on 22 km of the Hawke Bay coast, from Clifton to Tangoio, where an elevated coastal barrier separates the sea from low-lying hinterland. Waves action surging over the barrier is therefore a key component of the coastal hazard-scape in this location. On the balance of representing the key physical processes and covering the spatial extent, the surf-beat inundation model excited by XBeach-GPU was used to simulate dynamic inundation. Model behaviour was calibrated using debris lines mapped during Cyclone Pam (2015) before being applied to simulate coastal inundation for a range of future climate change and storm scenarios to inform building code compliance for Napier and Hastings. The site is influenced by highly variable vertical land movement, from close to zero at Haumoana, to -5 mm/yr in Napier. To account for this variability in the hydrodynamic model, the topography was adjusted using a VLM deformation approach to offset elevation over the scenario timeframe.

Computational methods are making it increasingly accessible to model dynamic wave inundation, that better represents the physical processes. This increases confidence in the modelling output and can help inform more nuanced coastal risk and adaptation pathways.

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Some pitfalls of a risk-based approach to adaptation planning

Risk-based approaches, comprising risk analysis, assessment and treatment, have a long history of application as a structured framework to managing risk that is supported internationally by ISO 31000 standards (which incidentally are targeted at organisations).

Increasingly, risk-based approaches have been applied to climate adaptation. Such an approach is embedded in the 2010 NZ Coastal Policy Statement (NZCPS) and the revised 2024 MfE coastal guidance for local government, with hazard and risk assessments and addressing the question "What can we do about it?" key components of the iterative decision-making cycle. Primarily, the coastal guidance is underpinned by a dynamic adaptive pathways planning (DAPP) approach, which is in turn informed by vulnerability and risk assessments and evaluation methods. Similarly, the earlier NZCPS outlines principles and strategies for reducing risk (including from climate change) that include "identifying and planning for transition mechanisms and timeframes for moving to more sustainable options".

However, there are some pitfalls in translating conventional risk analysis and treatment approaches to time-varying risks, and in some cases for coasts, irreversible ongoing increase in risk (with only the pace of change uncertain).

The presentation will cover some of the pitfalls of relying too closely on a conventional risk-based approach to developing coastal adaptation plans or strategies. These include: addressing time-variant hazards (exacerbated by climate change); deepening uncertainty and its link with likelihood (with the need to stress test plans and policies using scenarios); traps in prioritization of risks from risk analyses; common foci on the big 3 risk elements (safety, critical infrastructure and economic values) rather than a broader systems or place-based analysis; and a continued tendency towards an up-front single-investment treatment of risk (compared with a flexible DAPP approach that keeps options open and to avoid maladaptation).

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Nature's Shield 2: Leveraging Saltmarsh Vegetation for Coastal Protection

The Wi Neera to Onepoto Project being delivered by Porirua City Council comprises a 1.4km shared pathway and coastal protection along Titahi Bay Road. This project has two key coastal focused objectives: firstly, to restore the natural harbour margin, thereby enhancing the landscape, and enriching the local ecological value. Secondly, to address past coastal erosion and enhance the shoreline's future coastal erosion resilience. These objectives were realized through the adoption of saltmarsh vegetation supported by a low-crested rock sill.

The Nature's Sheild 1 presentation will focus on the design, objectives, challenges and key outcomes of this project. This presentation will focus specifically on the innovative approach adopted in the design of the saltmarsh.

As a first step in this assessment, a literature review of recent design guidance and literature was undertaken, which identified a notable lack of tangible guidance that can be applied to inform design. This presentation will focus on how this challenge was addressed. Specifically, we will focus on the ability of the selected saltmarsh species (*Juncus Krausii*) to dissipate wave energy (and hence reduce erosion) and how this erosion risk may change during vegetation establishment when the vegetation has a lower plant density.

Given the lack of design guidance, a multi-model assessment approach was implemented, using field testing, numerical modelling, and empirical equations. In the field, RBR pressure sensors were deployed through a transect of salt marsh in the Pāuatahanui arm of Porirua Harbour. Alongside wave monitoring, saltmarsh species were surveyed to understand diversity of species as well as the elevation of species relative to tidal levels. After completing field monitoring, numerical XBeach modelling was undertaken to further explore wave energy dissipation, this was supplemented with an empirical dissipation assessment. From this wave energy dissipation curves were formed for a variety of storm conditions and planting densities. The dissipated wave heights along the shoreline extent could then be related to erosion risk by forming a relationship between the dissipated wave height and peak shear force (and hence erosion risk) induced at the shoreline.

During this presentation the design methodology and key outputs will be discussed with hopes of providing an example framework for nature-based design. In addition, this presentation will emphasise the inherent uncertainties tied to nature-based design while highlighting potential avenues for future advancements. These include the long-term deployment of field monitoring equipment to observe wave energy dissipation, as well as expanding industry-specific data related to the performance and application of such nature-based designs.

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Groundwater hazards and impacts of sea-level rise on coastal low-elevation zone: Perspectives of practitioners

Climate change is causing sea levels to rise, posing an unprecedented threat to coastal communities and infrastructure in the low-elevation zone from flooding and other hazards. The impact of sea-level rise on coastal shallow groundwater and subsequent impacts on infrastructure assets is an aspect that is not well understood. Semi-structured interviews were conducted with infrastructure engineers, asset managers and climate adaptation scientists. This study aimed to identify perspectives of practitioners from city- to regional-scale government organisations to capture their understanding of shallow groundwater impacts and adaptation responses to these current and anticipated issues in New Zealand. In this context, interviewees practice in the field of infrastructure asset management that provides services by local authorities in relation to the following activities: water supply, sewerage and the treatment and disposal of sewage, stormwater drainage, flood protection and control works, the provision of roads and footpaths.

The study shows that shallow groundwater already poses challenges to infrastructure asset managers. These issues are saltwater intrusion, flooding, increased liquefaction hazard, vulnerability of stormwater, wastewater management, drainage systems and coastal protection and long-term planning and financing. Climate change and sea-level rise will exacerbate current and future issues. At present and in the future, a key issue is who will take responsibility for shallow groundwater management in the face of new challenges from growing climate risks. This study highlights that current approaches to managing groundwater variability will continue to be applied in future adaptation strategies. New Zealand has transitioned from historically monitoring freshwater resources to also monitoring shallow groundwater in relation to interactions with infrastructure assets. Further, groundwater monitoring and infrastructure asset management approaches to adaptation are limited less by technical understanding and more by political and economic considerations. Adaptive groundwater-resilient infrastructure systems will reduce leakage and infiltration and mitigate shallow groundwater impacts on assets. However, key challenges remain in engagement and communication with professionals. Further education of decision-makers and communities on shallow groundwater processes and interaction with infrastructure assets is essential for groundwater hazard adaptation.

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Sea-level rise effects on coastal shallow groundwater dynamics in the built environment

From small coastal settlements to large cities, communities are exposed to both the direct and indirect consequences of climate-change-induced sea-level rise. Above the ground surface, short- and long-term coastal effects of sea-level rise are visible and cause damage from flooding, erosion, and loss of habitats and ecosystems. Below the ground surface, the effects are less visible but nonetheless extensive. Groundwater is present at shallow depth in the coastal zone and the effects of sea-level rise on shallow groundwater threaten water security, agricultural production and infrastructure. Groundwater flooding, a hydrological hazard results from the process of water table rise, where the groundwater surface intersects or goes above the land surface due to changing conditions. The coastal zone is a complex dynamic space between saltwater and freshwater environments above and below the ground surface, and coastal groundwater hazards are intensified due to sea-level rise. However, current monitoring of coastal shallow groundwater levels and salinity does not occur sufficiently to mitigate and adapt to the groundwater hazard. This research provides insights into the dynamics of coastal shallow groundwater, urban monitoring networks, simulations of water table rise, and the issues posed by shallow groundwater changes driven by sea-level rise on infrastructure assets.

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25-years of wave monitoring offshore of Steep Head, Te Pātaka-o-Rākaihautū/Banks Peninsula

Steep head wave monitoring site is located in 75m depth offshore of Te Pātaka-o-Rākaihautū/Banks Peninsula. The site has been occupied with wave monitoring devices since 1999. This presentation celebrates the 25-year of wave data collection by presenting a history of buoy deployment and recovery, and a comprehensive wave climate analysis.

During the 25-year period the buoy recorded significant wave height, ranging from 0.46 m and 8.83 m with a mean of 2.08 m. Most of the waves (87%) are between 1.0 and 3.0 m and most (55%) originate from the south (between 150º to 210º) and most waves (55%) have mean periods between 4 and 6.5s.

Deeper analysis of wave climate was completed including average conditions over seasonal, inter-annual and decadal scales, frequency analysis of bulk wave parameters (wave height, period and direction). An extreme analysis was also completed and whether trends can be identified in the record.

Continued in-situ monitoring of offshore condition is a challenging task in Te Waiponamu/South Island. But the wave data collected is extremely valuable to understand coastal hazard as well as the variability and changes in the environment and climate.

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Coastal resilience AND coastal enhancement: could a chenier ridge enhance ecological and cultural values of Thames whilst saving money on rocks and protecting houses?

To complement the implementation stage of shoreline adaptation planning, the Thames Protection & Resilience Project Governance Group (co-governed by Thames-Coromandel District Council, Ngāti Maru, and Waikato Regional Council) is exploring nature-based solutions to enhance coastal ecological and cultural values along the Thames foreshore. In addition to exploring a range of options, a key focus is exploring constructing a chenier ridge-like structure to provide some of the services provided by naturally occurring chenier formations. These are typically composed of coarse coastal sediments such as shell gravel and sand and are already present near Thames. This could provide elevated habitats for bird species, encourage mangrove development, support various ecosystem services, offer natural wave protection, and support and enhance cultural and community values. By constructing around 1400m of chenier-ridge, a key aim will be to delay traditional rock armour protection and reduce the overall impact of coastal storms and erosion. It is anticipated this approach will highlight the opportunities available when looking beyond traditional protection options.

Integral to this project, is the collaboration with Ngāti Maru to include kōrero tuku iho (passed down knowledge), values and aspirations of their rohe into the planning and implementation. This will be supported by a cultural values assessment and resourcing to meaningfully work together to consider the various technical assessments with Ngāti Maru values and knowledge. Initial work will evaluate the feasibility, costs, benefits, and potential risks associated with creating a chenier ridge, including mana whenua and key stakeholder perspectives. In this kōrero, we are looking forward to sharing ideas and having some interesting discussions.

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3D Coastal Mapping – Improving key baseline datasets

New Zealand's people, infrastructure, culture and environmental assets near and on the coast are forecast to become increasingly exposed to hazards generated by climate change induced sea-level rise and more frequent storms and surge events.

To understand our communities' current and changing exposure to these hazards, it is essential to accurately map the near shore seabed. Existing understanding of coastal hazards is impaired by disjointed, limited, and low-accuracy coastal mapping data, which makes it hard to know what the sea-level rise, wave action and coastal inundation impacts will be, and where they may occur.

The 3D Coastal Mapping (3DCM) initiative, developed by Toitū Te Whenua Land Information New Zealand in collaboration with the Ministry for the Environment, will significantly improve the baseline data upon which resilience to coastal hazards and climate change impacts can be assessed and mitigated. 3DCM will enable better mapping by extending the accurate coastal elevation model out past the waterline, up to 25 metre depth where feasible. Uncertainty of sea level rise predictions related to vertical land movement will be reduced by adding co-located Global Navigation Satellite System (GNSS) monitoring stations to six tide gauge locations.

3DCM will invest $29.5 million over three years in high-resolution airborne LiDAR mapping of up to 40% of Aotearoa's coastline. This includes investing in 10 Global Navigation Satellite System (GNSS) stations co-located at existing tide gauge stations, reducing the uncertainty of sea-level rise predictions related to vertical land movement.

This presentation will present the results of a trial of LiDAR technology carried out over Bluff and Tauranga in April 2024 and provide an update to the project as we plan the programme for the next three years and, hopefully, beyond.

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Climate change risk to supply chains – national road distribution from ports

Climate risk assessment for a nationwide entity used network analysis to determine if disruption is likely to their supply chain – from port facilities through to individual outlets throughout the country. The RCP8.5 climate change scenario was examined out to 2040, based on the potential for greater flooding from sea level rise, increased intensity of rainfall, riverbank overtopping, and increased landslides.

Delivery routes under normal conditions were determined, with flood and landslide scenarios overlaid to identify potentially exposed routes, with these sections excluded from the analysis to create an alternative network (where possible). A web-based geospatial platform was created, with analysis showing that many routes are exposed, with alternative routes often not available around areas exposed to pluvial and fluvial flooding. However, tidal flooding had lower levels of disruption, due to impacts being isolated to the coast. It is concluded that access is likely to increasingly be cut off during extreme weather in the future. Pre-emptive planning for key supplies prior to weather events, and sufficient stocks will be required to avoid business disruption. Nationwide road network resilience should be considered by appropriate agencies.

Similar analysis can be applied to many other networks. Examples include rail, and infrastructure such as electricity, gas, telecommunications or water services.

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Building a reef as part of a major infrastructure project, Te Ara Tupua, Wellington.

The NZ Transport Agency (Waka Kotahi) via the Te Ara Tupua Alliance is constructing a cycling and walking link and improving transport resilience between Wellington and Lower Hutt. In a first of its kind for Aotearoa, the project has delivered a reef enhancement initiative made up of 56 engineered 'pyramid' units that are submerged off the north-western edge of Te Whanganui-a-Tara (Wellington harbour). Covering 5 ha, the reef forms part of a compensation package to address the loss of rocky reef and soft sediment habitat from construction of the Te Ara Tupua shared path and seawall upgrades. The reef is intended to reestablish a rocky reef marine ecosystem and become a source of mātaitai (kaimoana) for future generations, within an area of the harbour that has been relatively dormant for several generations. Working in partnership with iwi mana whenua, Taranaki Whānui ki te Upoko o te Ika and Ngāti Toa, the reef's progress will be monitored to assess the outcomes of this type of restoration. This presentation will explore the consenting process, design considerations, ongoing monitoring, and mana whenua's long-term aspirations for the reef and Te Whanganui-a-Tara. It will also explore potential next steps for the industry and recommendations for offsetting and compensation for future infrastructure projects.

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Factors that influence the local coastal knowledge of surfers in Aotearoa

This study presents the findings from an oral history research project which explored how surfers' experiential knowledge is developed, and how it may be usefully applied to formal coastal management in Aotearoa New Zealand. The surfing community is widely recognised as the primary authority on the location and values of surf breaks and this knowledge directly informs the management of surf breaks as coastal resources. However, there is an increasing understanding that through their sustained and often long-term relationships with coastal environments, surfers can develop a strong awareness and knowledge of environmental conditions, which has the potential to make further contributions to coastal management needs. Despite this, little is understood about the extent or origins of this knowledge, or the factors that influence its development in the community at large.

This study reaffirmed that surfers possess significant knowledge of the coastal environment and highlighted their detailed insights into specific surf spots they frequent as well as a broader regional understanding gained through site comparisons. Factors such as gender roles, local community dynamics, equipment preferences, and access to surf spots significantly influence how knowledge is developed and maintained. These factors intersect with and mediate the more obvious components of surfer's local knowledge that are generated through the observation of physical environment attributes (e.g., the mechanics of breaking waves), illustrating the importance of social and cultural contexts in the knowledge development process.

Several potential challenges can be identified for maintaining or supporting the depth of local knowledge which is generated by long-term relationships with specific locations. For example, findings from this study support calls for contemporary management practices to recognize the value of unique surf breaks which may be infrequently surfed due to isolation or their highly variable nature. In many cases, the nuanced and often detailed local knowledge of these locations forms the primary information base on the existence of these resources. As surf breaks face increasing threats, surfers' ability to develop and share their knowledge may also become endangered, particularly at these locations. More generally, the considerable local coastal knowledge that is supported and facilitated by relationships between people and surf breaks underscores the importance of preserving these resources for the many benefits they provide. Moreover, the social, cultural and wellbeing dimensions of these benefits are becoming increasingly recognised as relationships with surf breaks become better understood.

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Ancient and contemporary community coastal structures in Australia

This paper presents ancient and contemporary community coastal structures which are relatively unique to Australia. While aspects of these structures or similar structures occur elsewhere, their development or evolution within Australia has been globally unique. The paper considers and discusses the following classes of coastal structures:

- Indigenous fish traps;
- Ocean pools;
- Wave trap beaches;
- Fixed trestle, jet pump sand bypass plants;
- Groyne modifications for surfing.

All of the above structures and management options are substantially community projects, with benefits often flowing to diverse stakeholders. They often result in strengthened communities formed around the use of these assets. Sea level rise and the aggressive ocean environment present challenges in preserving and renewing these assets, while more complex planning regimes have increased the complexity in delivering new projects.

Examples of indigenous Australian fish trap coastal structures more than 1000 years old are presented, together with examples of the more than 50 ocean pools constructed on the coast of NSW over the past 200 years.

Surfing is a highly valued use of the coast in both Australia and New Zealand. Beneficial outcomes of coastal management actions on surfing amenity learned from Australia are presented – both through deliberate design and “happy accidents”.

There are some examples of these structures and projects in New Zealand. Given their high community benefit, there is likely to be ongoing community interest and lobbying for similar projects to be developed beyond Australia.

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From smartphones to satellite: leveraging different imagery technologies to monitor coastal change and support coastal management

Monitoring coastal change is essential for effective coastal management due to the dynamic nature of many coastal environments. Traditional techniques, such as surveying, can be labour-intensive and limited by the need for frequent field visits. Imagery provides a valuable tool for coastal monitoring, as it is able to capture comprehensive, high-resolution snapshots of these environments. Images collected through smartphones, fixed cameras and satellite can be leveraged for both qualitative and quantitative long-term changes to beaches at a local and global scale.

CoastSnap is a low-cost community beach monitoring program that provides a platform for local communities to collect and contribute measurements of coastline changes using their smartphones. Since its inception in 2017, Coastsnap has been successful in amassing a substantial number of photographs with over 30,000 images uploaded at over 150 official CoastSnap stations in Australia and New Zealand alone. Internationally, CoastSnap has established over 500 sites in 34 countries, making it the largest coordinated network of coastal monitoring, with over 60,000 images contributed by more than 5,000 users.

In collaboration with local governments, WRL manages a number of fixed camera networks which collectively capture thousands of images each day. Where CoastSnap plays an important role in community engagement and low-cost monitoring, fixed cameras allow the capture of high temporal resolution data at as low as minute-scale. Images captured at this frequency can be used to count numbers of beach users through AI object detection methods, in addition to the extraction of comprehensive shoreline datasets. The largest of these networks was established in collaboration with the City of Gold Coast Council, and includes 44 rooftop mounted cameras providing panoramic views over a 40 km stretch of coastline.

WRL’s shoreline mapping tool, CoastSat, leverages publicly available multispectral satellite imagery to monitor shorelines and beach width changes on a global scale. CoastSat currently analyses shorelines along much of Australia's east coast, South America's west coast, North America's east and west coasts, and parts of the Hawaiian Islands. Locally, the same toolkit and methodology have been applied to projects investigating historical morphological changes of estuary entrances and hazard warning systems.

By examining the strengths and applications of CoastSnap, fixed camera networks, and CoastSat, this presentation underscores the value of integrating diverse monitoring technologies to enhance coastal management practices. The insights gained from these complementary approaches will help inform strategies for sustainable coastal development and resilience against environmental changes.

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Modelling complex wave environments and novel armour protection: Insights from recent NZ-based physical model projects

Wave processes and their interactions with structures are complex and can be difficult to describe analytically or model numerically. Physical modelling can offer a valuable tool for understanding these complex interactions as identified in recent NZ based physical model projects conducted by the Water Research Laboratory (WRL).

One recent WRL project in New Zealand was at Ōhau Point, located 170 km north of Christchurch. Post-earthquake, this area faced significant overtopping causing road closures and danger to pedestrians. With complex bathymetric features complicating numerical modelling, physical model testing was conducted by WRL. Following rapid testing of different options, it was indicated that overtopping could be reduced with the removal of existing concrete slabs at the seawall's toe, the implementation of a crown wall and installation of hanbar units.

Other key projects involved futureproofing of Wellington Harbour's foreshore, specifically Te Ara Tupua (West) and Tupua Horo Nuku (Northeast) developments. These projects protect a vital infrastructure corridor including roads, railway and footpaths, from severe storm damage. WRL modelled the complex wave environment using a bimodal wave spectrum considering both wind generated within and swell waves entering the harbour. Physical model testing results showed that overtopping volumes were highly sensitive to the swell wave component within the bimodal spectrum. WRL also assessed armour stability novel concrete armour units including XblocPlus and Econcrete, as well as overtopping rates on this novel kind of revetment. With limited previous studies and literature, physical model testing was able to provide valuable insights to inform design and construction of these structures.

The Ōpōtiki Harbour Development project, located in the eastern Bay of Plenty, aimed to improve maritime access by stabilizing the Waioeka River mouth and dredging a navigable channel. WRL began the preliminary assessment with 2D physical modelling to focus on key parts of the project, progressing to 3D modelling for the detailed assessment. The study addressed nearshore wave processes, training wall stability, overtopping, and wave penetration within the entrance channel, providing critical information for optimizing the harbour's protective structures.

WRL's extensive experience and recent projects demonstrate that physical modelling is an indispensable component of the coastal design suite, complementing desktop calculations and numerical modelling. This is especially true in complex wave environment or where existing information is limited. Additionally, these projects have indicated the value of physical modelling for rapid testing of various design options and for offering an interactive medium to understand and communicate complex wave processes and interactions with coastal structures.

Christchurch City Council, Christchurch

Christchurch City Council's Coastal Hazard Adaption Planning Team – The What Why and How

The Christchurch City Council Coastal Hazard Adaption Planning Team's (CHAP) purpose is to assist in preparing adaption responses, education and raising awareness to reduce effects from climate change (specifically coastal hazards) on communities and infrastructure. The team aims to put community engagement at the centre of decision making, including partnering with the Papatipu Rūnanga. It also supports the delivery of the climate change learning programme which is delivered in six schools.

Between 2005 and 2020, we have experienced around 10cm of sea level rise. Sea level will not only affect the open coast but also allow high tides and the effects of storms to reach further inland, including up rivers. This means that more land may be affected by coastal flooding, erosion and rising groundwater in the future, and the severity of those impacts will be greater. It is therefore key that our communities can adapt to this change. We consider it highly important to undertake our adaption processes using a holistic approach to ensure everything (including the natural and built environment, our cultural values, community aspirations and expectations, uncertainties and risk) are taken into consideration before proceeding with action. Education is also at the forefront to provide awareness of climate change and start conversations about the impacts of sea-level rise and how we can respond as a city, including giving youth a voice.

The latest work the team has conducted is to develop a Coastal Adaption Framework (2022) and adaption plans (2024). Our adaption plans utilise Dynamic Policy Pathways (DAPP) to determine actions to mitigate coastal hazard effects on public infrastructure. First off the rank was the Whakaraupō - Lyttelton Harbour and Koukourarata - Port Levy area. To determine draft pathways, we have been using a Coastal Panel that includes a diverse group of community and Rūnanga representatives from the area, along with some city-wide representatives and specifically including youth. The Coastal Panel will provide preferred adaptation pathways as a recommendation to Council. The Coastal Panel has taken on board feedback from the wider community throughout the drafting of the adaption plan and has developed community objectives which they aim to achieve with their recommendations.

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A Landowner's Guide to Coastal Erosion

Coastal erosion can be hugely stressful – especially when it impacts your own property. The natural first response is to want to do something to stop the erosion. However, it is important to think carefully about what action to take; there are rules to comply with and potential impacts on the wider community and environment to consider.

SLR Consulting were engaged by Northland Regional Council to prepare a Coastal Protection Works Guidance targeted specifically at the individual landowner(s) response level. The purpose of the guidance is to provide the public easy-to-understand information on the options and best practice for responding to coastal hazards. It includes a simple outline of the policy direction (e.g. preference for soft options) and provides Northland-specific advice on the regulatory process for the various options. The guidance focuses solely on coastal erosion, because it is by far the most common coastal hazard individual landowners are wanting to respond to in Northland.

The guidance is intended as an introduction to coastal erosion, the options for tackling it, the rules for coastal protection works and where to get further advice. It also aims to point individuals towards the need for adaptation, and councils' opportunity for supporting communities to do this through resilience planning. Recognising adaptation plans as the 'ultimate' plan for how a community will respond to coastal hazards, the guidance has been prepared in the context that any recommended options should not compromise future decisions made in adaptation plans. The idea being to leave the reader with a sense of the community needs and/or opportunities. We also want the reader to be aware of the wider community impacts of the underlying coastal erosions issue and the potential impacts of coastal erosion protection structures

The guidance document is a compilation work, rather than any form of analysis. It balances being informative while also being concise and has achieved the desired outcome of explaining policy planning settings and coastal processes science in plain language within the context of climate adaptation.

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Modelling the Influence of Coastal Geology on Seawater Intrusion in New Zealand

Coastal aquifers are invaluable drinking water sources for many cities around New Zealand. Increased abstraction and decreased recharge due to increasing groundwater use, and sea-level rise will place increasing pressure on these resources. A key component of understanding this vulnerability is the influence of geological complexity on groundwater flow and transport. We explore the effects of two different aspects of coastal geology using numerical modelling. The first is the influence of heterogeneity within an alluvial aquifer, in the Central Canterbury Plains. The second is the influence of variability in the thickness of a confining silt, in the Hutt Valley.

Alluvial aquifers are widespread around New Zealand, forming vital freshwater resources. Connected high hydraulic conductivity pathways formed by open framework gravel deposits lead to preferential groundwater flow and transport in these aquifers. We modelled the rate of seawater intrusion under an imposed decrease in onshore groundwater head, for 25 heterogeneous realizations of a confined coastal aquifer based on the Central Canterbury Plains Aquifer System. The salinization rates observed vary widely across the realization and in the alongshore direction within each realization. We compare the results from our heterogeneous model to an equivalent homogeneous model, as well as a simple analytical solution. These results help to inform assessments of seawater intrusion vulnerability for alluvial aquifers.

Te Whanganui-a-Tara/Wellington Harbour features numerous seafloor pockmarks, which are associated with submarine groundwater discharge. This discharge is a key component of the Hutt Valley aquifer system water balance. Under a combination of sea level rise and reduced groundwater heads, the discharge at these pockmarks may be reversed, leading to preferential seawater intrusion. We model submarine groundwater discharge at the cluster of pockmarks near the Hutt River mouth, which are closest to groundwater extraction wells. A finely discretized bathymetry is used to represent the seafloor, and the reduction in thickness of the confining silt layer at the pockmarks. The response of the system to an imposed sea level rise and reduced groundwater head scenario is analysed. This will improve understanding of submarine groundwater discharge in the harbour, and the risk of seawater intrusion associated with it.

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**Forecasting inundation maps in real-time with machine learning:
A Westport case-study**

Flooding is the most frequent natural disaster internationally and in NZ, and when it comes to forecasting the impact of flooding, predicting river flows is not enough. Inundation maps are the best tool for informing evacuation and emergence management decisions and enabling clear communication of risks. Unfortunately, the hydrodynamic modelling required to forecast flood maps is computationally demanding and slow. In this work, we present a machine learning (ML) surrogate model that can predict hourly inundation maps over a 5-day forecast, in real-time.

The ML model presented here is developed using Westport as a case study. In recent years, Westport has been particularly affected by flooding, receiving “red alert” heavy rainfall warnings once in July 2021, and twice in February 2022. As is the case for much of New Zealand, forecasting inundation maps for a coastal region such as Westport requires careful consideration of tidal affects, as well as river flows. For example, during ex-tropical cyclone Fehi in February 2018, the flooding over low lying areas of Westport around the Orowaiti Lagoon was entirely due to storm surge and wave setup.

The convolutional neural network ML model developed here is therefore trained using a library of pre-computed scenarios that span a wide range of river flow and sea level combinations. The model outputs hourly flood depths at each grid cell across Westport, using the predicted sea level in the preceding 8 hours, and corresponding hydrograph forecast at the Buller River Te Kuha gauge. In this presentation, we’ll describe the model, and demonstrate its potential through application to a diverse test set as well as ensemble forecasts for the July 2021 Westport flood event.

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The importance of tino rangatiratanga and Mātauranga Māori for eco-cultural resilience: A comparison of highly modified coastal lagoons

Including Mātauranga Māori in modern planning regimes is a dimension of tino rangatiratanga that is integral to cultural and ecosystem resilience in Aotearoa. Mana whenua have deep, intergenerational Mātauranga that guide decision making for the longevity of the system, preserving mauri and mana of the whenua. However, highly modified systems are often considered devoid of indigenous value, as the 'natural' state of the system has been altered. This societal conceptualisation limits the application of indigenous knowledge in management and resilience strategies, thereby excluding indigenous voices.

The Waituna and Waitarakao coastal lagoons exemplify Western management regimes that have rendered these systems inaccessible to mana whenua, eroding their connection and Mātauranga. Using these highly modified systems as case studies, we assessed the socio-ecologicalsystem traps and the empowerment of tino rangatiratanga. We explored tino rangatiratanga in highly modified systems through the analysis of grey literature and interviews with key stakeholders and kaumatua. We expect to find that the inclusion of mana whenua in institutional governance and active planning not only creates better outcomes for the lagoons, but also increases the mana of each rōhe through empowering tino rangatiratanga. The findings from our comparative case study can be applied across the wai māori in Aotearoa, through informing modern freshwater co-management.

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Unravelling sediment transport pathways in a complex ebb-tidal delta and predicting channel sediment infill.

As the global freight market rises, ports around the world are racing to keep pace. Traditionally, this means expanding existing facilities or reclaiming land. But when space becomes a constraint, the solution often involves investigating new locations to meet long-term freight demands. In New Zealand, the Manukau Harbour - a large ebb-tidal delta on the West Coast of the North Island in the Auckland Region - has previously been identified as a potential port location. Despite its potential, this harbour is characterised by a complex and dynamic entrance, exposed to large swells and fast tidal currents.

MetOcean Solutions undertook a numerical modelling study to better understand the sediment dynamics and transport mechanisms near the entrance bar of Manukau Harbour. The hydrodynamic and sediment transport modelling was run using Delft3D-FM and coupled with waves in depth-averaged (2D) mode.

We selected a series of control scenarios representative of different wave conditions typical in the area. Each modelled scenario involved sediment transport simulations over a complete 12-hour tidal cycle and were run for two bathymetry configurations: the 'existing' bathymetry (developed from a recent survey), and the channel 'design' bathymetry (the existing bathymetry with the addition of a dredged channel). The bathymetries considered the bedforms and morphology of Manukau's ebb-tidal delta. Based on the results of sediment transport, we created a conceptual model for sediment pathways for different control scenarios representative of distinct sediment dynamics.

Subsequently, the wave climate in the area was analysed to select a range of Input Reduction (IR) wave events. These events were run for 12-hours, similarly to the control runs, and infill rates were calculated. A transformation process was used to determine the annual sediment infill estimate, which was undertaken through a 4D scattered interpolation using the IR scenarios (run matrix). Wave parameter timeseries from an offshore 41-year SWAN wave hindcast was resampled to give the 12-hour average wave conditions. The 12-hour wave parameter timeseries was interpolated against the run matrix and assigned a 12-hour infill volume. For the final annual infill estimate we have repeated this methodology by shifting the start of the 12-hour averaging window by one-hour increments and were averaged to give the final infill timeseries. Additionally, results were evaluated for a 5% increase in Hs to the hindcast to account for climate change.

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Seeing the seafloor: can we do better?

New Zealand's coastal and near-shore marine environment is highly dynamic and reflective of the nation's variable geology/geomorphology. Ranging from gently sloped beaches and pleasant swimming spots to dramatic rocky shorelines with dangerous undertow currents, the strategies required to map such variable environments is, consequently, difficult to standardise.

Onshore, using techniques such as drone-mounted LiDAR or photogrammetry systems, it is possible to resolve topographic features to centimetre-scale resolution. Through continued enhancements in acoustic imaging techniques such as multibeam echosounders and remotely operated vehicles, it is now possible to image large regions of shallow seafloor (< 50 m water depth) at optimal resolutions of decimetres. The accuracy (and therefore spatial resolution) of multibeam echosounders, however, rapidly reduces with increasing water depth. Additionally, the implementation of these technologies can be prohibitively expensive, either requiring significant investment in surveying technology or the commissioning of labour-intensive survey campaigns. As such, whenever the opportunity arises to survey the marine environment, it is essential that the data acquired can be used by a variety of different stakeholders, some of whom may be unknown at the time of the survey itself.

Here we explore a variety of different methods that can be used to image the marine environment, considering factors such as past and present technologies, methods of processing legacy datasets, and expanding into future techniques. Particularly, we focus on multibeam echosounders and towed camera systems, discussing how these different methods can be integrated for future detailed seafloor survey programs.

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Historic Data vs Bruun Rule
Alternate Methodology for Predictions of Soft Sediment Shoreline Retreat due to Sea Level Rise

It is standard current practice to predict shoreline retreat associated with sea level rise at soft sediment shorelines based on some general form of the Bruun Rule. The rule asserts that on a long or two-dimensional coastline the retreats of the shoreline is driven by a mass balance. The shoreline retreat associated to a given rise in average means sea level is readily calculable in direct proportion to the average slope of the active beach face.

There have been many critical academic assessments of flaws with the rule and its applicability to various situations. Determination of an average slope, calculation of the depth of closure and therefore extent of the active profile are areas of potential discretion and dispute with these types of calculations. Probably more questionable is the applicability to various differing types coastline, for example embayed or pocket beach coastlines and those with defined sand supplies that will not change in direct proportion to changes in sea level.

However, despite the limitations, the rule or derivations thereof, tend to be used in the absence of an alternative methodology of deriving a behaviour of a soft coast line subject to sea level rise.

On many beaches on the east coast of the North Island, beach monitoring records extend back to about 1980. Some of the older records are limited but quite detailed records are available from the 1990-2000s. Over this period time, sea level in New Zealand has been rising. There is therefore 30-40 years real data of beach response to sea levels rise of the same order as that that can be expected over the next 50 years. This data is at or very close to the actual beaches where predictions are being made. This information is largely ignored in predicting future shoreline behaviour. Over longer timeframes, sea levels will rise an order of magnitude more than historic measured rises and beach responses. This may elicit differing beach responses.

However, it is suggested that the actual measured response of real beach systems to actual measured rises in sea level should be considered carefully when forecasting likely beach response. This may be particularly appropriate when such features as, the meso-tidal nature of our beaches and resulting response to high tide storm erosion, discrete pocket beach morphology and ebb delta driven embayed beaches are very poorly represented by the underlying assumptions of the Bruun-type models.

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Adaptation knowledge sharing: how the ACAN and PEERS communities of practice are helping bridge the science-policy-implementation gap

While adaptation responses are quickly becoming a foundational aspect of mainstream risk management, effective actions are limited by the lack of coherent and pragmatic frameworks to support knowledge sharing between practitioners who are responsible for the on-ground implementation of adaptation strategies and actions.

This presentation explores the diverse challenges facing adaptation practitioners from across Aotearoa New Zealand and internationally, and how practitioner networks are beginning to play a critical role addressing these challenges through the sharing of actionable knowledge, research and policy approaches.

Networks like the Aotearoa Climate Adaptation Network (ACAN) and the Practitioner Exchange for the Effective Response to Sea Level Rise (PEERS) provide opportunities for peer-to-peer learning, support, knowledge exchange, advocacy and improving the nexus between new research, policy development and practice.

In NZ, ACAN has grown to include members from almost all local governments across an increasingly broad range of disciplines, with pressure coming from outside local government to 'open the doors'. In 2024 the Aotearoa Society of Adaptation Professionals (ASAP) was borne to bring all adaptation practitioners together and provide the foundation for the ongoing professional development of this emergent practice.

The Practitioner Exchange for Effective Response to Sea Level Rise (PEERS) is the first international collaborative led by practitioners working together collaboratively to share knowledge, develop and disseminate leading practices, and solve complex problems regarding coastal adaptation and sea level rise. PEERS was developed out of practitioner-led global workshops and convenings that identified poor consistency in how science is used, how policy is developed, and how adaptation actions are taken.

PEERS Oceania is building networks between coastal adaptation practitioners in Australia and New Zealand. The group is currently working with Natural Resources Canada to help identify and communicate international leading practices for coastal adaptation, working with Canadian coastal adaptation practitioners and PEERS global members.

The intersectionality of these networks reinforces the importance of collaborative approaches in order to continually enhance efficacy of actions, avoid maladaptation and ultimately enable climate resilient planning and decision-making.

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Iongairo: Te Pātaka o Rākaihautū. A collaboration to better understand the status and distribution of marine habitats and species around Banks Peninsula

Iongairo is a collaboration between Environment Canterbury, Department of Conservation, Papatipu Rūnanga and University of Otago as the science provider and stemed from the LINZ commissioned seafloor survey that occurred in 2021/22 around Te Pātaka. Over the past two years, extensive ground truthing, data analysis and model construction has been undertaken to generate spatial datasets that will aid decision making processes. The focal study region includes two marine reserves, two customary protection areas and fisheries management areas as well as a range of industries including aquaculture and tourism.

Here we present an overview of the process that led to the prioritisation of work through a multi-partner engagement approach. We detail the methods employed and highlight some of the key findings that these data have provided.

This project is an exemplar of how nation-wide bathymetric surveys can be leveraged to significantly advance the understanding of coastal ecosystems, their health and distribution. The data produced highlights the types of products needed to support management and transistion to more bespoke, locally led approaches.

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What's in a shoreline? From single to multi-proxy coastal change assessment

The changing position of the shoreline has been of interest to coastal scientists, engineers and managers for many decades. Multiple data sources have been used including aerial photographs, cadastral maps and beach profile surveys, and researchers have taken a broad perspective on the word 'shoreline', mapping a vast array of shoreline proxies (or indicators) such as the high-water line, vegetation line, storm scarp, cliff toe or cliff top.

Over the past decade, increasing availability of satellite imagery and rapid advances in data processing have transformed the nature of coastal change analyses. Research attention has overwhelmingly focused on automated extraction of the Instantaneous Waterline (IWL), with tools such as CoastSat streamlining extraction of IWL shorelines from publicly available satellite imagery at large scales.

The IWL represents a highly dynamic boundary between the land and water that is useful for understanding short-term changes in shoreline position due to tidal cycles, wave action, and storm events. However, the dynamic nature of this boundary also limits its accuracy, because individual IWL positions are subject to very high uncertainties associated with issues such as wave runup. In contrast, the edge of coastal vegetation is typically indicative of a more stable, longer-term position of the shoreline that is less susceptible to short-term fluctuations providing a more averaged representation of coastal changes over extended periods. In this context, it is somewhat surprising that relatively little attention has been placed by coastal scientists on algorithmic extraction of the Vegetation Line (VL).

In this presentation we compare IWL and VL shoreline proxies mapped at multiple beaches around the coast of New Zealand. IWL were obtained from CoastSat whereas VL were mapped manually as part of a national programme of historical coastal mapping. We find that in comparison to the use of a single shoreline proxy (i.e. the IWL), which reveals three dominant coastal-change patterns (erosion, accretion and stability), the addition of a second shoreline proxy (the VL), reveals many additional coastal change patterns, such as beach widening and narrowing. This presentation discusses how these patterns might potentially serve as leading indicators of future coastal change, and considers prospects for widespread algorithmic mapping of both VL and IWL shoreline proxies.

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"Sign new lease or face eviction: D-day looms for Selwyn Huts residents"

Sensationalist headlines like the title of this abstract, taken from the Star News, are appearing in the media with increasing regularity throughout New Zealand. These headlines often use emotionally charged language to grab attention and can exaggerate the issue or present a one-sided account of the issue. As sea levels rise and climate change impacts become more evident, the pressure on local Councils and communities to take action increases. However, the sensationalist nature of some media reports can increase public anxiety and further exacerbate the distrust between councils and the community.

The Upper Selwyn Huts are a small settlement on the banks of the Selwyn River near the mouth of Te Waihora. The huts were established in the 1890s as fisherman's huts and occupy 202m^2 each of Crown-owned land, managed by the Selwyn District Council. In 2019, Selwyn District Council made the decision that the leases for the Upper Selwyn Huts would be for a finite term. In March 2024, Council confirmed the leases would be for 15 years expiring in 2039. The community were upset with the decision and upset with the process. In July 2024, Council agreed to start the process again – this time working with the community. There are many bach and hut communities scattered along the coastline which were never developed to be permanently occupied and are now feeling the impacts of climate change.

This presentation will explore some of the differences in discussing retreat of leasehold verse freehold land, the challenges associated with the relocation of low-cost settlements beyond the economics, the decision paralysis faced by Councils, and the importance of empathic and consistent engagement. It is time we stopped being the ambulance at the bottom of the cliff and instead turn our focus on being the fence at the top.

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Enhancing coastal monitoring through morphological analysis and satellite imagery: A case study in Hawke's Bay

Coastal regions are crucial for global socio-economic development but are increasingly threatened by storms, sea level rise, and other climate change-related hazards. These threats, along with rapid urbanisation, highlight the need to identify and address vulnerable areas through accurate and up-to-date morphological data. However, obtaining high-quality data is resource-intensive, requiring significant funds and processing capacity. Additionally, outputs from the data collected in coastal monitoring surveys have usually been limited to specific metrics, such as beach volume and excursion distance, with little linking of the observed trends to geophysical processes. Coastal monitoring in some locations also lacks the temporal resolution necessary to analyse the effect of events such as storms on the coastline. This presentation explores how data analysis methods can address these limitations using cross-sectional beach profile datasets obtained along the Hawkes Bay coastline. These beach profile datasets, provided by Hawke's Bay Regional Council, date back to the 1970s and were obtained for 90 transect locations along the Hawkes Bay coastline.

We present the analysis of the beach profile data and propose novel ways to visualise each location, such as 3D surface plots and time series for beach volume, centroid, shoreline, and dune crest position, all compiled into an interactive dashboard requiring minimal inputs. These data analysis methods can be applied to coastal monitoring survey datasets obtained for any location around New Zealand. Additionally, we analysed the correlation of these beach metrics with changes in climate indices, sea states, and water level to determine the effects of the geophysical and climatic processes on these shorelines' morphodynamics. Connecting individual transects along a particular beach also facilitated the analysis of longshore processes along the coastline.

The analysis was extended to the processing of Sentinel-2 satellite imagery using the open-source Python toolkit 'CoastSat'. This toolkit employs a shoreline detection algorithm to compute shoreline time series for user-defined transects. Although the shoreline position time series produced by CoastSat were subject to errors and uncertainties, these were partially addressed through georectification and tidal correction. Similar trends in shoreline position were observed for the satellite and profile datasets. CoastSat offers the opportunity to increase the spatial and temporal resolution of shoreline position.

The key findings of this research suggest that metrics like centroid location provide valuable insights into beach behaviour, such as whether a beach is steepening, flattening, advancing, retreating, or showing a combination of these changes. Additionally, the study highlights the value of combining beach metrics and other environmental data such as climate indices and wave records. The use of satellite imagery further enhances temporal resolution, allowing for more frequent data collection than beach surveys, which is particularly useful for assessing beach responses to short-term events like storms. The methodologies developed and applied to the Hawke's Bay dataset can be adapted for use across other regions in New Zealand.

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Towards a national shallow groundwater hazard exposure assessment: statistical modelling of water table depth in New Zealand's coastal lowlands

Rising sea levels and stage propagation through tidal waterways cause water tables to rise in coastal lowlands, a phenomenon known as water table shoaling. Rising water tables can cause dry weather flooding, exacerbate pluvial flooding and cause damage and loss of utility to coastal zone assets and land uses. Evaluating water table shoaling hazard exposure at national scale is challenged by low monitoring data density relative to spatial variability, interpolation accuracy and exposure depth sensitivity.

We use the term exposure depth sensitivity to characterise the precision with which water table depth must be defined to determine whether an asset is exposed. By way of example, slab-founded buildings are unlikely to experience water damage if the depth to groundwater exceeds 0.15 m. Above this depth, depending on the building design and construction, water could potentially penetrate the damp-proof membrane with subsequential damp ingress to the building via the slab. A small change in groundwater level could therefore cause a significant increase in exposure.

Regional council groundwater monitoring programmes focus on productive and highly utilised aquifers which tend to comprise deeper confined or semi-confined units, beneath the shallow water table aquifer. The monitoring data density for the water table aquifer is relatively low. Coupling this with spatial variability in water table depth, which is high in the context of exposure depth sensitivity, means that relatively precise estimates of the current depth to water table and water table shoaling are required to reliability estimate exposure to water table shoaling.

This paper presents the results of a statistical model using Random Forest machine learning techniques to estimate the current water table depth in the coastal lowlands of Aotearoa New Zealand. The Random Forest model was selected for its robust handling of non-linear relationships and resistance to overfitting. The training dataset comprised water level measurements from the New Zealand Depth to Water Database; predictor variables encompassed approximately 210 datasets including precipitation, evapotranspiration (with various rolling averages), aquifer properties, soil data, and proximity to surface water bodies.

Initial Random Forest regression models, while promising overall, lacked accuracy in predicting shallow water levels. To address this limitation, a categorical approach was adopted, utilising binary depth classes. Type II error (under prediction of exposure) minimisation was prioritised via iterative testing of depth thresholds to establish optimal cutoff points for shallow versus deep categories. The current water table depth model results will be used in conjunction with water table shoaling model outputs and exposure depth assessments for a range of coastal zone assets and land uses to provide a national shallow groundwater hazard exposure assessment. This work forms part of the Future Coasts Aotearoa MBIE research programme outputs.

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Agent models of tsunami evacuation behaviour to improve planning and preparedness

Located in the South Pacific, Aotearoa-New Zealand is exposed to distant, regional, and local tsunamis. Near-field tsunamis generated in the Hikurangi Subduction Zone are of special concern for coastal communities on eastern coastlines. Due to the limited time before the tsunami waves reach the coast, fast evacuation is crucial to minimize casualties in at-risk areas. Over 430,000 people (9% of New Zealanders) live in tsunami risk zones. In the Canterbury area, nearly 31,000 people reside in 'orange' and 37,000 live in 'yellow' zones (Paulik et al., 2020).

To better understand the evacuation patterns and needs of coastal communities in the event of a local tsunami, geographically explicit agent-based models are under development for the area of South New Brighton in Christchurch, and the cities of Napier and Gisborne. Pre-evacuation time is considered for each agent, and the transportation mode of evacuees on their way to the safe zone includes both pedestrians and vehicles. Both nighttime and daytime scenarios are considered. A preliminary approximation of congestion levels is estimated for agents evacuating on foot and individuals driving cars. Within the future work of this project, is the inclusion of a post-earthquake environment aiming to reproduce road damage due to liquefaction or blockage due to debris. Additionally, behavioural data collection by means of Virtual Reality experiments will be used to inform the models about the decision-making process behind car abandonment behaviour.

Participatory community workshops have been conducted in Napier and Gisborne, where the feedback from the communities regarding the model outputs has been discussed. Members of the public have highlighted improvements to the current version of the models to reproduce more realistic behaviours. Moreover, they commented about previous tsunami evacuation or drill experiences, and means of transport for future evacuations. They elaborated about challenges in mixed mode evacuations, viable solutions for safer evacuations, and perceptions about the use of vertical evacuation buildings as shelters.

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Up, down and all around. An overview of Environment Canterbury's coastal hazard monitoring program.

Environment Canterbury's coastal hazard monitoring program involves the collection of data on the drivers of change along the Canterbury coast as well as the resulting impacts on the coast from those drivers. Through long-term partnerships and relationships with outside organisations, waves are monitored at a directional waverider buoy located off the coast of Banks Peninsula, and sea levels are monitored at Sumner Head. Additional sea level data is collected by the ports of Lyttelton and Timaru to provide a wider coverage of long-term changes across the region.

Change along the open coast of Canterbury is monitored across a network of approximately 250 sites from the Waitaki River through to Kekerengu. A cross-sectional profile is taken at each of these sites on an at least annual basis from the hinterland to the ocean through the active beach, and many of these sites have survey records of over 30 years. Such detailed records are invaluable for recording short-term changes and for calculating long term rates of change along the coast, particularly when determining areas along the coast that may potentially be impacted into the future, as they provide a way of verifying rates of change calculated from aerial photographic records.

Frequent region-wide imagery of the coast is available through Environment Canterbury's subscription to the www.planet.com/explorer satellite photographic service, and live video imagery is also available at selected locations along the coast through a subscription to the outdooraccess.co.nz service.

The combination of these information sources provides a comprehensive overview and record of the changes that are occurring along the coast of Canterbury. This presentation will outline the background, methods and coverage of this coastal monitoring program, and will show some of the results including how the collected information is used and presented.

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Coastal Erosion Hazard Management - what have we learned since the 1970s?

Here we consider the history of two eastern Coromandel case studies to reflect on the realities and challenges faced when attempting to limit coastal erosion hazard risk now and in the future.

Within relatively easy reach of Hamilton and Auckland, beaches of the eastern Coromandel Peninsula experienced rapid development from the late 1950s. Holocene dune barriers fronted by beautiful white sand beaches provided an easily accessible area for subdivision. Frontal dunes were bulldozed to improve views and beachfront sections were located close to the shoreline.

Although coastal management through hazard avoidance and adaptation is often considered to be a relatively modern concept, records show that those tasked with coastal management on the Coromandel provided clear advice to authorities in the 1970s about the need to apply the “concept of avoidance”. Recommendations included the implementation of a foredune zone within which new development was to be avoided and existing development restricted to relocatable buildings. The advice was that “Coastal defence works should neither be undertaken nor permitted to be undertaken, and such funds as might be available in this direction (if any) spent in assisting with the relocation of the houses.”

Numerous investigations, hazard reports and strategies have been completed since, and several iterations of Policy. However, the outcomes and recommendations remain broadly consistent with those presented in the 1970s. Coastal hazards have been identified on titles and requirements for relocatable design applied through building consent and (more recently) District Planning mechanisms. The most recent strategy in the form of a Shoreline Management Plan presents a pathway for most eastern Coromandel beaches of dune management and managed relocation over time as sea level rises and coastal hazard risk increases. This adaptation pathway is consistent with the original broad management approach presented in the 1970s.

The construction of seawalls and the extraordinary increase in land value of beachfront properties suggests that the concept of avoidance and adaption intended by the coastal managers in the 1970s has not been delivered. Despite the efforts and intentions, it has not been possible to affect a genuine change in the way that marginal coastal land is perceived. Communities now face the possible degradation of many of the Region’s most precious beaches by further coastal protection works as some of the most valuable land parcels in the Region sit within metres of the dune scarp. We consider the obstacles that communities and authorities face prevent meaningful implementation of coastal management plans when trying to set in place actions that will protect beaches, which are in many cases the cornerstone of coastal communities.

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How important are Ex-Tropical Cyclones in the erosion of marine terraces?

Ex-tropical cyclones (ETCs) like Cyclone Gabrielle are rare extreme weather events that induce significant rainfall resulting in regionally damaging floods and slope instability. At the coast ETCs are also associated with significant low pressure systems and resultant storm surges concomitant with increased onshore waves. As a result, it is expected that ETCs will also produce significant erosion at the coast and damage to coastal landforms and infrastructure. The objective here is to evaluate the effects of ETCs on coastal erosion of rock coasts, specifically on the shore platform of Māhia Peninsula. A simple water level inundation model was developed for Kahutara Point at Māhia for the period 1980–2023 using offshore wave heights from Wave Watch III, and modified to predict onshore water level accounting for wave setup and runup calibrated to deployments of pressure transducers on the shore platform.

During the observation period 22 ETCs have made landfall around Aotearoa/New Zealand, but relatively few (e.g., Bernie, 1982; Gabrielle, 2023) have trajectories that have directly intersected Kahutara Point concurrent with high tide or spring tides. As such the analysis of water levels suggests that ETCs may not be a frequent cause of inundation of the youngest marine terrace, but storm waves do frequently reach the terrace riser. Under our reconstruction of water levels, it is suggested that winter storms are more likely to reach the terrace riser and potentially contribute to backwearing of the marine terrace. However, extreme events, like Cyclone Gabrielle, which make landfall concurrent with high tide may be an important episodic/stochastic scaled event that undertakes significant damage to the marine terrace.

Analysis of retreat rates around Kahutara Point derived from remote imagery and calculated using the DSAS geospatial tool reveal variable retreat rates of the marine terrace, which are commensurate with the exposure to wave energy measured on the shore platform. More concerning, however, is that the rate of retreat appears to have accelerated since 2015, and is associated with an uptick in storm intensity. The rates of backwearing, are, however, highly variable across the 5 transect locations. Such variability in backwearing rates may reflect that the periodicity of stochastic events is an important consideration for generating long-term retreat rates, and that the higher retreat rates observed between 2020–2023 are marked by the incidence of two large storm events (Cyclone Gabrielle and a winter storm in 2022), which results in an over-prediction of long term retreat rates.

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How can a hierarchical geomorphic framework be used to improve coastal management on the East Otago Coast?

The presented MSc research explores how a hierarchical geomorphic framework can be used to improve coastal management within the Otago Region. A hierarchical classification system is established based on physical processes in study area. This is used as a framework to identify a series of nested coastal compartments. The largest of these is a regional scale compartment encompassing elements of Canterbury and Southland. Housed within this is a series of smaller coastal compartments that are at the primary (100’s km), secondary (10’s km), and tertiary (1 km) in scale. These smaller compartments are within- and illuminated by-properties of the broader regional compartment. Working on advancing the literature, this research aims to improve the onshore boundaries of primary and secondary scale compartments. By incorporating consideration of physical terrestrial processes in this onshore boundary location, a more comprehensive framework is established. As a case study, compartments on the East Otago Coast will be used to assess the sensitivity of the area to change through time. This analysis works with local groups in East Otago and contributes to community-based management in the area.

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An evaluation of Citizen Science approaches to monitor landslides and reduce the associated community risk in coastal cliff environments.

Coastal cliffs, constituting 50% of the world's coastline, are highly susceptible to landslides due to substrate weathering, wave action undercutting, and triggers from seismic or meteorological events. How much climate change will exacerbate the landslide and erosion hazard along coastal cliffs is largely unknown, necessitating comprehensive investigations into the relationships between environmental changes and landslide occurrence.

Traditional landslide monitoring approaches are expensive and cannot always provide reliable and comprehensive data acquisition in coastal cliff environments, due to the challenges of site inaccessibility and the harsh (corrosive) environments. This research addresses these challenges by exploring the potential of integrating citizen science principles into landslide monitoring programs in coastal cliff environments.

Focusing on three distinct regions, Cape Kidnappers in Hawke's Bay, Urenui and Onaero in North Taranaki, and Mairangi bay in Auckland City. This project aims to assess the effectiveness of citizen science in enhancing landslide monitoring and risk reduction efforts. These regions offer diverse geological settings, meteomarine conditions, and beach users, providing a test for how different citizen science methods can be applied across different coastal cliff environments.

The study will evaluate a range of citizen science data sources for collecting landslide inventory data, identifying landslide pre-cursors (e.g., incipient failures), and increasing the understanding of coastal cliff behaviour. Additionally, it considers the bidirectional impact of citizen engagement, assessing changes in hazard identification accuracy and hazard avoidance behaviour among participants of landslide hazard monitoring initiatives.

By leveraging citizen science, this project seeks to bridge knowledge gaps associated with coastal cliff erosion, triggers, failure magnitudes, and event frequencies. The findings aim to contribute to improved risk management strategies, enhancing the safety of both local communities and tourists exploring these captivating yet hazard-prone environments.

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Short-term defence for long-term retreat in the Coromandel

Over 100 properties are at risk now of coastal inundation in 1% and 5% annual exceedance probability (AEP) storm events in Te Puru, on the West coast of the Coromandel Peninsula. Making it a priority location for adaptation for Thames Coromandel District Council (TCDC).

The Coastal Adaptation Plan (CAP) developed by a 'Thames Coast Community Panel' for Te Puru, as part of TCDC's Shoreline Management Pathways (SMP) project, proposed the following short-term adaptation measures:

- Sediment recycling - use of dredged material from the stream mouth (discharging from the steep stream catchment into the Firth of Thames and creating the fan delta on which Te Puru was built) to 're-enforce' the beach frontage to the south of the stream.
- Formalising and enhancing the existing storm bund, and the construction of a new transitional defence where there is no existing coast protection.

An important component of the CAP developed for Te Puru is that the proposed adaptation actions that follow these short- to medium-term measures, align with a longer-term managed retreat strategy. That is, the proposal is for a 'transitional defence' to be constructed, to protect the community from the present (short and medium term / 30 year) risk and "buy time" while a cost-effective managed retreat strategy is developed.

The pathway will contribute to the long-term resilience of the area by moving people out of harm's way. In the meantime, the transitional defence will provide protection and community resilience (comfort) while personnel and public plans are developed for retreat. Further, it will allow the existing community/generation to maintain their current lifestyle and connection to the sea (without a large hard structure limiting this).

Planning controls to avoid maladaptation, however, will be key to success.

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A collaboration of mātauranga Māori and western science for monitoring of Pipi *(Paphies australis)* in Tauranga Harbour.

From October 2015 to July 2016 dredging was carried out in the Tauranga Harbour for the expansion of the main shipping channel to allow larger ships into the port. In that process approximately 95m of subtidal shell bank was removed from Te Paritaha (a culturally significant harvesting bank in the middle of Tauranga Harbour).

A condition of consent from that dredging campaign was to prepare and implement a Te Paritaha Monitoring Plan (TPMP). Monitoring of pipi on Te Paritaha has been carried out pre and post dredging by Fairlie et al., (2017) and Ross & Culliford, (2018), however, long term monitoring was required. In 2022, Boffa Miskell was engaged by the Port of Tauranga to prepare a TPMP with the overarching aim to assess temporal trends in the size and abundance of pipi and physical structure of the benthic habitat. Preparation of the TPMP started with input from Tauranga Moana Iwi Customary Fisheries Trust, whereby mātauranga Māori was shared around culturally important harvesting areas that generations had collected pipi from. This informed the methodology and location of sampling grids. It also prompted further testing of potential pollutants and surrounding ecology as a more indigenous wholistic approach.

The first round of surveys commenced in October 2022, which was a collaboration of Boffa Miskell ecologists, the Port of Tauranga, Tauranga Moana Iwi Customary Fisheries Trust, and Toi Ohomai (polytechnic). Iwi and hapū were invited to this (and subsequent) sampling events. Across three days 90 benthic cores were excavated, sieved, and pipi retained were counted and measured. In addition, benthic invertebrate cores, sediment grain size, sediment contaminants and shellfish flesh samples were collected for laboratory analysis. Findings from the 2022 surveys showed significant changes in the abundance and population structure of pipi on Te Paritaha compared to previous surveys undertaken between 2013 and 2017 (Fairlie et al., (2017) and Ross & Culliford, (2018). These differences included high abundances of intertidal juvenile pipi combined with a large decrease in the abundance of adult pipi. These findings prompted further monitoring and the expansion of the 2022 TPMP. Sampling in 2023 followed similar methods, however, a revised TMPM was written to expand the spatial coverage of the surveys to allow for additional information to be collected, with the aim to better understand the mechanisms underlying the 2022 results. Sampling was increased to 270 cores across three shallow subtidal grids, and 160 cores from subtidal sites located along the edge of Te Paritaha into the main shipping channel (where dredging had occurred).

Since 2022, four Te Paritaha monitoring rounds have been completed with the help of iwi and hapū. Total number of pipi have fluctuated between 827 individuals to 16,267 per survey. Size class percentage of recruits, juveniles and adults has varied with each survey; however, we have observed a shift from recruit dominated populations to juvenile dominated populations. Sediment grain size has remained relatively consistent through time. Sediment contaminants have remained below default guideline values; however, in May 2024 elevated polycyclic aromatic hydrocarbons (PAHs) were detected in pipi flesh samples (with previous analysis results for PAHs being below laboratory detection limits). This detection coincided with a hydrocarbon event in Tauranga Harbour (investigation to identify the source is ongoing). We have recommended the continuation of annual Te Paritaha due to its cultural value and variability population characteristics. In summary, high recruitment has been observed through our monitoring and suggests the potential for replenishment of adult stocks over time.

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Dynamic adaptive pathways planning for adaptation: Lessons learned from a decade of practice in Aotearoa New Zealand

There is a climate change adaptation implementation gap. We have information about the likely impacts and implications, but concrete action is elusive. Key to addressing this are alternative planning approaches that enable decision makers to anticipate impacts and design alternate pathways depending on how conditions change, in time for adaptation actions to be implemented. Over the last 10 years, dynamic adaptive pathways planning (DAPP) has been applied in Aotearoa New Zealand (A-NZ) to assist in such circumstances. Pathways planning has now been applied in diverse decision settings and has motivated the use and development of complementary methods and tools for evaluating adaptation options and pathways. Different governance and engagement models have emerged, tailored with and for different communities. DAPP research in A-NZ has advanced the design of monitoring systems, decision signals and triggers, staging managed retreat over time, and serious games to prime decision makers for dealing with uncertainty. Indigenous Māori worldviews, knowledge and values have intersected and informed DAPP applications, but significant untapped opportunities exist. This paper presents lessons learned from these applications and further research needed. Opportunities for supporting and extending the DAPP process for adaptation decision making through governance, engagement and indigenous knowledge and values are suggested.

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A case study: exploring sediment accumulation rates in the Southern Firth of Thames using high-frequency E-SUDS measurements

The Estuary-Surface Ultrasonic Distance Sensor (E-SUDS), is a telemetered system, developed by the NIWA Physical Coastal and Estuarine Processes Group, capable of collecting continuous high-frequency measurements of bed elevations, water levels and waves in intertidal environments over long periods of times (years). Measuring bed elevation changes within estuaries provides insights into the processes governing the evolution of these dynamic receiving environments. Which includes how estuaries will likely respond to changes in catchment sediment loads and sea level rise. From a management perspective these types of measurements are critical to enhance state-of-the-environment (SOE) and trend monitoring.

Since late 2019, four E-SUDS were deployed to form a ~150 m cross-shore transect (i.e., mud flat to fringe forest) in the Southern Firth of Thames. Time-series of bed-level changes show significant rates of sediment accumulation (~50 mm/yr). In this presentation, we use data analysis technics such as Boosted Regression Trees to elucidate sediment-transport and geomorphic processes at tidal/event to interannual scales.

In addition to discussing the analysis of existing data, we also highlight future plans for the E-SUDS system in the Wharekawa estuary. The Wharekawa estuary provides a high-profile and topical issue, that is, the impacts of a production forest on estuary sedimentation at event to interannual time scales that the E-SUDS is uniquely capable of quantifying. This information is needed to enable regional councils to develop guidelines and SOE metrics for reporting of land use impacts on estuary sedimentation.

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The Beach is Back! A story of natural shoreline recovery after Cyclone Gabrielle

Storms are a primary driver of coastal change, and we often spend a lot of energy trying to understand what the impacts of storms might be. While it is often anticipated that sandy beaches may not recover following major storm events, they are inherently dynamic systems capable of rapid natural recovery, provided sufficient sand is available.

The Pakiri Embayment, located north of Auckland, New Zealand, experienced substantial impacts from Cyclone Gabrielle in February 2023. The preceding prolonged La Niña period had already left the beach in a vulnerable state. Surveys conducted before Cyclone Gabrielle (late 2022) and after (March 2023) documented the cyclone's effects, along with seven other isolated storm events over a six-month period. Post-storm surveys revealed significant dune erosion (up to 11 meters at the dune toe) and a loss of over 270,000 m^3 of sediment across the embayment.

Subsequent regular surveys over the following 12 months have tracked the natural recovery of the beach. The results, influenced by a calmer summer and a shift to El Niño conditions, demonstrated significant natural recovery. Over 750,000 m^3 of sediment has since been naturally redeposited onto the beach within the embayment during the summer of 2023/2024, nearly three times the sediment lost during the 2022/2023 summer due to Cyclone Gabrielle.

This presentation will explore the resilience of coastlines and their capacity for natural recovery following significant storm events such as Cyclone Gabrielle.

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Setting "limits" or values for estuaries: Opportunities and lessons learnt

Regional Councils are responsible for management of the marine space from the Mean High-Water Spring (MHWS) out to 12nm, with overlapping policies that have jurisdiction over this zone. The 2020 National Policy Statement for Freshwater Management (NPS-FM) outlines how regional councils need to manage freshwater while taking into account the sensitive receiving environments. While freshwater management via limits set in the National Objectives Framework are well defined, there are currently no national limits for estuaries to drive management upstream leaving a grey area in integrated management. Additionally, challenges remain with linking estuarine health to catchment reductions in stressor concentrations both temporally and spatially.

This has provided regional councils with a challenge as to the best way to manage estuarine systems, linking freshwater modelling/monitoring, and the required reductions of stressors, to outcomes for estuarine health. Many estuarine specific models have high levels of uncertainty.

Currently regional councils are at different phases of implementing both the NPS-FM, and whether estuarine outcomes are included as attributes within planning documents. This talk will outline some of the approaches taken by different councils to improve estuary condition through the NPS-FM. It will highlight pitfalls, potential ways to undertake this work, and lessons learnt.

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Quantification and Characterisation of Microplastics in Remote Fiords' and Highly Populated Harbours, Two Extremes of Aotearoa - New Zealand

Microplastics are extremely persistent environmental pollutants that are widely spread throughout all environments. Quantifying microplastic pollution in the environment is important for determining the potential impact they have. Identifying accumulation zones driven by environmental conditions, such as within and outside natural harbours and fiords, is important to better understand this risk.

Aotearoa - New Zealand is an understudied region of the world when it comes to microplastic pollution. This study aimed to quantify microplastics in sea-surface water adjacent to highly populated regions and a remote national park and consider how off-shore islands, harbours, and fiords affect microplastic accumulation. Sampling was undertaken as part of two separate expeditions in June and October of 2021. Samples were collected from 41 sites using a manta trawl in three harbours, four fiords and over 430 km of coastline in Aotearoa - New Zealand. Plastic particles were isolated by sieving and enzymatic digestion, allowing for characterisation by stereomicroscope for colour, morphotype and size, as well as polymer type by utilising Micro-Fourier Transform Infrared Spectroscopy.

Microplastics were detected in all samples at varying levels of abundance. Higher concentrations were detected in highly populated locations compared to remote fiords. Higher concentrations in harbours compared to open ocean locations showed possible accumulation and entrapment of microplastics. However, this accumulation was not observed in remote fiords. This study has shown the presence and characteristics of microplastics in remote and highly populated parts of Aotearoa - New Zealand. It also identified how harbours and fiords affected the accumulation of these persistent environmental pollutants.

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Integrating Mātauranga Māori into Science-based Flood Risk Models

Compounding impacts of inundation/flood hazards under a warming climate are expected to exacerbate natural threats to communities of elements of interest in Aotearoa New Zealand, which includes taonga (objects of high value) and wāhi tapu (sites of cultural significance). For example, in the northwest portion of Te Pokohiwi o Kupe (the Wairau Bar) in the Marlborough region, ongoing erosion coupled with the effects of SLR threaten the loss of one of Aotearoa New Zealand's earliest archaeological/taonga sites dating to c.1280 AD. The site is one of the nation's most significant cultural heritage locations which Te Rūnanga a Rangitāne o Wairau are Kaitiaki (guardians).

This paper presents on progress of a study aimed at understanding multi-dimensional flooding impacts on Māori whenua, wāhi tapu and taonga; with a particular focus on the Wairau Bar and the adjacent environs in Blenheim, Marlborough District. The objectives are to develop scalable methods for integrating Te Ao Māori into the science-based models that planners use to make decisions about coastal adaptation in the Marlborough region, with potential applications to other parts of Aotearoa New Zealand.

We discuss the preliminary results of key study components encompassing: 1) expert elicitations from, and hui/wānanga with, Rangitāne o Wairau kaumatua and whanau to develop mātauranga-inclusive statistical models for use in quantitative flood risk modelling applications; 2) tsunami inundation models developed to inform hazard susceptibility areas; 3) Ground Penetrating Radar (GPR) surveys at Te Pokohiwi o Kupe to develop 3D geospatial models and identify/validate archaeological sites/taonga (such as urupā) for integration into the risk modelling workflow. We interpret / discuss the preliminary findings within the context of the research objectives and longer-term implications on coastal adaptation in Aotearoa.

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Auckland Council's Coastal Monitoring Program

Auckland is the most populated city in New Zealand, with a coastline length of about 1800 km. A large part of its population lives near the coast. Coastal communities face challenges due to their exposure to rising sea levels and increased frequency and intensity of storms. Coastal inundation and erosion can damage infrastructure, recreation areas, and ecosystems. Coastal management requires the ability to respond to short-term events (e.g., storms), medium-term (e.g., ENSO events) and long-term changes (e.g., sea level rise, climate change). Monitoring programs, help facilitate our understanding of how coastlines change, with historical data enabling future planning and informed decision-making.

In the Auckland Region, coastal monitoring has occurred since the 1960s, mainly focusing on beach profiling. Sixteen beaches are presently monitored on a regular basis. In 2022, The Auckland Council Coastal Monitoring Program (CMP) underwent a review which identified the need to expand the program. Over the last two years, through the integration of innovative technologies, the CMP delivers comprehensive multi-instrument data. This data assists scientists, planners, asset managers, coastal engineers, and other decision makers in understanding Auckland's coastal systems.

The CMP now utilizes a network of 7 Obscape coastal monitoring cameras at 6 beaches, and 3 Obscape wave buoys to capture accurate wave and tide data. In addition, aerial UAV SfM surveys are utilized to replace beach profiling and identify sand volume changes. Beach survey frequencies have been increased to better capture seasonal variability. In collaborative projects, Auckland Council have developed a customized high-resolution wave and hydrodynamic model for the region, and have conducted new bathymetry surveys as a benchmark against past and future surveys.

Here we present an overview of the advances to the CMP, examples of the datasets produced and a new online data portal where this information can be accessed.

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South Island Wave Monitoring Network: Updates and one year of data

Ocean waves are a main driver of shoreline change globally. Changes in wave climate directly influence coastal sediment transport and shoreline position, with implications for people, infrastructure, and the environment. Storms also pose an erosion and inundation hazard, with storm impacts being felt more often as sea level rises. To accurately quantify wave conditions and benchmark against future change, real-world buoy data is needed. In 2023, four Sofar Spotter^{TM} wave buoys were deployed around the Canterbury coast to better quantify spatial variability in wave and synoptic conditions. These locations included Kaikoura, Pegasus Bay, Timaru Port, and Glenavey. In conjunction with existing buoys from Environment Canterbury/NIWA and PrimePort Timaru, these buoys have been instrumental in characterising wave processes, building a database of free historic data, and providing near-real time monitoring.

In 2024, the wave monitoring network expanded to include three locations in Otago, and a further two in Canterbury, bringing the total number of buoys in the network to nine. This collaborative effort has led to the rebranding of the wave monitoring network to "South Island Waves" to reflect its wider spatial extent. Wave data is stored and displayed in near-real time on our website: www.southislandwaves.com, with wave conditions updated every 30 mins to 1 hour. The buoys also measure sea surface temperature, MSLP, and wind conditions, and store partitioned wave data. With some of the buoys being in place for over a year, we can now start to quantify interannual variability in wave processes across the east coast of the South Island and analyse the propagation of storm waves during different events.

In this talk I will discuss the expansion of our wave monitoring network and share some of the initial findings. This includes statistical analyses of longer-term wave climate, tracking of individual storm events, and comparison to hindcast wind and wave models. I will also discuss ongoing and future uses of the data including validating directional wave models, improving nearshore sediment budgets, and linking to river mouth processes. Establishing and maintaining the network is a collaborative effort. We thank all who have been involved and to those who have helped promote the network as it grows.

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Monitoring of Environmental Change due to Conversion of Oyster Farms from Traditional Racks to the Innovative Flip-Farm System

Moana NZ commissioned eCoast to design and implement a multi-year monitoring program to measure and record environmental changes due to oyster farm conversion from the traditional intertidal timber racks to the flip-farm floating long-line system (www.flipfarm.co.nz). The dense intertidal timber racks effectively reduce and redirect tidal currents, as well as reduce the penetration of wind-generated wave activity, resulting in reduced water flow through the farm (due to structures reducing tidal and wind-driven currents) and less influence of wind-generated waves on the seabed (i.e., reduced sediment resuspension). As a consequence, fine sediments (land and farm-derived) are trapped under the farms and ultimately change the seabed quality (thickness of sediment layer, chemistry, biological communities, etc.).

By converting to the flip-farm system it is expected that positive changes to the sediment under the farms will occur due to increased resuspension of sediments (which occurs along the water's edge as the tide moves up and down during wind events) and increased currents and flushing. Moana NZ, the largest Pacific oyster producer in the country, wanted to document and quantify this transformation through an appropriately designed and implemented monitoring programme.

In order to confidently measure the effects that the conversion to the flip-farm system has on the marine environment, the monitoring methodology followed a BACI (Before/After, Control/Impact) monitoring design. Pre-conversion monitoring represents the 'before' monitoring, with both control and impact sites being surveyed to develop comparable data sets to statistically measure change. The results of monitoring of oyster farm conversions in Whangaroa, Parengarenga and Coromandel Harbours are presented, which indicate a variety of recovery, changes to physical processes and the broader influence of extreme weather events.

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Rewilding Bluff Harbour via active marine restoration: Sea Nest/Kōhanga Moana Pilot Study

Anthropogenic disturbances have modified the subtidal topography of Bluff Harbour, along with most harbour environments in Aotearoa, and around the world. Rocky reef habitats are fragmented amongst developments, which limits ecological corridors and artificial rock structures, such as rock armouring, can be largely devoid of biodiversity. Restoration in the marine environment is challenging as restoration projects are often costly, resource-heavy, and can have large carbon footprints. To combat these challenges, we have developed Kōhanga Moana/ Sea Nests® an eco-engineered, rugose, low cost, stackable structure designed and built in NZ for NZ marine environments. The Sea Nests provide both a habitat for fauna and suitable substrate for flora such as *Macrocysitis pyrifera* for kelp restoration or carbon sequestration. They aim to restore, enhance and protect the capacity to harvest mahinga kai; provide effective technology for the construction or retrofitting of 'living' breakwaters for coastal protection or surf breaks, have low carbon footprints and can be delivered cost effectively NZ-wide.

A pilot study in collaboration with Southern Marine Farms, Kelp Blue Aotearoa and Foveaux Pāua is underway in Bluff Harbour where Sea Nests® were deployed in May 2024 and actively seeded with *M. pyrifera* sporophytes from Kelp Blue. Sea Nest is also working with Foveaux Pāua to trial seeding the Sea Nests® with pāua. Monitoring of the Sea Nests® to-date have shown an impressive increase in biodiversity and native species abundance, whilst trials continue in the Kelp Blue lab and at the Sea Nest open water site to investigate the most effective method of kelp seeding.

The outcome of this project will be important for rocky reef and *M. pyrifera* kelp restoration in Australasia and around the globe as it will support the basis for economically viable marine restoration and offsetting, effective kelp bottom-seeding techniques (as an alternative to surface line kelp farming) and add to the dataset of the importance of rocky reef substrates in biodiversity enhancement.

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Cyclone Gabrielle sediment impacts on the seabed environment off Te Matau a Māui/Hawke's Bay and Tairāwhiti/Gisborne coasts

Cyclone Gabrielle caused devastating and widespread impacts in catchments and coastal zone of the Te Matau a Māui/Hawkes Bay and Tairāwhiti/Gisborne regions. The magnitude and duration of the storm event suggests that the extent and nature of impacts on marine ecosystems are potentially significant. However, direct observations offshore were logistically challenging to achieve in the aftermath and only recently have been formally documented.

Fisheries New Zealand commissioned several studies to evaluate the impacts of Cyclone Gabrielle on marine habitats and the fisheries they support. NIWA conducted boat-based surveys at priority coastal and shelf environments off Te Matau a Māui and Tairāwhiti to document changes in seabed geomorphology, cyclone-related sedimentation, fresh debris, and fisheries habitats and benthic communities. Survey effort mainly targeted priority areas where pre-cyclone multibeam bathymetry and biological data were available for comparison, but also extended to unsampled areas on the outermost continental shelf to map the possible extent of impact. In this presentation, we summarise the results from these NIWA response surveys, including any evidence of geomorphic and habitat change, together with new benthic imagery and substrate observations.

We include a follow-up survey to monitor short-term recovery, and modelling work to characterize the cyclone floodwater, along with sedimentation footprints and their possible impact on habitat-forming species. An important element of our approach was to provide regional, seasonal and inter-annual context for the scale of disturbance. We also summarise an initial investigation to trace the contributions of major rivers to marine sedimentation associated with Cyclone Gabrielle.

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Nature's Shield 1: The Wi Neera to Onepoto Project – Engineering Differently

The Wi Neera to Onepoto Project being delivered by Porirua City Council is located on the Onepoto arm of Te Awarua o Porirua, alongside Wi Neera Drive and Titahi Bay Road. The project includes two main elements, a 1.4km shared pathway connecting Porirua City and Titahi Bay and nature led coastal protection. The key objectives being providing an improved pedestrian and cycle connection, resilience to the road corridor, and restoration of the degraded harbour edge.

The Porirua Harbour faces several environmental challenges with significant historic modification of the Harbour edge through reclamation, particularly within the Onepoto arm, and high levels of ongoing sedimentation from a degraded catchment. Coastal erosion affects the road corridor along the western edge of the Harbour, contributing to sediment loads, and is the focus of the resilience aspect of this project.

The coastal protection solutions adopted by the project focus on nature-led design and includes:

- 9,000m^2 of saltmarsh (*Juncus Kraussii*) planting protected by a low height rock sill,
- 3,500m^2 of gravel beach and cobble headlands formed with material extracted from the Hutt River for flood control,
- 350m of traditional rock revetment, targeted to protection of areas of high value seagrass beds.

Adopting nature-led design comes with inherent challenges as engineers. Specifically gaps in design guidance and lack of certainty in performance. This is particularly difficult when solutions are being implemented to protect assets, and risk of failure has consequences beyond that of the solution itself and there is a need to strike a balance between the competing drivers of ‘natural restoration’ and ‘engineering performance’.

We will discuss how this was addressed on this project through the adopted design approach along with key project drivers, overview and lessons learnt. The Nature’s Shield 2 presentation focussing specifically on the innovative approach adopted in design of the saltmarsh as coastal protection.

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Producing a nationwide hydrologically conditioned DEM

Many coastal hazard modelling approaches rely on accurate Digital Elevation Models. We present a nationwide hydrologically conditioned DEM produced as part of Mā te haumaru ō te wai: Flood resilience Aotearoa, which is designed for use in coastal, river and tsunami flood modelling. Our product includes an 8m and 4m resolution offering covering the three main islands of Aotearoa New Zealand to a distance of 20km offshore. LiDAR is used where available on land, while composite depth measurements are used offshore to provide an integrated land and near-shore DEM product.

Hydrological conditioning of DEMs is important prior to flood modelling to ensure the accurate representation of flow paths and barrier to flow. On land, this can be achieved through the inclusion of natural (e.g. waterways) and artificial (culverts, canals, stopbanks) features. In our product, we focus on the daylighting of natural and artificial waterways (removal of spurious obstructions and opening of culverts to the sky), the inclusion of river and estuarine bed elevations where available, and the inclusion of flood defences (specifically stopbanks crest heights). Along the coast, we ensure key river mouths are open to provide a continuation of flow paths offshore, alongside the smooth interpolation between land and ocean elevation measurements.

The production of derived nationwide data products typically requires the synesis of many different datasets in the same horizontal and vertical datum. In our case, we defined a hierarchy of data to determine how we would synthesise different datasets. We give highest priority to surveyed measurements (e.g. river cross sections), then dense point data (e.g. LiDAR or multibeam sonar), then derived elevation rasters, and finally sparse point data (e.g. sounding point depth measurements). Fortunately, we now have LiDAR surveys covering most of Aotearoa. In areas where multiple LiDAR surveys exist, we used the latest LiDAR survey in preference to older surveys. This was applied at the pixel level. Although, New Zealand's LiDAR coverage has increased dramatically in recent years, around a quarter of the country has not yet been surveyed. We used an up sampled nationwide 30m DEM product where no LiDAR data exists on land. As we do not yet have widespread blue-green LiDAR along the coast of Aotearoa, we used a composite dataset of offshore elevation depths derived from multibeam and sound point depth measurements.

These different datasets have very different data densities and require different interpolation approaches. Specifically, we use inverse distance weighted interpolation for dense LiDAR data, and thin-plate-spline radial basis function interpolation for the relatively sparse offshore elevation dataset. Given the ongoing collection of elevation data over Aotearoa we prioritised the reproducibility and automation of our DEM generation approach. Specifically, we used our open-source software tool, GeoFabrics. Finally, we demonstrate the usefulness of our DEM products through the presentation of flood inundation maps produced at two catchments prone to coastal river flooding as part of Mā te haumaru ō te wai: Flood resilience Aotearoa.

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A community of practice for carbon storage in coastal wetlands around Aotearoa New Zealand

Coastal wetlands (seagrass, mangroves, saltmarsh and intertidal flats) are unique ecosystems, with high cultural and ecological value. There is growing recognition of the carbon storage value of coastal wetlands. This may be viewed as an opportunity: carbon storage can be added to the extensive list of 'values' or 'services' we might assign to these systems – either qualitatively, or quantitatively where various credit mechanisms can promote further sequestration. However, this 'new value' must be mindful of the other significant value(s) (e.g. coastal adaptation, cultural materials, biodiversity) as there is a risk of unintended consequences for coastal wetlands and associated communities from policy focussed only on carbon sequestration. Protection of existing coastal wetlands is equally important for nett carbon gains. There is also the opportunity of positive solutions by using integrated thinking to enhance the suite of values.

An informal, wide-reaching, community of practice focussed on carbon storage in coastal wetlands around Aotearoa New Zealand has formed around this need to explore and understand the opportunities, risks, and barriers. Activities of this community in the last 2 years include:

- Hui organised by the Tasman Environmental Trust (TET) in 2023 developed national and Australasian networks, and shared a collaborative methods development project led by TET, Ngāti Apa ki te Ra Tō, Beca, Nelson City Council, and Cawthron Institute, delineating carbon in saltmarsh and seagrass habitats in Te Tauihu. https://www.tet.org.nz/projects/blue-carbon-core-and-restore/
- a series of hui in 2023 organised by The Nature Conservancy and the Department of Conservation, where various needs and objectives were explored (socio-ecological research, empowering communities, market development and policy, Te Ao Māori and Mātauranga Māori, coastal wetland habitat protection and restoration, and national coastal wetland blue carbon strategy),
- two small-group workshops held at GNS and NIWA in the first half of 2024, exploring the elements required for a national 'coastal wetland blue carbon strategy', and
- a 1-day workshop in late 2024 at Victoria University of Wellington, focussed on understanding the latest results emerging from a range of research programmes.

In this presentation, we summarise the outcomes of these sessions and offer possibilities for future points of connection. As we are an evolving and inclusive community, we are keen for feedback, and engagement, on moving forwards together.

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Field Monitoring and its Role in Advancing Complex Hydrodynamic Modelling at Te Wai Manawa | Little Shoal Bay

In 2023, Tonkin & Taylor Ltd. commenced field monitoring in conjunction with the development of a hydrodynamic model at Te Wai Manawa | Little Shoal Bay for Auckland Council. This site, featuring both freshwater and marine wetlands alongside a mix of public recreational areas, makes it an ideal case study for coastal management. The freshwater wetland within Te Wai Manawa | Little Shoal Bay comprises of Raupō, with mangroves occupying marine dominated areas.

Our aim was to develop a hydrodynamic model, with scenarios to help us better understand potential ecological ('Habitat focused') and flood-related ('Flood focused') changes under various Relative Sea Level Rise (RSLR) scenarios. We were additionally able to assess the effects of different coastal management interventions to inform future management and adaptation in the area. Field data collection and analysis was a critical step to validate our hydrodynamic model, but also in establishing an understanding of complex hydrodynamics within the wetland.

As part of our field monitoring work, we utilised an array of telemetered sensors placed throughout the wetland to measure water level, temperature, and salinity variances. We deployed these sensors to track salinity levels over 12 months. The sensors were strategically placed at different locations, allowing us to map out tidal influence and salinity gradients across the wetland. Within the ecological focused objective of the project, we were then able to use this to infer the salinity gradients that define the Raupō freshwater habitat.

Through this presentation, we hope to share our experience and findings, in particular our fieldwork methodology and the value of long-term datasets that have both high geospatial and temporal resolution to build confidence in our understanding of complex wetland hydrodynamics. This understanding is critical to forecasting changes in wetland habitats due to RSLR and broader decision-making regarding the coastal management of areas, particularly nature-based solutions.

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Investigating the connection between metocean conditions and boating safety: An analysis of incident data

New Zealand hosts a multitude of interests along its coastline and in its coastal waters, ranging from recreational and small-scale commercial activities to tourism and large-scale industry. Robust coastal risk management is essential to secure both economic interests and the safety of life. Despite a widespread appreciation of the relationship between weather and coastal safety, objective analysis at scale in this area is largely lacking.

In 2024, Maritime New Zealand (MNZ) and the National Institute of Water and Atmospheric Research (NIWA) collaborated on a three-month secondment to further research this relationship. This research aims to enable improved communication about risk from weather conditions, generate more proactive risk mitigation and support more engagement around specific types of risk in coastal environments.

We propose to use statistical relationships between weather and incident occurrence to develop a risk characterization framework tailored for different coastal areas and vessels in New Zealand. Results from this initial investigation will reveal varying sensitivities to coastal marine meteorological parameters.

In a previous study based on available search and rescue data for South Africa (de Vos & Rautenbach, 2019), activities in which individuals are inherently more vulnerable (e.g., swimming) had the highest incident frequency during good weather conditions. For activities involving small personal watercraft (e.g., kayaks), incidents were most frequent during marginal conditions. Incidents involving small vessels (e.g., rigid-inflatable boats) were most numerous during bad conditions, with no clear pattern for larger commercial vessels (e.g., fishing trawlers).

These results differ in the New Zealand context and vary depending on the region of interest. Finally, we aim to present empirically derived risk coefficients, showing the relationship between risk, user vulnerability, and user exposure for given weather severity scenarios.

Reference:

de Vos, M., & Rautenbach, C. (2019). Investigating the connection between metocean conditions and coastal user safety: An analysis of search and rescue data. Safety science, 117, 217-228.

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New high-resolution tide, storm tide and current predictions for New Zealand.

The NIWA TideForecaster model and derived red-alert tide calendars are widely used in NZ by fishermen, beach-goers and emergency managers. We have upgraded the tide model to include a much higher grid resolution, which gives greater accuracy near the coast, and to include most of the large estuaries in NZ. The model has been re-calibrated against a much larger tide gauge dataset. We have also coupled the tide model to NIWA's wind models, which allows us to operationally forecast extreme storm tides and also barotropic surface currents.

A storm tide is the extreme water level that is observed at a specific location during a storm. It represents the combination of the storm surge and the astronomical tide. Storm tide flooding is a natural hazard with significant global social and economic consequences. Modelling of tides and storm surge together in one model is a deviation from the global norm—most models simulate storm-surge in the absence of tides and add harmonic tides to the prediction later. But most extreme storm tides in New Zealand are driven by moderate skew surges combined with high perigean spring tides. Modelling storm tides directly accounts for the interaction between storm surges and astronomical tides, leading to more accurate predictions of extreme water levels and provide a more realistic representation of conditions during a storm event, which is crucial for real-time forecasting and emergency response. For this reason, NIWA has developed a high-resolution operational storm tide for New Zealand.

Here, we demonstrate the accuracy of the storm tide model, and showcase some of the derived products including red-alert tide warning calendars, storm-tide warnings, surface current predictions, and navigation aids.

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What matters most... thresholds?

There is a case to be made that the development of adaptation thresholds m*atters most* and should occur earlier during adaptation planning. Thresholds provide the critical 'so what' addition to a risk assessment, allowing risks to be categorised based upon the level of management they will require. Exposure and vulnerability analyses may be the building blocks for identifying and assessing risk but determining the adaptation thresholds for each risk provide a basis for categorising risks beyond their risk scores. Understanding that you have a certain number of risks is only meaningful when you know that out of the identified risks, there are specific risks that require active management within the next 100 years.

The Ministry for the Environment Coastal Hazards and Climate Change Guidance (2024) ten-step decision cycle has the development of signals, triggers and thresholds occurring in Step 7, after adaptation options and pathways are identified (Step 5) and evaluated (Step 6). We propose that thresholds should be considered as part of the risk assessment in Step 4, rounding out the *What Matters Most* phase of adaptation planning. Without thresholds against each risk, there is not clarity whether the risk will require managing within 100 years, necessitating adaptive action or if it is acceptable. Some risks simply do not require action, and that needs to be acknowledged, allowing the risks that do require actions to be focused on and enabling a risk-based approach to further investment.

For example, in the Defence Estate Climate Adaptation Plans, some risks require just monitoring and management when other risks need immediate intervention. The difference in recommendation is largely due to the threshold and the projected lead time before the threshold will be reached. Where a risk requires immediate intervention, the threshold may already have been reached or is expected to be reached in the short-term. In contrast, the recommendation of monitoring and management is the acknowledgement of a risk that is not likely to result in unacceptable level of service or performance until the long-term. In the Republic of the Marshall Islands Vulnerability and Adaptation Planning project, the thresholds for habitation drives the adaption pathways in absence of detailed exposure data.

Quantified exposure data is required to accurately project when physical climate thresholds may occur in time. This information on exposure helps to understand the urgency of the risk and the timing of the threshold. If it isn't plausible for the threshold to be reached within 100 years, this risk would require different management than a risk that has a threshold likely to be reached within 20 years.

In this presentation, we will discuss the elements of risk assessments – focused on vulnerability and exposure – alongside thresholds to evaluate what matters most... thresholds or something else?

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How coastal ecosystems can help to mitigate tsunami impact in New Zealand?

Tsunami have demonstrated their capability of destruction over the past two decades with large transoceanic events, as well as very localized ones. While many man-made hard structures have been designed to stop tsunami propagation or reduce their impact, they show limitations and are most of the time very expensive. However, past events and research studies have demonstrated that in certain conditions nature-based solutions can mitigate tsunami impact. A comprehensive literature review was performed through a systematic search of relevant English-language scientific articles in online platforms. A total of 173 studies specifically deal with the role coastal ecosystems can play to reduce the impact of tsunami waves. We found that 36% of the studies focused on mangroves, followed by coastal forest (21%) and coral reefs (15%). The rest focuses on coastal dunes, coastal vegetation in general and coastal ecosystems in general. The scientific approaches include numerical modellings (33%), reviews (18%), field studies (15%), and laboratory experiments (12%). Most of the field studies were in southeast Asia and Japan, mainly following the 2004 Indian Ocean and 2011 Japan tsunamis, respectively. Two of these studies have been realized in New Zealand. Concerning the effectiveness of the different ecosystems, 73.4% of the analysed studies show that ecosystems are effective in mitigating tsunami waves, and 9.8% that ecosystems are ineffective in mitigating tsunami waves. All ecosystems seem to provide a protective service up to certain threshold values directly linked to tsunami characteristics (e.g., amplitude, periodicity, current speed) and ecosystem state (e.g., health, surface coverage).

GNS Science is leading a project to assess potential roles some coastal ecosystems around New Zealand could play in mitigating tsunami impact and to define how they could be integrated to tsunami mitigation plans. To this aim, critical experimental sites have been determined with the help of partners and stakeholders, including councils, Crown Research Institutes, Maritime New Zealand, and others, who also shared their views, experience, and needs in terms of tsunami hazard management.

The research tests the efficiency of different ecosystems in reducing tsunami and other coastal hazard risks to Aotearoa New Zealand coastal communities and infrastructure. To support stakeholders in making robust decisions, the research endeavours to present a methodology to quantify risk reduction benefits from different types of ecosystems (e.g., mangroves, kelp forests, dunes), and hybrid systems (nature-based & hard infrastructure) compared to no interventions. Existing numerical tsunami simulation models are adapted to approximate tsunami energy dissipation effects of multi-ecosystems coverage in coastal areas though the application of appropriate friction coefficients over the digital elevation models, i.e. friction grid. This grid is developed in agreement with up-to-date knowledge about coastal ecosystems extents and friction. Preliminary simulations are performed in identical locations with or without the friction grid, and with hypothetical improvement/degradation of the current ecosystem coverage.

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Observations and alterations of the opening regime of te Roto o Wairewa: New salinity observations and effects of a proposed fish passage.

Te Roto o Wairewa [Lake Forsyth] is an intermittently brackish and rarely open coastal lake. The lake is an important but threatened tuna fishery due to disconnection from the ocean and harmful *Nodularia spumigena* blooms. The lake was deeper and open more often before the catchment was deforested, and is now infilled with P-rich sediment. The opening regime of the lake changed in the 1800s as Kaitorete barrier thickened, and again in 2009 when a canal was excavated to attempt a more regular connection. Both lake salinity and the frequency of cyanobacteria blooms decreased after the canal construction. The lake's water balance is primarily between the inflowing catchment, percolation through the barrier, evaporation, and intrusion after openings; all are unconstrained during openings as only lake level data are historically available.

A water quality sonde (temperature, salinity, chl-*a*, turbidity) and horizontal ADCP placed in the canal, supported by flow transects, constrain the salinity balance over multiple months and will continue through a lake opening and closure sequence. Salinity intrusion events of up to 23 ‰ have been observed without lake opening, confirmed from nearby buoy data as wave overtopping flux and transported by observed wind-forced lakeward currents in the canal of 2-5 cm/s. The saline intrusions appear to be modulated by lake levels, potentially allowing an estimate of the seepage rate. These processes will be compared with intrusions during opening events.

Implications for these data on the lake water balance and a potential engineered fish passage include a new understanding of the opening event flow rates and the potential for salinity intrusion before, during, and after openings. The re-introduction of brackish water into the ocean through a fish passage should provide the requisite homing signal for tuna. A model of the re-engineered lake and canal indicates that a brackish canal can be selectively flushed after an intrusion, reducing the potential for stratification and subsequent hypoxia or cyanobacteria bloom events while reconnecting this taonga species to its roto.

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A new national typology of coastal change for Aotearoa New Zealand

Accelerating sea-level rise poses a global threat to coastal communities. Our understanding of sea-level rise impacts on coastal erosion risk remains limited in Aotearoa New Zealand, partly due to an incomplete understanding of historical baseline changes in our beaches over multi-decadal timescales. In 2024, an updated national dataset of coastal change rates and patterns was published (see coastalchange.co.nz), detailing movement of the position of the coast between the 1940s to 2023 for most of Aotearoa's open coast beaches and soft cliffs. This new dataset allows coastal practitioners, managers and scientists to consider baseline coastal erosion and accretion rates at a range of spatial scales (local community- to regional- to national-scale) when planning for adaptation to coastal hazards and climate change.

The authors of Aotearoa's national coastal change dataset have developed New Zealand's first typology of coastal change, which is presented in this talk. This coastal change typology will describe and visualise the range of trends and patterns in coastal erosion and accretion rates around the country. The typology is applicable at national scale and identifies coastlines that have continually or episodically eroded, continually or episodically accreted, are highly dynamic or stable throughout the time period of analysis. Importantly, this typology indicates beaches and coastlines that have experienced an acceleration in erosion, or a switch from accretion/stability to erosion in recent decades. This talk will introduce New Zealand's inaugural coastal change typology and discuss applications of the typology for decision-making.

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Blocks vs Rocks: Construction Lessons from Te Ara Tupua

The Te Ara Tupua Alliance is delivering coastal resilience and mode shift projects around Te Whanganui-a-Tara. The Te Ara Tupua Ngā Ūranga ki Pito-One Project comprises a 4.5 km shared (pedestrian/cycling) pathway between Ngā Ūranga and Pito-One with dual outcomes of rail/road corridor resilience improvement and mode shift. The project is in the construction phase and includes the use of thousands of tonnes of rock armour and precast armour units.

The Project is constrained by very tight environmental and ecological constraints, budget expectations, a difficult design environment, a limited local rock supply, and narrow consented construction workspace between a busy railway corridor and the harbour. These constraints drove design innovation towards the use of a precast armouring solution – the XblocPlus® unit – a first for Australasia.

This presentation will explore the practical complexities in designing, producing, and installing an innovative alternate armour solution in a constrained project site. The key focus of the presentation will be on:

- The driver for adoption of the XblocPlus® concrete armour units for primary armouring of the revetment structures in place of the consented rock armour. The single layer, pattern placed units have resulted in significant cost and programme savings to the project.
- Construction tools and methods which were considered during the design and construction establishment phases of the project
- Construction methodology limitations at this site, and in general for placing rock armour and XblocPlus® units below line of sight underwater.
- Lessons learnt during construction to date, and how design and construction methodologies, construction monitoring, and quality assurance processes have been adapted to suit the armour units, narrow site, available plant, and site conditions.

Presenter: Hayden Sander is a Civil Engineer for Tonkin + Taylor based in Wellington. Hayden's background is primarily in Civil Engineering, and has worked as a Civil Engineering designer, and as a part of the Designer's Site Representative teams on a number of major projects in Wellington and the Central North Island. Hayden has been involved in the construction phase of Tonkin + Taylor's more recent coastal erosion protection projects in the Wellington region, and Hayden is currently the Construction Phase Support Lead for the Te Ara Tupua Alliance.

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Wave Forecast Investigations around Aotearoa New Zealand

This study evaluates the effects of downscaling, source terms, and tidal interactions on numerical wave forecasts in Aotearoa New Zealand. We utilised a set of three nested domains (from global to regional scale) to examine significant wave height (Hs), mean period (Tm01), and peak wave direction at two coastal locations, Banks Peninsula and Baring Head. Downscaling markedly improved forecast accuracy at Baring Head, a tidally constricted region, reducing Hs forecast error by 25%. However, improvements at Banks Peninsula were minimal, likely due to its open coast characteristics which are adequately represented even by lower resolution models. Source term enhancements using default ST6 parameters generally improved Hs predictions on the west coast but worsened them on the east, indicating a geographical dependency in model performance. This variability was also evident in the Tm01 predictions, with notable improvements in bias reduction through model downscaling, particularly at Baring Head. Tidal influences were significant, especially at Baring Head, where they enhanced the forecast accuracy of wave height and direction due to the strong tidal currents characteristic of this location. In contrast, at Banks Peninsula, tidal effects were less pronounced. The study underscores the importance of tailored modelling approaches that consider local geographical and hydrodynamic conditions to optimise wave forecasting.

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**Improving our relationship with the coast:
collaborative climate action at Waihī Beach**

In an inspiring journey of transformation, this project witnessed a community in the western Bay of Plenty region transition from a state of ambivalence and fear towards climate risks, to a state of awareness, knowledge, and empowerment. This project saw Bay of Plenty Regional Council (hereafter Regional Council) partner with Waihī Beach Lifeguard Services (hereafter WBLS or the club), a registered charity and a group of dynamic volunteers offering emergency services along the 10km peninsula and 75km coastline, and key stakeholders to create an actionable plan that will help them navigate climate changes. The wider community was engaged every step of the way with representatives from the Western Bay of Plenty District Council, Surf Life Saving New Zealand, NZ Police, Coast Care, Coastguard, Emergency Management Bay of Plenty, and the Waihī Beach Community Board playing pivotal roles.

The project was prompted in 2023 in response to several flood events and the WBLS board receiving a report by GNS Science identifying the club as a priority site vulnerable to coastal flooding. Based on central government guidance, a series of in-person workshops were co-facilitated by the WBLS board Chair and Regional Council climate resilience staff. These sessions explored the overlap between the club's strategic objectives and the numerous climate hazards they face, resulting in a resilient and actionable plan to prepare the club for the future.

The collaborative spirit was the driving force behind the project's success, ensuring that local and diverse perspectives and expertise were harnessed at every step. The process has not only empowered a climate-ready community but also offers valuable lessons that can be scaled and shared.

In our presentation at the New Zealand Coastal Society conference, we will unveil the journey of a community that has not only enhanced its understanding of hazards and adaptation strategies but is now equipped to confront future climate uncertainties with newfound readiness. This is a story of resilience, collaboration, and empowerment that you won't want to miss.

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Cliff erosion due to swash abrasion: An experimental investigation

Rock coasts constitute more than half of the global coastline. However, in contrast to the extensive studies on beaches and wetlands, rock coasts have received less attention. Our understanding of wave-induced cliff retreat is still quite basic. When waves attack a rock cliff, they gradually remove material from the base of the cliff, creating a wave-cut notch. As the notch deepens, the gravitational force on the overburden exceeds its resistive force, eventually causing the overburden to collapse. Over time, waves remove the collapsed material and restart the cycle.

This study focuses on the first phase of this cycle: notch development. In field settings, notch development occurs over years to decades and is influenced by various complex processes, including mechanical wave erosion (abrasion and quarrying), weathering, bioerosion, and dissolution. Controlled laboratory experiments provide a potential means for speeding up the notch development at a reduced scale while isolating key variables. In this paper, we used synthetic foam as a rock analogue to investigate the fundamental mechanics of abrasion notch development under periodic sediment-laden bore impacts. In these experiments, periodic dam-break bores, simulating broken waves within the swash zone, were released into the flume. They ran up on a sediment beach, collided with the cliff face, were reflected from the cliff, and drained before the subsequent release.

Our experiments reveal the dynamics of notch development over time. Initially, vortex and uprush jointly shape a shallow and wide notch. Subsequently, upward erosion ceases as sediment-laden uprush fails to abrade the notch roof. The vortex dominates notch backwear and downwear. Eventually, sediment deposition armours the notch floor, leaving only horizontal erosion and notch deepening. Our experiments draw attention to upper and lower threshold grain sizes that are associated with negligible erosion, and a range of grain sizes that are linked to maximum erosion. These results indicate an optimal momentum transfer governed by grain mass and velocity. Precisely measuring particle velocity upon collision with a notch and quantifying the momentum exchange require further investigation. This research reveals fundamental notch formation mechanisms related to swash abrasion, which has important applications for ongoing efforts to predict cliff recession rates.

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Applying an understanding of vertical land movement in post-quake Christchurch

In 2022, the NZ SeaRise: Te Tai Pari O Aotearoa programme released location-specific sea-level rise projections for every 2km of the coast of Aotearoa. For each 2km section of coast, inter-seismic vertical land movement (VLM) rates have been estimated and local rates of relative sea level rise have been projected.

In Ōtautahi Christchurch, many parts of the city are subsiding following the Canterbury Earthquake Sequence, accelerating local rates of relative sea-level rise. This has meant that while NZ SeaRise provides helpful information, a greater understanding of vertical land movement over the post-quake period is necessary to support various planning processes.

Since the release the of the NZ SeaRise web portal in 2022, Christchurch City Council and Environment Canterbury have collaborated to commission new reporting on post-quake VLM with GNS Science. The findings of this research indicate that rates of land subsidence in Christchurch's east are approaching 10mm/year in some locations and exceed 5mm/year in many parts of the city. These rates of VLM, mean that the rate of relative sea level rise is more than doubled in many parts of the city, at least for as long as the accelerated rates of VLM continue.

At Christchurch City Council, staff have been using this new information (supplemented by other sources) to inform a range of areas of work, including local adaptation planning processes, proposed district plan changes, and stormwater management and stopbank design. In particular, this has involved adding a combination of post and inter-seismic VLM data to upper-end SSP projections and using this information to identify the early onset of impacts and understand the possible timing of signals, triggers and thresholds.

As one of many parts of the country that has been heavily impacted by earthquake-induced land movements or could be subject to such changes in the future, Christchurch is a great example of why it is so important to understand the various factors that contribute to rising seas. Because VLM, in the form of subsidence has manifested as physical changes such as accelerated shoreline erosion, (often observed by communities) this information has been fairly simple to explain to communities and has been well understood. Because VLM is independent of greenhouse gas emissions, unlike the other factors that contribute to rising seas, we know that it is outside of our control (as a society) and so places even greater emphasis on the need to act now!

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The use of joint-probability analysis within coastal hazard assessments in NZ

Coastal hazards are compound events, driven by multiple coinciding drivers, including tide, wind surge, breaking waves, mean sea level variability, interaction with rivers, and relative sea-level rise (includes vertical land motion).

This presentation reviews the application of joint-probability methods to assess coastal hazards in New Zealand, what we have learned, and implications for future work.

We present results from a national extreme sea level assessment, a national assessment of rainfall and river flow dependence with sea surge, and regional assessments of wave and storm-surge joint-probability. We reflect on the relative influence of these compound interactions in relation to future relative sea-level rise.

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Forests on the brink: exploring the fate of Pacific atoll mangrove forests under rising seas

Mangrove forests and the ecosystem services they provide are vulnerable to climate change as they must keep pace with sea level rise (SLR) by accumulating sediment. On continental margins, reduced sediment supply from rivers, land subsidence and deforestation pose ongoing threats. The situation is more critical on low-lying Indo-Pacific atolls distant from rivers, where mangrove forests must rely on organic-sediment production alone. Ouvéa Atoll (New Caledonia) provides an ideal laboratory to explore the fate of these endmember systems under rising sea levels.

The Ouvéan mangrove forest is dominated by *Rhizophora stylosa* (stilted mangrove) and *Bruguiera gymnorrhiza* (large-leafed orange mangrove), with the later species being less tolerant to inundation. Both species occur as large trees near the outlet to the atoll's lagoon and as scrub trees in the forest's upper reaches. We combined observations and modelling over seasons-to-decades to determine mangrove-forest resilience to SLR. Measurements included bed elevation trends (RSET, 2017–2023), sedimentation, freshwater and sediment source tracing, mangrove growth (above & below-ground), organic-carbon sequestration and habitat mapping. These data informed projections of the likely fate of the Ouvéan mangrove forest using the WARMER model.

The major finding of our study is that Indo-Pacific atoll mangrove forests are likely to be lost to SLR from mid-century. Organic sediment production is insufficient to maintain mangrove forest elevation relative to sea level that is optimal for survival. On Ouvéa, tectonic subsidence and substrate elevation loss (several mm/yr) is compounding SLR impacts. Modelling the forests' future trajectory suggests that large mangrove trees may survive until the 2080s through organic sediment production. Scrub mangroves will likely be lost by the 2050s due to insufficient carbonate sediment supply. Our findings highlight the importance of sediment supply and local tectonic setting to the resilience of coastal wetland systems to SLR over the coming decades. Integrated catchment-to-coast management will be needed to mitigate adverse effects of SLR and avoid unanticipated outcomes. NIWA's *Future Coasts Aotearoa* Programme is exploring the future fate of New Zealand's coastal wetlands under rising sea levels.

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Restoration Plan for Te Awarua-o-Porirua

Te Awarua-o-Porirua (Porirua Harbour) is an exposed estuarine environment consisting of three (3) main areas: Pāuatahanui Inlet, the Onepoto Arm, and the outer harbour. The associated harbour margins provide a multitude of social, economic, cultural, and ecosystem services. An increase in urban development, agriculture, and road infrastructure has resulted in significant and ongoing environmental and ecological degradation of Te Awarua-o-Porirua.

Understanding the sites typologies and constraints enabled our Ecologists and Landscape Architects to develop a comprehensive approach to restoration through observation of previous efforts and future efforts by identifying treatments and phasing strategies. This innovative approach supplements the ecological habitats and biodiversity outcomes as part of an overarching effort to sustainably manage our degrading coastal margins.

The restoration plan was developed in consultation with Porirua City Council (PCC) with a focus on sustainability; it aims to restore, extend, and protect the indigenous wildlife of Pāuatahanui Inlet and Onepoto Arm. The restoration plan includes innovative guidance on pest animal and pest plant control, with best practice methods for planting. The plan is to be read in coordination with the Te Awarua-o-Porirua Strategy and Action Plan (2012-2020) and aims to be flexible should budget or ground conditions vary at the time of implementation.

The purpose of the restoration plan is to highlight to the communities how important our coastal margins are during flood events, and what climate adaptation initiatives we can do now to help protect our whānau, environment and future generations. The diversity of the planting intends to mitigate sediment and coastal erosion and increase habitats for indigenous species, both plant and animal. The scale of restoration is critical to minimise further ecological degradation while adapting to climatic changes. It provides an understanding of how urban intensification, road infrastructure, and agriculture have changed our coastal environments.

The restoration plan now forms part of PCC's 2051 work plan, which is driven by a new Harbour Accord between Greater Wellington, Wellington City, Wellington Water, and Ngāti Toa. Field assessments and restoration plans are essential to support the rehabilitation of natural areas, community sense of place (and involvement), and funding to ensure these efforts can be achieved.

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Using low-cost GNSS receivers for precise measurements in the marine environment

Low-cost Real Time Kinematic (RTK) Global Navigation Satellite System (GNSS) receivers offer a modern, flexible and precise means of making measurements in the marine environment. Over time, these low-cost receivers have been developed to track multiple constellations (e.g. the United States Global Positioning System (GPS), Russian Global Navigation Satellite System (GLONASS), Chinese BeiDou (BDS) European Galileo and Japanese Quasi-Zenith Satellite System (QZSS)) and multiple frequencies leading to higher precision measurements. Low-cost receivers - in the order of a few hundred dollars compared to survey-grade receivers of several thousand, or tens of thousands, of dollars (Odolinski and Teunissen, 2016) – offer flexibility in the marine environment by increasing the ability for hydrographers, engineers and scientists to improve their measurement uncertainty calculations and/or take more simultaneous measurements in an area.

We have tested low-cost receivers in the marine environment with a variety of setups and applications and will share the findings here:

1. In 2018, with multi-constellation, low-cost single-frequency RTK GNSS we have shown stationary horizontal measurements meet the most stringent International Hydrographic Organisation (IHO) Standard-44 at base station ranges of up to 27km. We have also demonstrated the ability to make water-level measurements comparable to electronic tide gauge readings. (Tidey & Odolinski, 2023).
2. In 2024, as part of an undergraduate honours project, we are investigating the use of multi-constellation, low-cost, dual-frequency RTK GNSS on buoys designed to be moored to measure water levels. Factors such as the effect of the buoys' protective plastic dome on the GNSS results, comparisons with pressure tide gauges and areas of application are considered.

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The Importance of Storm Duration and Antecedent Beach Conditions in Storm Damage, July 2023 Storm at the Clutha Mouth, Otago

In assessing or ranking the severity of coastal storm events, the focus is most commonly on wave energy (combination of height and period) and storm tide level. This approach was initially used in assessing a very damaging storm event in early July 2023 that overtopped the beach adjacent to the Koau mouth of the Clutha River, resulting in a scale of changes to the barrier beach system that had not previously been recorded and assessed in detail. These included barrier retreat of 100-150 m, lowering of the beach crest by up to 2 m, natural breaching of barrier beach by the Puerua Estuary, and damage to the Clutha mouth training wall and the Puerua outlet culverts.

However, the assessment of wave and storm tide hindcast records during the storm event revealed that significant wave height, wave period, and storm tide levels were not extreme, all being less than an annual return period. Wave direction was found to be normal for coastal storm events on this section of coast. Therefore, some other storm or beach characteristics were considered to be the primary driver as to why the scale of shoreline change occurred.

Further assessment found that prolonged storm wave duration and antecedent beach heights and slopes were the most likely the primary factors in determining the scale of beach change experienced during the storm event. There were nine consecutive high tides with storm tide levels above MHWS, of which seven coincided with significant wave heights greater than 3 m, and five with wave heights above 4 m in which wave run-up was likely to have the potential to reach or overtop the beach crest. However, this analysis was limited by the lack of certainty around the pre-storm antecedent beach conditions.

As a result of these storm responses, a qualitive re-assessment of the projected future shoreline positions around the Clutha Mouth has been undertaken, with consideration of the likelihood and frequency of similar responses being repeated in the future.

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The Impact of Extreme Weather Events on Estuarine Sediment Pathways and Estuarine Infilling

Estuarine systems play a crucial role in coastal dynamics and habitat formation, yet they face significant challenges due to infilling processes. Following European settlement in Aotearoa NZ, logging activities in catchment areas have intensified sediment runoff, exacerbating estuarine infilling. Understanding the mechanisms of these processes is crucial, as excessive sediment can degrade marine ecosystems, while insufficient infilling may fail the same ecosystems to keep up with sea level rise. Traditional studies often focus on equilibrium conditions, but estuarine systems are dynamic and rarely achieve true equilibrium due to stochastic events like storms.

Storms play a significant role in shaping estuarine sediment dynamics by shifting systems between different equilibrium states or accelerating their movement towards a new equilibrium. Despite their importance, the complex interactions between storm characteristics (such as wind speed, wave height, and tide phases) and local estuarine morphology are still not well understood. Gaining insight into how storms influence sediment pathways and deposition is essential for effective coastal management.

In this study, we investigate sediment dynamics during a significant storm event in the Whangateau Harbour (NZ, Auckland Region), characterised by extreme (>99th percentile) water levels. Our research involved the deployment of instruments along the tidal channel of a subsection of the harbour to monitor flow velocities, water levels, and suspended sediment concentrations (SSC) during the storm.

Our findings reveal that under calm conditions, Whangateau harbour is experiencing gradual infilling and sediment trapping. However, during the storm event, this infilling substantially increases, with flow velocities becoming more flood-dominant and SSC concentrations rising two to threefold compared to pre-storm levels. The storm-induced sediment transport primarily redirects sediments towards the upper estuary, where mangroves and saltmarshes capture and retain this material, potentially enhancing tidal flat expansion and creating more favourable conditions for mangrove settlement and expansion.

This study underscores the importance of incorporating stochastic events into estuarine research to better understand and predict sedimentary processes and their implication for coastal wetland development.

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Climate-induced Sea-Level Rise Inundation Exposure and Losses in Pacific Island Contexts

The Pacific Risk Tool for Resilience project, phase 2 (PARTneR-2) aims to build capacity in 6 Pacific Island countries (Cook Islands, Republic of Marshall Islands, Samoa, Tonga, Tuvalu and Vanuatu) to become more resilient to climate hazards through risk informed decision making. A key output of this project has been the development of hazard and risk models focusing on coastal inundation, tropical cyclones and drought. This poster will discuss the coastal inundation hazard and risk models developed for this project, and the national SLR profiles of each of the countries.

For each of the 6 countries national inundation models were produced. This involved the development of modified 5m digital elevation models (DEMs) that used down-sampled LiDAR and up-sampled FABDEM. These were used to create national static inundation models using a bathtub modelling process for ARIs from 1 to 250, coupled with sea level rise from 0 to 2m.

The impact of this coastal inundation on a variety of assets, such as buildings, roads and infrastructure were calculated using RiskScape, a customisable multi-hazard risk modelling software. Using RiskScape, we determined exposure, loss and average annualised loss to these assets, to look at the national SLR profile for each of the countries.

Findings from these different country environments can provide useful insights for application in coastal inundation hazard risk assessments and adaptation planning under changing sea level conditions in analogous island environments, and Aotearoa New Zealand.

Faye R White, Hamish Rennie

Repurposing newly-claimed seascapes in the New Zealand context

Communities and governments worldwide are facing difficult choices in responding to changing coastlines and estuaries. Standard 'Protect, Accommodate, Retreat, Avoid' (PARA) approaches have paid little attention to the potential for repurposing inundated areas. The emphasis tends to be on the socio-economic costs of PARA and this can result in significant political conflict as has occurred in Kapiti Coast. We suggest that if areas of 'land' inundated as a consequence of sea level rise are reconceptualised as 'newly-claimed seascapes', emphasis can shift to beneficial repurposing for these new seascapes. In New Zealand, sheltered coastal areas, shallow estuaries and harbours may have potential for repurposing for aquaculture, fisheries, wetlands and/or blue carbon. Abandoned and decontaminated structures may provide fish nursery habitat as artificial reefs or marine tourism attractions. The concept of repurposing could therefore enhance adaptation management in local contexts.

Whether that is realistic in the short-term is debatable, and perhaps unlikely in regions or districts with limited resources to even deal effectively with the PARA components. Nevertheless, repurposing may have immediate benefits as a new approach, if only to widen the scope of possibilities in certain situations beyond abandonment and loss. Here, we refine the results of our recent systematic international literature review of potential repurposing options, benefits and implementation barriers into a New Zealand-specific set of considerations for coastal decision-makers.

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Wave impacts on cliffs and vertical structures: Lessons from the lab and the field

Cliff erosion is of great importance due to the communities and cultural sites of significance occupying the top of cliffs that are vulnerable to erosion. Continuing global mean sea level rise and changes in storminess are generally expected to enhance the erosion of rock coastlines, as larger waves can reach the cliff toe without breaking offshore. However, the science underpinning wave-induced cliff erosion is still at a relatively early stage. Even the relative contributions of waves to cliff erosion, which include hydraulic forces, impulse pressures and abrasion, are not well resolved.

Many insights into these processes are obtained from field observations of large ground motion during storm events, as periods of large ground motion tend to correlate with increased erosion. The largest impacts occur when tidal levels and storm surge combine to promote wave breaking on the cliffs; these conditions are not always associated with the largest waves or the deepest water levels. While laboratory experiments into wave impacts on cliffs are relatively rare, a larger body of experimental work has been undertaken to investigate impacts on steep or vertical engineered structures. However, even experiments undertaken under carefully controlled conditions are subject to the inherent variability of wave breaking and impacts upon the structure, while not all experiments use appropriate wave conditions.

The current study aims to enhance understanding of this problem by undertaking wave flume experiments to investigate wave impacts on a vertical wall. These experiments are informed by the analysis of field data classifying different types of wave impacts on cliffs. The controlled experimental conditions allow a wave-by-wave classification of these different impact classes, providing information on the properties of the waves that create the largest impacts and their probability of occurrence within an irregular sea state.

The results of the experiments confirm some of the findings from previous field investigations; the largest impacts are not necessarily generated by the largest wave heights, and impacts are relatively sensitive to the phase of the incident waves. Although frequently used in early experimental campaigns, regular waves are inappropriate for impact experiments of this type, due to the enhanced reflection and lack of modulation compared to other wave conditions. Comparisons of focused and irregular wave impacts provide insights into the relative frequency of wave impacts under the conditions tested. Results are also compared to field data to determine the average shape of waves providing the largest impacts. These results will inform laboratory studies into cliff erosion by wave impacts, with the overall goal of advancing understanding of the fundamental mechanisms and timescales of wave-driven cliff erosion, and hence assessments of cliff erosion hazard in high-energy wave environments as sea levels rise.

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How to design trigger levels for adaptation using mean sea level measurements

Sea-level rise will force coastal communities to take adaptive actions. Trigger points must be designed ahead of time, so that adaptive actions can be planned for and can begin when the trigger point is reached. There is interest in designing trigger points based on mean sea level thresholds. Due to the variability in annual mean sea levels, it is difficult to determine whether we have reached a trigger point for adaptation. Here we developed a present-day indicator of sea level that can be used for adaptation. We tested three models (multivariate linear regression MLR, artificial neural network ANN and long-short term memory LSTM) for forward-predicting sea levels based on prior time series. The preposed methods can be incorporated into coastal inundation and exposure risk models to quantify the coastal flood damage.

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Urban Beach Responses to Wave Conditions and Storms in Auckland

Urban beaches are of great significance to their surrounding communities, providing amenity value, economic value, and often serving as iconic landmarks to both locals and visitors. These beaches are dynamic environments, with short-term processes, such as waves and storms, and longer-term processes, such as sea level rise and climate oscillations, driving a multitude of cross-shore and alongshore changes. With urban beaches being constrained by a higher density of nearby development, understanding these beach changes is essential for coastal hazard management and planning of resilient coastal communities. Auckland Council has an extensive coastal monitoring programme, with beach profile records dating back from 1998. This historical dataset allows the observation of general trends. For instance, significant erosion has been observed on many of Auckland's east coast beaches throughout the three consecutive La Niña years between 2019 and 2022. Conversely, while specific events such as Cyclone Gabrielle and Cyclone Lola were devastating for some east coast Auckland beaches (e.g., Browns Bay), beach recovery was observed in areas like Takapuna during these same events. While these erosional trends have been evident within the monitoring data, the specific local drivers that trigger these beach responses are not well understood, with the dataset requiring further in-depth analysis and interpretation.

The aim of the project was to analyse data to determine the responses of beaches in Auckland to the wave climate, storms, and decadal climate patterns. The study focuses on Takapuna Beach, due to the availability of profile data from 1998. Temporal analysis of the data was undertaken to observe how shoreline position, beach volumes, and beach centroids change over time. Centroid analysis gave insights into the dominant modes of beach adjustment, such as whether the profile tended to undergo advance, retreat, steepening, or flattening. Analysis of wave data from a high-resolution wave hindcast model enabled the investigation of correlations between the beach response and the wave climate and storms, specifically Cyclone Gabrielle and Cyclone Lola. Camera data since August 2023, taken every 30 minutes, allowed further qualitative insights on the beach response during these storm events.

Profile and camera data analysis confirmed that significant storm events such as Cyclone Gabrielle caused accretion rather than erosion on Takapuna Beach. We will discuss how the different wave climates, including wave height and directions, may have impacted this anomalous beach response. In addition, a cumulative series of storms are likely to have different impacts on the beach volume compared to a single extreme event. Our presentation will discuss the key factors related to these behaviours to better understand the short-term and longer-term trends. These results are valuable for Auckland Council to predict the impact of future changes in beach movement and provide protection from coastal hazards. Future work will expand the analysis on beaches across Auckland to compare beach behaviour between the different areas as well as incorporate satellite data into the beach analysis.

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Coastal Flooding Impacts on New Zealand's Interdependent Infrastructure Networks

We present recent studies investigating the impacts of coastal flooding on New Zealand's infrastructure at multiple scales. The research utilizes updated national coastal flood hazard maps and a network-based approach to assess direct and indirect disruptions to critical interdependent infrastructure networks. A separate spatiotemporal analysis for the wider road network projects that the combination of coastal flooding and vertical land movement could lead to annual damage costs ranging from NZD $86 million to $138 million by 2100. Local case studies in South Dunedin and Christchurch, alongside national-scale analyses, reveal key tipping points where service disruptions significantly escalate, particularly around 30-60 cm of sea level rise. The national-scale analyses underscore the significant interdependencies among infrastructure networks, where disruptions in one system can cascade into others, exacerbating the overall impact. The findings highlight the need for high-resolution data and integrated adaptation strategies to address cascading failures and ensure infrastructure reliability amidst increasing coastal flooding risks.

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Hindcasting estuary ecological states using sediment cores, modelled historic nutrient loads, and a Bayesian network for informed management.

Nutrient enrichment is an issue in many of Aotearoa New Zealand's estuaries, however guidance on how to assess the extent of eutrophication with a view to management is limited. The Estuarine Trophic Index toolkit was developed to assist regional councils in determining the susceptibility of an estuary to eutrophication, assess its current trophic state, and assess how changes to nutrient load limits may alter its current state. However, for most of Aotearoa's estuaries ecological monitoring data are unavailable or only cover recent periods, meaning trophic 'starting points' for estuaries and the long-term effects of land-use change and intensification are poorly documented.

To overcome this lack of knowledge, we have developed a multidisciplinary method to hindcast historic estuary condition, providing a time series of land-use, point source discharges, trophic health scores and associated ecological parameters. Having developed this method in the New River Estuary, Southland, reconstructing estuarine condition back to 1847, we are currently expanding this work to validate it in other Southland estuaries.

Our approach identifies nutrient and sediment loadings associated with 'tipping points' for indicators and can inform policy by identification of hazardous levels of contaminant loading for other estuaries.

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Te Hunga Takutai o Aotearoa
NEW ZEALAND
COASTAL SOCIETY