Te Hunga Takutai o Aotearoa
NEW ZEALAND COASTAL SOCIETY

Coastal News

Newsletter of the New Zealand Coastal Society: a Technical Group of Engineering New Zealand

Issue 81 • July 2023

Dispatches from the firing line...

February's Cyclone Gabrielle was both a significant and widely reported event. Much of the media response focused on the inland impacts; in this issue we look specifically at the coastal impacts, including a comprehensive regional roundup, beginning on page 3.

Cyclone Gabrielle above New Zealand (Photo: JMA/Himawari 8 satellite).

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Word from the Chair

Kia ora koutou katoa, and welcome to the July 2023 edition of *Coastal News*. As the dust settles and the flood waters have receded, we now bring you an issue that documents the impacts of Cyclone Gabrielle around Aotearoa.

Ben Noll and Connon Andrews discuss the intensity of Gabrielle in the context of other significant storms that affected our country over the last century, before considering the role of our changing climate on the frequency and severity of storms that will occur in the future. Our NZCS regional representatives have joined forces to describe Cyclone Gabrielle's impacts on our coastal systems, including the increased volume of litter entering the coastal environment as well as the anticipated coastal hazards. Their pictures are worth many thousands of words.

On a more positive note, we are all looking forward to the 2023 NZCS Conference, to be held in Wellington on 21-24 November. The geographical and political centre of New Zealand has also been the focus of extreme weather impacts, large coastal and navigation projects, and challenging discussions around the future management of our coastlines. The call for abstracts is now open, and we would welcome your contribution – plus a big thanks to Sam Morgan and the local organising committee for their efforts thus far. We are also happy to announce the call for contributions for our next Special Issue of the *Coastal News*. This special publication will take a deep dive into the management, impacts and measurement of coastal sediments, bringing together a diverse range of perspectives on an issue of great importance to our coastal communities.

In addition to the focus on Cyclone Gabrielle, this edition of *Coastal News* will introduce the recipients of the NZCS 2023 Research Scholarships, Leana Barriball, Lucy Coyle and Louis Alexander, and describe the objectives of their respective research projects. We look forward to hearing about their progress in future editions.

One of our 2022 scholarship winners, Alasdair Hall, also describes his research findings on the impacts of a coastal state highway on the New Zealand fur seal colonies in the Kaikōura area. Matthew Hayward also describes his numerical modelling of volcanic tsunami, and we hear from some recent successful regional events from the Bay of Plenty and Canterbury.

We hope you enjoy the issue!

Amy Robinson and Colin Whittaker
NZ Coastal Society Co-Chairs

About the NZCS

The New Zealand Coastal Society was inaugurated in 1992 'to promote and advance sustainable management of the coastal environment'. The society provides a forum for those with a genuine interest in the coastal zone to communicate amongst themselves and with the public.

The society's mission is to take a leading role in facilitating robust discussion and nationally-coordinated interactions to better manage and learn about our coastal and marine environment.

The society currently has over 400 members based in New Zealand and overseas, including representatives from a wide range of coastal science, engineering and planning disciplines, employed in the consulting industry; local, regional and central government; research centres; and universities.

Membership applications can be sent to the NZCS Administrator Renée Coutts at: nzcoastalsociety@gmail.com

More information is available at: www.coastalsociety.org.nz

Cyclone Gabrielle, more to come?

Ben Noll[a] and Connon Andrews[b]

February 2023 will go into the record books as a month during which Aotearoa New Zealand experienced one of its worst weather disasters in modern history, by way of ex-tropical cyclone Gabrielle.

From 12-14 February, Cyclone Gabrielle passed the northern and eastern regions of the North Island, exposing much of the island to extreme rainfall and river flooding not seen in many years, catastrophic wind damage, and substantial storm surge.

The Gisborne Te Tairāwhiti and Hawke's Bay Te Matau-a-Māui regions were particularly affected. Rainfall rates exceeded 20 mm/hour for more than six hours across multiple high-elevation rain gauges in these regions. This culminated in widespread destruction of critical infrastructure and agricultural and land, dozens of impassable roads, severe coastal erosion, the country's third-ever national state of emergency declaration, and loss-of-life. Significant damage also occurred in Northland, Auckland, the Coromandel Peninsula, and east-coastal Manawatū-Whanganui.

A significant event

Among other storms, Cyclone Gabrielle will be remembered alongside Cyclone Bola (1988), Gisele (1968), and the 'Cyclone of 1936' for its historically significant impact. The available meteorological data supports this comparison. February 14, the day on which Gabrielle was closest to New Zealand, was the North Island's second lowest 'pressure day'[1] on record using all available climate station data since 1960. At 4:00 am on 14 February, NIWA's climate station at Whitianga reported a minimum mean sea level pressure of 968 hPa (Figure 1), which, since at least 1960, was surpassed only by pressure observations during the 26 July 2008 storm in the North Island. This low air pressure reading helps contextualise the strength of the cyclone, which reintensified as it approached the northern North Island. As with Gabrielle, reintensification can happen when former tropical cyclones interact with the mid-latitude jet stream and/or other atmospheric disturbances, leading to a widening of the zone of impact.

In comparison, Bola had a minimum central pressure around 980 hPa[2], Gisele 964 hPa[3], and 'Cyclone of 1936' 970 hPa[4] based on available records. While Bola wasn't as intense as Gabrielle from a pressure perspective, it came with an impact that was drawn out over several days whereby the storm's southward progression was blocked by a ridge of high pressure. The worst of Gabrielle's rain, wind, and surge was confined to a 24-hour window for most regions. Figure 2 shows the air pressure patterns that were associated with Gabrielle, Bola, and Gisele in the Southwest Pacific. Based on this analysis, guided by ECMWF ERA5, Gabrielle was one of the most intense storms to pass near New Zealand's coastlines since at least 1950[5].

Climate drivers

Gabrielle occurred amidst a unique set of climate drivers – specifically, a 'triple dip' (third consecutive) La Niña, which, although its strength was waning, continued to have a meaningful influence on New Zealand's weather patterns. Notably, seasonal sea surface temperature (SST) anomalies in the Coral Sea, where Gabrielle formed, were 0.5°C to 1.5°C above average. Sub-surface waters were unusually warm by a similar magnitude. This abnormally warm water sat along the periphery of La Ninã's 'West Pacific Warm Pool' and was fuel for Gabrielle's development. In the atmosphere, a pulse of the Madden-Julian Oscillation, or area of cloud and thunderstorm activity that circumnavigates the globe every 30-60 days, was active over the warm waters of the west-central Pacific during the first half of February. This contributed to more favourable environmental conditions for tropical cyclone development in the Southwest Pacific.

Monthly mean sea level pressure, as shown in Figure 3, was below normal across the country, producing frequent cyclonic air flows from the easterly quarter. This was consistent with the widespread heavy rainfall and excess cloud cover that was experienced in the North Island and northern South Island.

A marine heatwave persisted near the South Island during February (Figure 4). Monthly SSTs were record breaking (since at least 1982) in the west of the South Island, with a regional anomaly of +2.9°C. SSTs around the North Island were above average, ranging from +0.4°C in the east to +1.2°C in the west.

Prior to the arrival of Cyclone Gabrielle, much of the North Island had experienced several

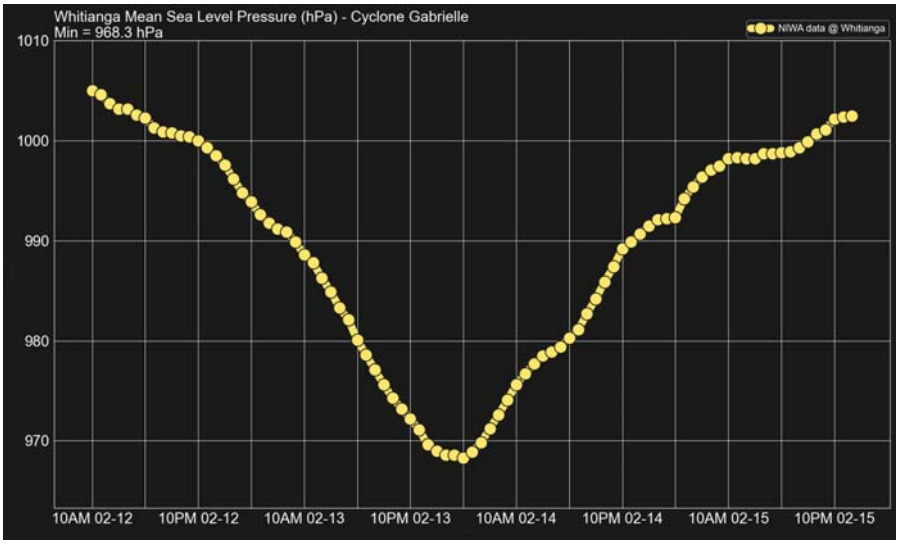


Figure 1: Mean sea level pressure readings at Whitianga from 12-15 February; the centre of Gabrielle made its closest approach in the early morning hours of 14 February, seeing the pressure dip to 968 hPa.

(a) Meteorologist/Forecaster, NIWA.

(b) Scientist, Coastal climate risk & infrastructure, NIWA.

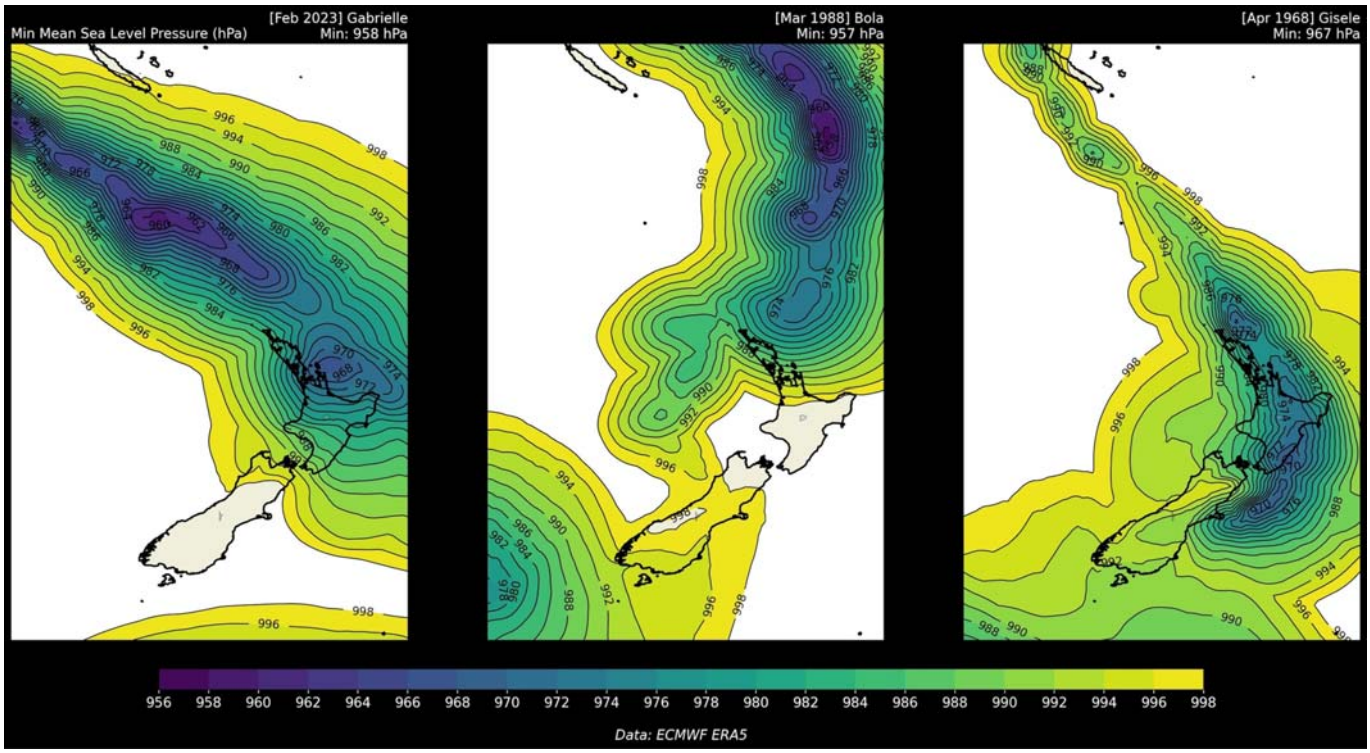


Figure 2: Minimum mean sea level pressure 'swathes' associated with Gabrielle (left), Bola (centre), and Gisele (right), showing the approximate track and strength of each of the cyclones; data: ECMWF ERA5 (atmospheric reanalysis).

high rainfall events, including the Auckland-Tāmaki Makaurau Anniversary floods which also affected Northland-Te Tai Tokerau. Earlier in January, Cyclone Hale also resulted in significant rainfall across many regions of North Island. It was the wettest January on record for nearly all locations in the North Island that were subsequently impacted by Gabrielle (Figure 5), with such precursor conditions exacerbating the speed that rivers rose and the number of landslides that occurred in the aftermath of Gabrielle.

The impact of climate change

With all the record breaking weather, a key question that keeps arising is whether the impacts from Gabrielle were exacerbated by climate change.

Attribution is a fast-growing field of climate science that aims to identify the 'fingerprint' of climate change on extreme-weather events. An attribution study[6], undertaken via the World Weather Attribution (WWA) initiative, was completed by a cross-disciple team to investigate the impact of climate change on rainfall from Gabrielle over New Zealand.

The attribution study used climate models that inform future projections of climate change to compare the world as it is today to a world without human-caused climate change. The intent of this study was to distinguish the climate change signal in rainfall from the cyclone over New Zealand.

The attribution study analysed 24 rainfall stations operated by NIWA and MetService throughout the Gisborne and Hawke's Bay regions, noting that only six recorded rainfall during the cyclone with the remaining stations losing power. Figure 6 shows the 24 weather stations. The black crosses indicate stations that recorded rainfall data during the cyclone, while blue crosses indicate stations that did not. A further three rainfall records curated by the councils are shown by numbers 1-3. The shading indicates the two-day accumulated rainfall from Cyclone Gabrielle over 13-14 February from the Multi-Source Weighted-Ensemble Precipitation (MSWEP) v2.8 dataset, where darker shading indicates heavier rainfall. MSWEP combines gauge, satellite, and reanalysis-based data for reliable precipitation estimates, globally.

The study found that the extreme rainfall seen during Cyclone Gabrielle is rare. Rainfall of that level has return periods ranging from once every 70 to 320 years

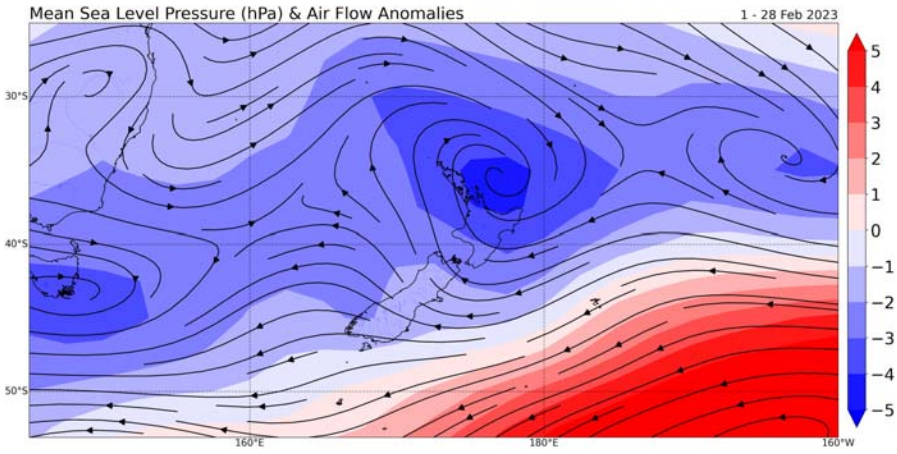
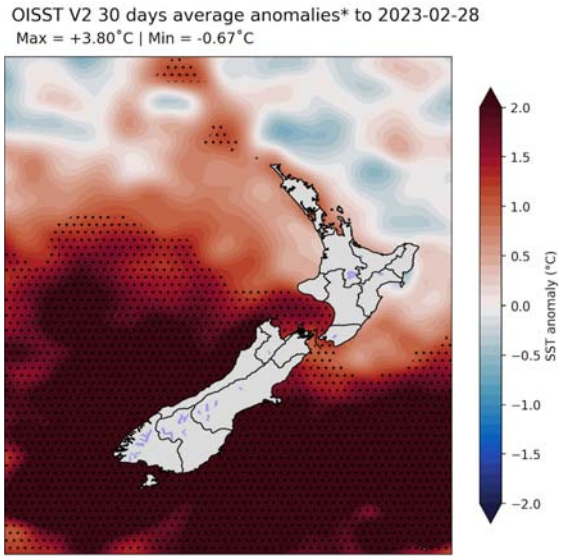


Figure 3: Mean sea level pressure anomalies (shaded) and air flow anomalies during February (Data: NCEP).



*Marine heatwave conditions stippled

North NI	+0.49˚C
West NI	+1.15˚C
East NI	+0.36˚C
North SI	+1.65˚C
West SI	+2.88˚C
East SI	+2.20˚C

NZ 30-day coastal SST anomalies (to 28 February 2023)

Figure 4: 30-day SST anomalies and marine heatwave conditions (stippled), calculated with respect to the 1991-2020 climatological period.

across the different measurement stations, and averaged over the whole study area, the return period was between 10 and 35 years.

The study could not quantify the specific role of human-induced climate change for Gabrielle due to the confined study area (relative to climate model resolution) and the reliability of the available models in simulating rainfall over the affected region. However, the study did find based on the relationship between historical weather station data (1979-2023) and global mean temperature to extrapolate back to colder climates, the 2-day maximum rainfall over the Gisborne and Hawke's Bay regions is now about 30% more intense than it might have been compared to pre-industrial times when the climate was 1.2°C cooler. Furthermore, 'very heavy rain', comparable to the extreme rainfall event seen during Cyclone Gabrielle, is now four times more common in the region.

Future projections

A warmer atmosphere can hold more moisture, about 7%-8% more for every 1°C increase in temperature, so there is potential for heavier extreme rainfall with global increases in temperatures under climate change. IPCC (2013; 2021) concluded that the frequency of heavy precipitation events is 'very likely' to increase over most mid-latitude land areas, including New Zealand. Given the mountainous nature of New Zealand, spatial patterns of changes in rainfall extremes are expected to depend on changes in atmospheric circulation and storm tracks.

Past research including the IPCC (2021) AR6 assessment shows that climate change will most likely lead to slightly reduced numbers of tropical cyclones in the Southern Hemisphere, while increasing the intensity of the cyclones that do form.

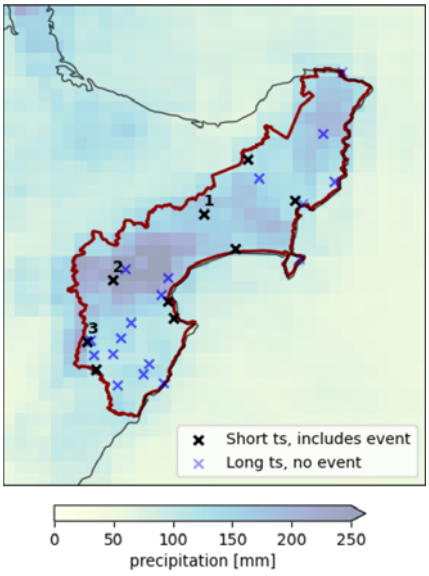


Figure 6: 2-day accumulated precipitation [mm] from Cyclone Gabrielle in the MSWEP data with station locations overplotted (Source: WWA, 2023).

For the Gisborne and Hawke's Bay regions the NIWA climate projections are consistent with global trends with extreme, rare rainfall events projected to become more severe in the future[7]. Short duration rainfall events are likely to have the largest relative increases compared with longer duration rainfall events. Rainfall depths for 1-in-50-year and 1-in-100-year events are projected to increase across the greenhouse gas concentration scenarios and future time periods.

NIWA is currently downscaling AR6 projections for New Zealand as part of the National Adaptation Plan and updated projections, and these are expected to be available early- to mid-2024.

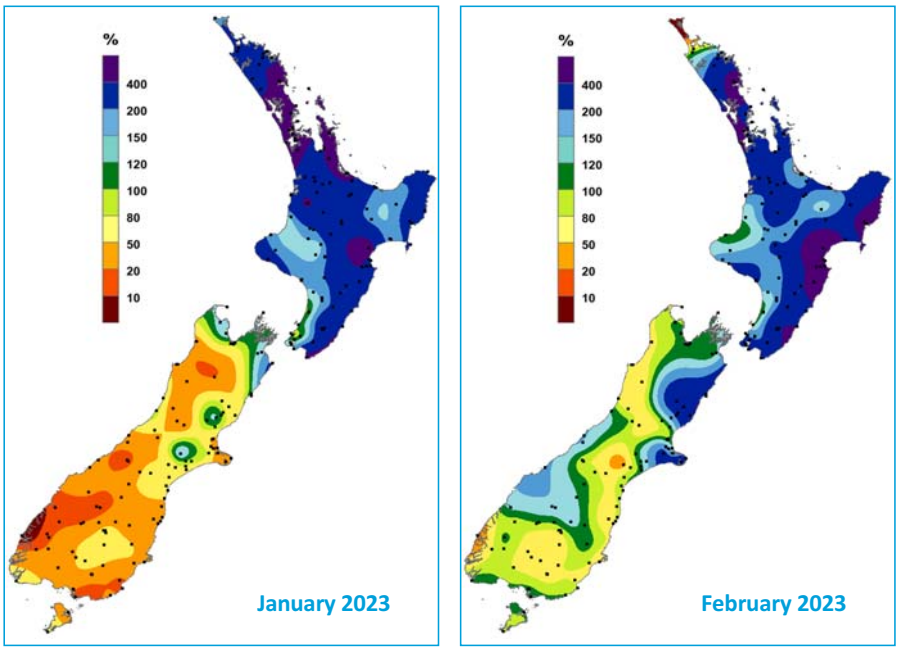


Figure 5: Monthly rainfall expressed as a percentage of the 1991-2020 normal.

Notes

1 The lowest air pressure observed on any given day.

2 From NIWA's *New Zealand Historic Weather Events Catalogue*.

3 Revell, MJ, and Gorman, RM (2003). The 'Wahine storm': Evaluation of a numerical forecast of a severe wind and wave event for the New Zealand coast. *New Zealand Journal of Marine and Freshwater Research*, 37:2, 251-266. https://doi.org/10.1080/00288330.2003.9517163

4 Stephens, SA, Reeve, G, and Bell, RG (2009). *Modelling of the 2 February 1936 Storm tide in Wellington Harbour*. NIWA Client Report HAM-2009-014.

5 Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset using the laws of physics.

6 Harrington, LJ et al (2023). *The role of climate change in extreme rainfall associated with Cyclone Gabrielle over Aotearoa New Zealand's East Coast*. World Weather Attribution Initiative Scientific Report. https://doi.org/10.25561/102624

7 NIWA (2020). *Climate change projections and impacts for Tairāwhiti and Hawke's Bay* (https://www.gdc.govt.nz/__data/assets/pdf_file/0023/19733/2020-Climate-Change-Projections-and-Impacts-for-Tairawhiti-and-Hawkes-Bay-Niwa-Report.pdf).

NZCS Conference and Special Publication 6

NZCS Conference 2023

The New Zealand Coastal Society invite you to share your knowledge, stories and love of the coastal and marine environment at this year's conference to be held at Rydges in the Wellington CBD, between November 21-24. While full details, including the schedule, field trips and sponsorships, will be progressively added to the conference website (www.coastalsociety.org.nz/conferences/2023), the Society is now inviting abstracts from potential contributors. We are looking for a diverse group of presentations and posters that delve into topics such as:

1 *Resilience and Adaptation to Change*

Approaches that improve resilience of our coasts and communities, that foster connection and allow them to adapt to change.

2 *Working with Nature*

'Soft' engineering, 'nature based solutions', 'nature led design'. The buzz words are numerous but the implementation is slow: what are the current approaches, successes and learnings?

3 *Physical and Ecological Processes*

Understanding the physical processes and natural cycles of coastal environments.

4 *Engineering and Shoreline Management*

Design, construction, operation, decommissioning, and restoration of engineered solutions in the coastal marine environment.

5 *Planning and Policy*

Legislation, regulations, plans, policy and customary practice in the coastal marine environment.

The organising committee particularly welcomes contributions that consider Te Ao Māori perspectives to all these sessions.

Presentations and key dates

Presenting at the conference can be via a 15-minute presentation or poster. We only require a 1-page (maximum) abstract for your presentation or poster – a template can be found under the 'Abstracts' link on the conference website, and there is also an option to electronically submit your abstract.

Further presentation specifics will be in the separate 'Information for Presenters', which will be available once the submission deadlines have closed.

Please note the deadline to receive abstracts is 6 October 2023. You will be advised of abstract acceptance by 13 October 2023.

NZCS Special publication 2024: Call for contributions

Special publications are now a biennial fixture on the NZCS calendar, and work has already begun on the sixth in the series. Special Publication 6 (SP6) will look at the 'Management, Impacts, and Measurements of Coastal Sediments' and the Society is now looking for potential contributors. In SP6 we aim to explore the multidimensional aspects of coastal sedimentation, delving into topics such as sediment routing, seabed resources from a Te Ao Māori perspective, extreme events, climate change, contaminated sediment management, oceanic carbon sequestration by sediments, and more.

We are seeking contributions from a broad range of perspectives, for example, planning, engineering, science, Māori communities, environmental management, policy, law, economics, and resource management. Contributed articles can be of almost any length (300 to 5000 words), ranging from short notes to full articles.

We would welcome Expressions of Interest (EOI) by 15 September 2023 – these can be sent to NZCS Publications Coordinator Ana Serrano (ana.serrano@boprc.govt.nz). In your EOI please send your article's preliminary title; a brief (100-word) descriptive outline; a list of intended co-authors; and your article's expected length. Successful EOIs will be confirmed soon after the submission date.

SP6 will be published in November 2024, and key dates for authors will be advised as part of the EOI process. Please note that an invitation to submit does not guarantee acceptance for publication; this will depend on the outcome of the normal peer review process and the authors meeting time schedules. A Contributors' Guide will be available later in the year that will include all key dates, the submission requirements for text, graphics and photos, and an outline of the editing, reviewing and publication process.

To find out more, please contact Ana Serrano on the email address above.

Cyclone Gabrielle: Regional reports

Northland region – Laura Shaft, Coastcare Co-ordinator NRC and NZCS Regional Representative; Loren Carr, Biodiversity Advisor NRC; and Nick Bamford, Environmental Monitoring Officer NRC

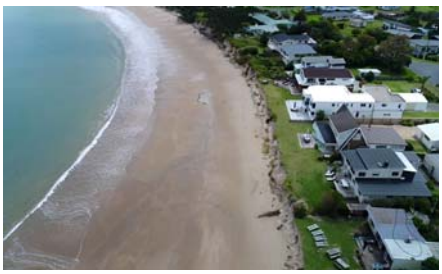
Cyclone Gabrielle had a significant impact on our coastline in February 2023, especially as it came on top of other storm events. The cyclone severely impacted our east coast beaches and the Poutō Peninsula.

Beaches and sand dunes bear the brunt of storm erosion and the result can be very ugly and even frightening for beach users and people who live near the coast, but this is the role of the dune system and part of its natural functioning. On most east coast beaches eroded sand is not lost to the system but rather forms a bar offshore. After storm erosion sand moves back onshore and rebuilds the beach. Over time, dune plants trap the sand blowing back over the dune, gradually rebuilding the dune. This dune rebuilding process can take some time and is dependent on weather condition. Vegetation will not stop storm erosion but having a good cover of the right species is crucial to dune building, putting 'money in the bank' before the next storm.

Northland Regional Council (NRC) undertakes annual dune monitoring of sites around our coast. This involves measuring dune transects and drone surveys to collect images and dune profile data. To assess the erosion from Cyclone Hale and Gabrielle, additional surveys were undertaken. The Bream Bay dune monitoring vegetation transects were measured in December and January and the length of some of these transects were re-measured at the end of February, to collect data on the amount of dune toe retreat. Drone surveys were also repeated at several sites.

Dune toe retreat levels varied considerably around Bream Bay, with Bream Tail providing protection to the more southern sites and the areas in the middle of the bay experiencing most erosion. At Waipū Cove the dune toe retreat varied between 2 m and 5 m. By contrast, the retreat in the area near Ruakākā surf club was up to 12.5 m and up to 17 m at Uretiti. However, at both sites there is a relatively wide, healthy dune and sufficient remaining width. The remaining width of dune and the presence of suitable dune plants will enable the dune to naturally

Erosion in front of Ruakākā surf club. Intensive weed control in this area means that there is a good buffer of spinifex dune which, given the right conditions, will self-recover over time (Photo: Northland Regional Council).



Top left: Erosion of dune at Marsden Point leaving these access steps at separated from the land. These have now been removed; Top right: Damaged accessway at Matapouri, February 2023; Bottom left: Whangaumu (Wellington) Bay, near Tutukaka, February 2023, showing storm erosion and damage to private access structures; Bottom right: Large slip behind Mangawhai surf club (Photos: Northland Regional Council).

Left: Drone image of Uretiti taken in the summer of 2021. Take note of the tree under the yellow arrow; Right: Drone image of Uretiti taken in March of 2023 after Cyclone Gabrielle. The tree under the yellow arrow demonstrates the extent of erosion (Photos: Northland Regional Council).

rebuild. At sites near Marsden Point/Mair Road the retreat was much less, but the impact greater, as the dunes were already very steep, weedy, less well-vegetated and very narrow in places. We will continue to monitor these sites to compare recovery over time.

Hard structures, such as access steps and boat ramps were badly impacted at many east coast beaches. In some areas these have been reinstated by district councils, with some modifications. At other sites more flexible options are being considered. Coastal businesses in Paihia and Waitangi suffered damage by either storm surge or by the physical impact of waves battering decks and wharfs. The Mangawhai Heads Surf Lifesaving club building was damaged by a slip on the maunga behind. Many Urupā and other sites of cultural significance around Northland are also at risk from coastal erosion.

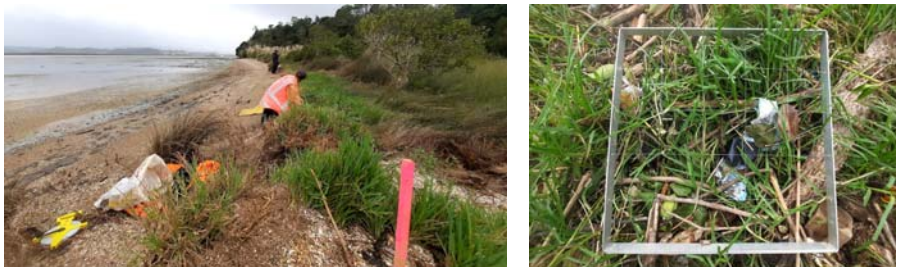
Cyclone Gabrielle not only caused erosion on our coastlines, but significantly increased litter entering the coastal environment. Many groups and individuals regularly pick up litter from our beaches and have had to increase this since the storm events. Some of the litter was from fences and accessways and this has been a reminder to consider what materials are used and, where possible, remove temporary fences before storm events.

NRC coastal monitoring team conducts annual surveys as part of the Litter Intelligence Programme. These surveys monitor plastic and litter pollution around Northland. Surveys were conducted at the Upper Hateā River, Whangārei Harbour and Onerahi, Pah Road sites on 7 Feb 2023. This data provided a useful comparison with which to assess the impact of Cyclone Gabrielle.

Post-cyclone 'quick surveys' were conducted at Hateā and Onerahi, with an additional ad hoc survey at Waikaraka Marine Reserve, on 16 and 17 Feb 2023. The surveys are conducted by placing three 0.5 x 0.5 m^2 quadrats at the start, middle, and end of a 100 m transect at all sites. The amount and type of litter is averaged to produce an estimated litter density per 1000 m^2 and plastic percentage. Post-cyclone surveys showed huge increases in litter density. For example, the Onerahi site was surveyed visually and had dropped from a Visual Assessment Grade A to C. Estimated litter density was 22,667 items per 1,000 m^2, in comparison to 203 items per 1,000 m^2 counted during the survey on 7 February 2023.

Sometimes a series of storm events occur without sufficient time between for dune rebuilding, as has been the case this year. We are likely to have more of this in the future. In this situation it is even more important to have a wide, healthy dune that can erode back and still have enough width to be able to self-repair when weather conditions allow.

Left: NRC staff picking rubbish out of a pile of storm deposited debris at the Ruakākā surf club ramp; Right: Some of the litter collected during Seaweek by Bream Bay Coastal Care Trust (Photos: Northland Regional Council).



Left: Post-cyclone litter Intelligence survey, Onerahi, May 2023; Right: One of the quadrats used in the survey (Photos: Northland Regional Council).

Auckland region – Lara Clarke, Matthew McNeil, Andrew Allison and Eddie Beetham, NZCS Regional Representatives

The Auckland coastline was significantly impacted by Cyclone Gabrielle, which crossed the Auckland Region over the 12-13th of February 2023 as an extra-tropical storm.

The Auckland east coast was subjected to significantly high wave energies and strong onshore winds, with wind gusts reaching 70 knots on the Whangaparaoa Peninsula. This, combined with extremely low atmospheric pressure, elevated coastal water levels in the order of 400 mm above the forecast tide height.

The storm event resulted in beach erosion, and damage to coastal assets and infrastructure. In places the effects were exacerbated by the impacts of the prior 27 January Auckland flooding event. The following are examples of sites where such impacts occurred.

Murrays Bay, East Coast Bays

A section of the Murrays Bay seawall adjacent the bays stream mouth was undermined and failed during the 27 January Auckland flooding event.

The Cyclone Gabrielle storm resulted in further sections of the seawall collapsing, the impacts exacerbated by scour and upper beach sand lowering during the prior flooding event.

This triggered the renewal of a 48 m length of failed seawall. The opportunity has been taken to implement an improved and more robust seawall design. The replacement structure is to be more visually consistent with immediately adjacent seawalls, and will provide for improved foreshore access.

Due to adjacent wastewater infrastructure and large Pohutukawa trees, landward realignment of the seawall is not practicable.

Browns Bay, East Coast Bays

Browns Bay is typically a relatively low energy beach, sheltered by an offshore reef. However, elevated water levels during the Cyclone Gabrielle event significantly increased the wave energies that the beach was exposed to. This resulted in significant lowering of the upper beach, eroded dune planting, exposed backstop rock armouring and wastewater infrastructure, and damaged the Browns Bay boat ramp.

Again, some effects were exacerbated by the prior flooding event, which lowered sand levels at the stream mouth.

Snells Beach, Rodney

Snells Beach is another relatively sheltered beach that was impacted due to the elevated water levels. A timber seawall towards the centre of the beach was overtopped and failed during the event peak.

This timber seawall was the only hard protection structure along the Snells Beach shoreline. The structure armoured fill material that had been previously placed on the beach when the esplanade reserve was created.

The seawall failure provides an opportunity to realign the seawall landward. In doing so this will gain dry high tide beach space, and take the seawall out of the typical intertidal zone, thereby reducing ongoing structure maintenance requirements. The design for such is being progressed, alongside community consultation.

Orewa Beach, Hibiscus Coast

With sand levels on Orewa Beach low following a series of storm events over summer, the impacts of Cyclone Gabrielle resulted in further significant beach erosion. This triggered an immediate full-scale sand transfer. Approximately 14,000 m^3 of sand was transferred from the southern end of the beach, and 1,500 m of sand 'scrapped' from the lower intertidal area, to replenish sand levels in front of Orewa Reserve and Kinloch Reserve. Working around the tides, works took eight days to complete, utilising three motorscrapers.

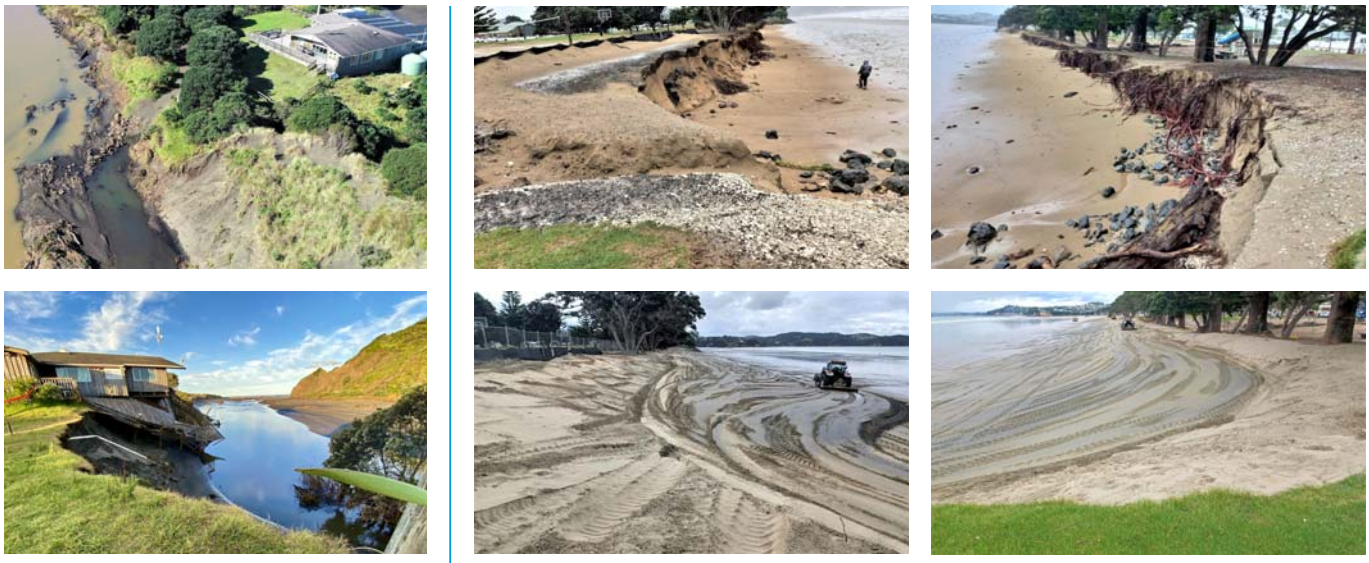
Te Henga/Bethells Beach, Auckland's West Coast

The Waitakere catchment received an extreme volume of rainfall during the Cyclone Gabrielle event. This catchment feeds into

Murrays Bay, East Coast Bays: Failed section of seawall during and post the Cyclone Gabrielle storm (Photos: Auckland Council).

Browns Bay, East Coast Bays: (Top left and right) Dune planting pre- and post-storm event; (Bottom left) The damaged Browns Bay boat ramp, and lowered sand levels (Photos: Auckland Council).

Snells Beach, Rodney: Failed timber seawall post event (Photos: Auckland Council).



Orewa Beach, Hibiscus Coast: (Top left and right) Post storm event erosion; (Bottom left and right) Post sand transfer works (Photos: Auckland Council).

the Te Henga coastal wetland, and the Waitakere River, which discharges onto Bethells Beach on the Auckland west coast.

The event resulted in significant flooding of low-lying areas surrounding the wetland and river. High river flows washed away a section of the beach access road and deposited large trees and debris across the beach. Large slips occurred along the Bethells Beach to Oneill Bay coastline, which have significantly compromised the Te Henga coastal walkway.

The flooded river resulted in significant erosion of the sand dune that previously provided a buffer between the river and the Bethells Beach Surf Life Saving Club clubrooms. The clubrooms were significantly damaged once exposed to flood waters.

The clubrooms have since been partially removed, and what remains is only able to be used for day-time activities. The club is urgently working on progressing a new facility in a new location at Bethells Beach.

Te Henga/Bethells Beach: (Top two) Clubrooms position 2021, and post-Cyclone Gabrielle event with dune buffer completely eroded and clubrooms impacted; (Bottom two) Debris at the Waitakere River mouth post event (Photos: Auckland Council).

Waikato region – William Dobbin, Jamie Boyle and Joshua Sargent, NZCS Regional Representatives

In the Waikato region, Cyclone Gabrielle caused a bit of an emergency for the Coromandel Peninsula[1]. Flooding halted transportation due to many damaged roads, strong winds knocked out cell phone communications for several communities, and residents were advised to conserve water due to impacted water treatment plants. Representatives from Waikato Regional Council, district councils, Civil Defence teams, and local contractors were kept busy working to restore a sense of normalcy to the region.

While the cyclone caused several issues, it also provided University of Waikato researchers with an opportunity to share their knowledge about how to understand this type of event and prepare for future events. Environmental Science Senior Lecturer Luke Harrington explained that climate change contributed to the extreme rainfall[2]. Marine Science Professor Conrad Pilditch shared some insights about how storm-agitated silt and sediments impact coastal zones[3]. Civil Engineering Senior Lecturer Krishanu Roy advised considering building material choices and risk profiles when building back better[4]. Environmental Planning Professor Ian White expressed some concerns about how New Zealand currently considers natural hazard risks in future environmental decision making[5].

Article links

For hard-copy readers, see the box on page 20 to access a file of active webinks.

1 https://www.nzherald.co.nz/waikato-news/news/cyclone-gabrielle-waikato-region-in-state-of-emergency-as-coromandel-cut-off/SJQNU7VQ4NHRHAHQD3MY6UYBUE/

2 https://www.rnz.co.nz/news/national/485990/niwa-scientist-in-no-doubt-climate-change-behind-cyclone-gabrielle-s-intensity?mc_cid=99e7b14ec2&mc_eid=2b57c62c44

3 https://www.rnz.co.nz/national/programmes/ninetonoon/audio/2018885772/cyclone-silt-depleting-our-seabeds-marine-scientist

4 https://theconversation.com/build-back-better-requires-a-framework-that-focuses-on-the-full-life-of-a-house-from-materials-to-its-end-of-life-203325

5 https://www.nzherald.co.nz/nz/qa-cyclone-gabrielles-biggest-climate-lessons-for-nz/7JHOAXYNQZF2FI25T6PA7S7VOI/

Activating flood gates (top left), dealing with flooded paddocks (top right), collecting wayward navigational buoys (bottom left), and cleaning up a vessel leaking oil in the Coromandel Peninsula (bottom right). These are examples of issues addressed by Waikato Regional Council, district councils, Civil Defence teams, and local contractors over the course of Cyclone Gabrielle (Photo credits: Instagram/Waikato Regional Council).

Bay of Plenty region – Jonathan Clarke, Scott Murray and Alison Clarke, NZCS Regional Representatives

Cyclone Gabrielle struck the Bay of Plenty region on February 13th 2023, and caused significant disruption across the region with felled trees, slips, flooding, home evacuations, widespread power outages, damaged roads, closed state highways, and 75 school closures. While the Bay of Plenty was not hit as hard as other regions such as Northland, Tairāwhiti, and the Hawkes Bay, the storm's powerful winds, heavy rainfall and storm surges led to widespread damage and a significant clean-up operation.

Ōpōtiki, Whakatāne, Bay of Plenty Civil Defence declared Regional State of Emergencies alongside the National State of Emergency that was declared on the 14 February. In the Eastern Bay of Plenty up to 400 properties were encouraged to evacuate in low lying areas of Ohiwa Spit, Kutarere, the Tirohanga Motor Camp, and low-lying areas along SH35. Additionally, 100 homes were ordered to evacuate from Whakatāne and in the West End of Ōhope. Around 50 homes were also evacuated across Waihi Beach, Athenree, Maketū and Little Waihi.

Luckily, the predominantly south-east wind direction meant these low-lying coastal settlements did not experience significant coastal inundation or widespread damage to communities. It is expected that if the more north-easterly winds had hit the Bay of Plenty, the effect of the storm surges would have had a much more significant impact on these coastal communities.

Cyclone Gabrielle erosion at Mount Maunganui (top left and right) and Pukehina (bottom) (Photos: Alison Clarke).

However, the coastal environment was not left unaffected by Cyclone Gabrielle. A maximum significant wave height (H_s) recorded at BOPRC's Pukehina wave buoy was 5.8 m. These large swells damaged a number of beach access structures and caused widespread erosion of the region's sand dunes. Dune scarps up to 2 m were reported across large sections of the Tauranga Coastline.

Due to strong swells and surging waves a number of beaches, coastal reserves and walkways (including both Mauao and Moturiki Island at Mount Maunganui) were closed for a number of days to ensure public safety due to the effects of the cyclone and subsequent debris clean up.

NZCS archive & downloads

The NZCS website houses an extensive archive of the Society's publications, including back issues of *Coastal News* (from issue 1, 1996 to date) and 'hot topic' reprints of significant articles from previous issues; newsletter author and article indexes (updated yearly); an author's guide to writing articles for NZCS publications; and copies of the five NZCS Special publications (published 2014-2022).

All these can be accessed at www.coastalsociety.org.nz under the 'Media>Publications' tab on the main menu.

Hawke's Bay region – José Beyá, NZCS Regional Representative

Cyclone Gabrielle produced extensive damage to the Hawke's Bay region, and while the most devastating effects were seen inland, the effects on the coast were still significant and these are highlighted below.

Coastal inundation and erosion

The recorded wave height data was provided by the Port buoy and a recently installed spotter buoy located in front of Westshore. The hourly averaged Port buoy significant wave height at the peak of the storm was 5.5 m before it failed (see graph below). This value is greater than the 100 y ARI assessed with data prior 2018 in the coastal strategy concept design report (Beya & Asmat, 2021, p. 47, https://www.hbcoast.co.nz/assets/Uploads/Design-report-full-final-bookmarked-reduce-size.pdf).

The measured wave peak period at the peak of the storm was 12.8 s. Despite these high values, the effects on the coast were not catastrophic, but were still significant.

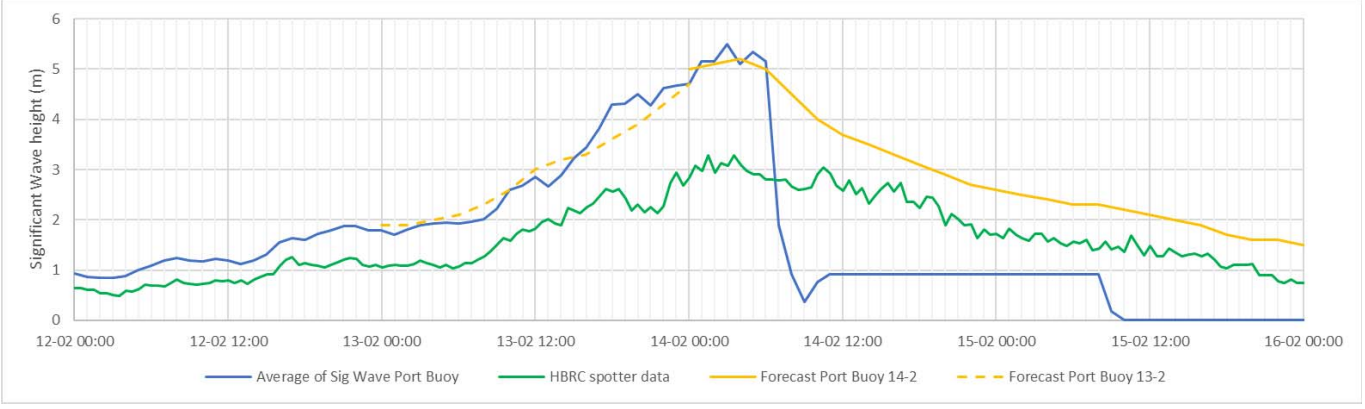
The main effects in terms of coastal inundation and coastal erosion were:

- The Te Awanga rivermouth changed its alignment from towards the east, creating erosion of the access to the surf break carpark.
- Tyres were exposed in front of the beach front houses at Te Awanga.
- There was overtopping at the Clifton Reserve at Haumoana.
- There were signs of overwash and breaching at the narrow gravel barrier at Haumoana, up to the road and carpark of the HDC Domain Reserve.
- Wave overtopping at Te Awanga Hall.
- Wave overtopping at Marine Parade.
- The Westshore gravel bund was damaged and properties at 10 and 12 North Terrace were flooded.
- Wave overtopping at Ferguson Road and Esplanade Rd, Westshore.
- Large amounts of debris washed up on beaches. Visible debris extending from Tangoio Beach to the Tukituki River mouth, with the area south of the Esk River mouth the worst affected. Waikare beach, Mahia, Wairoa and Mohaka also presented large amounts of woody debris.
- Port Wave buoys broke off their moorings and were recovered at Whirinaki.
- The HBRC Spotter Buoy, located at Westshore at the time, moved about 80 m to the east.

Accumulation of woody debris

Large amounts of woody debris were found at beaches, river berms, bridge abutments and piers, and floodplains. At some beaches, the accumulation of debris was higher than 2 m over the beach, as shown in the photos (below). Large rafts of floating woody debris in the sea were observed in aerial surveys after the cyclone.

Accumulation of woody debris at Waikare beach (top left, Photo: Dan Fake, HBRC) and at Westshore 14/2/2023 (top right, Photo: Pippa McKelvie-Sebileau); Beach debris south of Bay View (bottom, Photo: HBRC, from Coastal Sweep pictures taken 23/2/2023).



Significant wave height during Cyclone Gabrielle measured and forecasted at the Port Buoy and at the HBRC buoy in front of Westshore (Source: HBRC).

A study by Ecological Solutions was undertaken to understand the origin of this woody debris, particularly about community concerns on the influence pine plantations have on flooding. On average, the proportion of debris of pine origin was 56%, while the remaining was from poplar and willow (21%) and other species (23%). A low proportion of the pine debris was categorised as cut pine (with evidence of cuts or processing marks).

Woody debris is suspected to have worsened flooding in some areas, and to have been a contributing factor to bridge damage. The Regional Council woody debris report shows mixed results (see https://www.hbrc.govt.nz/home/article/1445/regional-council-woody-debris-report-shows-mixed-results?t=featured&s=1 *and* https://hbrc.info/woodydebris2023).

Another study commissioned by the Hawke's Bay forestry group (hbforestrygroup.co.nz) encompassing coastal areas and significant catchments of Hawke's Bay, found that the proportion of large woody debris (LWD) was 48% plantation pine origin, while willow or poplar accounted for 38%, with the balance being a mixture of native and other species, including post wood. The proportion of LWD with evidence of plantation pine harvest residue (commonly known as slash) origin was 4%. In this study, Planet satellite data was used in conjunction with the line intersect sampling (LIS) methodology on the ground (for a post-event woody debris assessment, see https://interpine.nz/post-event-woody-debris-assessment-cyclone-gabrielle-hawkes-bay).

Significant erosion at the Esk rivermouth (left, Photo: HBRC), and erosion at Westshore (right, Photo: HBRC, Post Cyclone Aerial Imagery).

Seabed effects

Large amounts of muddy sediments have been deposited in the seabed, potentially affecting marine ecosystems. NIWA undertook a survey to assess the impacts on reef environments in Hawke's Bay and the data is currently being analysed.

For a video overview of the seabed damage, see the TVNZ report at https://www.1news.co.nz/2023/04/30/hawkes-bay-seabed-damaged-in-the-wake-of-cyclone-gabrielle

News you might have missed...

Life and science

In *Coastal News* 80 we reported on the recent reef discoveries off the coast of Taranaki. Now another reef discovery has been made, this time in a previously unexplored part of the Galápagos marine reserve. The newly found deep-sea coral reefs are described as 'pristine', 'teeming with life' and of 'global significance'. For more, see www.theguardian.com/environment/2023/apr/18/scientists-discover-pristine-deep-sea-galapagos-reef-teeming-with-life

While we don't generally find elephants in the ocean, they, along with otters and whales, have something in common – all increase the amount of carbon that can be stored in their ecosystems. They do this by their eating, moving, trampling, digging, defecating and building, according to a recently published paper in *Nature*. For a summary and link to the full article, see www.theguardian.com/commentisfree/2023/apr/19/elephants-otters-whales-nature-climate-breakdown-carbon-ecosystems

In a story that features mangroves and the world's 'hottest sea', a recent CNN article looks at a marine forest in Abu Dhabi that is not only surviving in some remarkably harsh conditions, but thriving as well. For more, see https://edition.cnn.com/travel/article/abu-dhabi-jubail-mangroves/index.html

Health news

While Victorian doctors had some odd notions when it came to medical treatments, a favourite – a bracing dose of sea air – would seem to be on the mark. A neuroscientist reports that it helps people think with more clarity, while feeling sand between the toes is 'good for the brain'. To find out why, see www.dailymail.co.uk/travel/article-12306803/sea-air-good-health-benefits-Neuroscientist-reveals.html

Good sleep is part of a healthy lifestyle for any animal, but combining it with deep diving seems a bit of a stretch. However, this is exactly what Northern elephant seals do (presumably while knowing where the bottom is) as reported at https://edition.cnn.com/2023/04/20/world/sleep-diving-seals-scn/index.html. And still on the subject of health, it seems humpback whales have a liking for spas – though perhaps not as we know them. For a video tour of a whale 'spa', see https://edition.cnn.com/videos/us/2023/04/27/whale-day-spa-gold-coast-australia-cprog-orig-ht.cnn

Odd finds

If you're a fan of singing fish, the SEA Life London Aquarium have released a Eurovision homage featuring fish sounds from all the competing countries. Have a listen at www.dailymail.co.uk/sciencetech/article-12067483/EuroFISHion-Scientists-pay-homage-song-contest-track-comprised-sounds-FISH.html – it's possibly a lot better than you might think! And finally, a salutary lesson when describing an unusual marine find – be sure you identify the species properly before submitting your paper. See why at www.dailymail.co.uk/sciencetech/article-11907217/Scientists-retract-photo-goblin-shark-seen-Med-actually-TOY.html

NZCS 2023 Scholarship award winners

Leana Barriball (Ngāti Kahungunu, Rongomaiwahine, Te Atiawa, Ngāti Tama, University of Waikato) Māori/Pacific Island Student Research PhD Scholarship

Sea level rise impacts on Inanga spawning sites – utilising two different knowledge systems

Climate change will result in our seas rising; it is inevitable. It will impact on coastal species and those found in our freshwater systems. Inanga are a taonga species to Māori and an important part of the whitebait fishery of Aotearoa. Inanga are particularly reliant on tidal processes at the freshwater and marine junction. With rising seas, saltwater will move further and further upstream and will change the location of the spawning habitats of inanga.

To be able to prepare our coastal communities for change and to enhance coastal management, we need a much more detailed understanding of where these habitats will move upstream and the impact on traditional ways of interacting with inanga. This will allow us to prepare future habitat and access to that habitat for the potential change. Further, mātauranga Māori holds important information that may be utilised to make better management decisions on inanga and their spawning sites. Two case study rivers in the Hawke's Bay have been chosen for this study, Te Awa o Mokotūararo and the Wairoa.

The aim for this research is to identify the impacts that sea level rise will have on inanga spawning sites by utilising two different knowledge systems – mātauranga Māori and a hydrological model. This scholarship will mainly be used to conduct additional wānanga to better understand mātauranga Māori and its use, and also to disseminate the results of the model to mana whenua.

Lucy Coyle (University of Otago) Student Research PhD Scholarship

State of kōura (Crayfish, Jasus edwardsii*) on the North Otago Coastline*

Lucy's PhD research aims to provide up to date information on the state of the southern New Zealand red rock lobster (*Jasus edwardsii*, kōura), relative to historical fishing and future environmental conditions. The red rock lobster fishery holds high value within New Zealand, significant to commercial, customary, and recreational fishers. Despite their social, cultural, and economic value however, a number of populations are in decline, with the species declared 'functionally extinct' in the Hauraki Gulf in the mid 2010s. Largely attributed to overfishing, declines in lobster populations are likely to worsen as a result of climate change.

The past two summers have seen reports of red rock lobster being caught in unusually poor condition in southern New Zealand, thought to be linked to the back-to-back marine heatwave conditions during this time. With extreme temperature events predicted to become more frequent and intense over the next decade, it is important to have geographically relevant scientific information on fisheries to support and reduce the risk around local decision making.

Lucy's work aims to support local Tangata Tiaki/Kaitiaki (guardians), communities, and industry, through the provision of relevant information on the dynamics of the local fishery. This is key to informing local management and restoration of this taonga (treasure) species so that they remain for many future generations to come.

Lucy's research is under the supervision of Dr Gaya Gnanalingam, Prof Chris Hepburn, and Dr Bridie Allan.

Louis Alexander (University of Otago) Student Research MSc Scholarship

*The feeding ecology and diet preference of butterfish (*Odax pullus*)*

Butterfish (*Odax pullus*) are a herbivorous reef fish found throughout Aotearoa. Herbivorous fish exhibit top-down controls on the kelp forest ecosystem and have the potential to limit the distribution of certain kelp species.

The primary aim of Louis' project is to identify which species of algae butterfish prefer, and the magnitude at which they graze down these species. There is limited research surrounding the feeding preference of butterfish, particularly in the South Island. Feeding preferences will be assessed in both field and lab environments. Louis will be assessing the nutritional value of the tested algal species and observing if grazing rates are correlated with diet quality.

A focus of the project will be to identify if a preference is shown for wakame (*Undaria pinnatifida*), an invasive species of kelp originating from Japan. Wakame can displace native species and have negative impacts on kelp forest ecosystems.

A previous study reported a strong preference for wakame by butterfish. Louis' study will look at the implications of the feeding preferences shown. If selection is strong enough, could butterfish be used to control populations of wakame? Controlling invasive algal species is important for maintaining the diversity of kelp in these habitats. Without kelp diversity, species in Aotearoa that rely on kelp forests may suffer.

Louis' project will be undertaken in the East Otago Taiāpure and the Moeraki Mātaitai, which are both customary fisheries management areas. The project will involve working closely with local communities and iwi (Ngāi Tahu).

Leana Barriball

Lucy Coyle

Louis Alexander

Impacts of a coastal State Highway on a recovering pinniped population

Alasdair Hall

Alasdair Hall was a winner of the 2022 NZCS Student Research MSc Scholarship, and this article draws on his project research. His profile was published in Coastal News 79 (November 2022).

Introduction

At just after midnight on November 14th, 2016, a magnitude 7.8 earthquake struck the Kaikōura region of South Island. This event had dramatic impacts on the terrestrial and marine environment of the area, and on the people and wildlife living there.

The earthquake triggered numerous landslips along the coastline, caused significant coastal uplift and instigated a substantial flushing event in the Kaikōura marine canyon, with noticeable impacts on marine food chains (Guerra et al., 2020).

One of the most enduring impacts from a human perspective was the damage to State Highway 1 (SH 1), New Zealand's most significant road. In places, the road was destroyed, necessitating a lengthy reconstruction project to reconnect Kaikōura to the rest of New Zealand.

The road reconstruction was not only significant to humans, but also to several colonies of New Zealand fur seal (*Arctocephalus forsteri*: NZFS) that haul-out and breed very close to it. The occurrence of a protected pinniped species next to a major transport route is rare and provides opportunities to study the relationship between the animals and the road. Further, the post-earthquake reconstruction of SH1 provided a chance to understand how changes to human infrastructure can influence coastal species.

Past research showed that SH1 does impact Kaikōura's NZFS. Between 1996 and 2005, 120 NZFS (an average of 12 per year) were recorded on SH1 (Boren et al., 2008). Of these seals, 40% died due to vehicle collisions, and 61% of all mortalities were pups. At the time, it was predicted that the problem would worsen due to growth in the local NZFS population (Boren et al., 2008).

Given the substantial post-earthquake modifications to SH1, and suspected changes to the abundance and distribution of local NZFS, our research sought to establish the current impacts of the road on NZFS colonies. As well as drawing comparisons with previous research, we sought to identify the hotspots for NZFS 'incidents' (records of live or dead NZFS on the road), establish the factors that might make a certain part of the road more likely to experience incidents, determine whether the hotspot locations have changed through time, and whether certain environmental or temporal factors affect the timing of these incidents.

Methodology

This research used data collected by the New Zealand Transport Authority (NZTA) on NZFS incidents on SH1 between May 2012 and April 2022. NZTA is permitted by DOC to remove NZFS carcasses or herd live NZFS from the road, typically in response to callouts from members of the public or during road maintenance work.

There are some gaps in this record, most notably the time from the earthquake through to the re-opening of the road (November 2016 - June 2018). During this time, the road was either closed or operating at a much-reduced capacity due to the ongoing reconstruction.

Kernel density estimation plus (KDE+) (Bíl et al., 2013, 2016, 2019), was used to identify hotspots of NZFS incidents with traffic along 90 km of SH1 between Oaro and the border between the Canterbury and Marlborough regions. To ensure that our results reflected the current distribution of hotspots, we limited the NZFS incident data set to January 2021 to April 2022, leaving 91 incidents available for analysis.

To determine spatial features of the road where NZFS incidents occur, SH1 was divided into 250-metre segments. For each segment, a yes or no (binary) response variable was created indicating whether or not it contained at least one NZFS incident. Twenty-six segments contained at least one incident, and, to permit spatial variable modelling, 52 incident-free segments were also randomly selected for comparison. For each segment, we analysed variables to assess their impacts on whether NZFS incidents occurred, and these included: the presence or absence of various guard rails and other road barrier

Like all youngsters, seal pups can sometimes be found in unexpected, and possibly hazardous, places (Photo: Alasdair Hall).

types, the road width, the road height from sea level, the distance to the nearest stream or culvert, the distance to the nearest bend, the distance to the coast, the percentage coverage of roadside vegetation, the coastal substrate type, the location of the road relative to the railway line, and whether or not the road abutted an area of NZFS breeding.

To analyse whether the locations of NZFS hotspots had persisted through time, NZFS incidents between May 2012 and April 2022 were aggregated into kilometre segments. The incidents' spatial distribution was then compared with what would be expected in a random situation, where the probability of incidents in a given segment should follow a Poisson distribution.

A Poisson regression model was used to determine the impacts of environmental (temperature, rain, wind and wave and tide height) and temporal (traffic volume) drivers on the timing of NZFS incidents. An additional season variable was also created to determine whether the season impacted NZFS incidents.

Results and implications

A total of 393 dead and 57 live NZFS were recorded on SH1 within the study area between May 2012 and April 2022. For 'complete years' (those with a full 12 months' worth of data) there were an annual average of 59 (±17 s.d.) NZFS incidents. There was an average of 49 (±9 s.d.) dead and 9 (±10 s.d.) live NZFS recorded each year on SH1. Where an indication of an individual NZFS' age was recorded, pups accounted for 88% of road mortality.

Fifty-nine is a considerable increase on the average of 12 annual NZFS incidents by Boren et al. (2008), and the result is likely tied to local population growth. Approximately 600 pups were produced at Ohau Point in 2005 (Boren et al., 2006), but this had increased to nearly 2,500 in 2015 (Gooday, 2016). Given the proximity of some of Kaikōura's NZFS colonies to SH1, it is expected that increasing NZFS abundance will lead to increasing NZFS incidents. Similarly, there has been an increase in the number of pups as a proportion of overall road mortality since the previous study. This, again, is likely tied to growth in the local breeding population of NZFS in colonies near SH1. Importantly, post-earthquake road reconstruction and COVID-19 lockdowns, which both occurred during the study period, substantially reduced traffic volumes on SH1, meaning the incident total would likely have been higher without these events. Without mitigation we might, therefore, expect the problem to worsen as tourism continues to recover.

The hotspot analysis identified 10 clusters of NZFS incidents. Together, these clusters accounted for 89% of the NZFS incidents, and represented only 2.75 km of road. This suggests that, if it is possible to prevent NZFS from accessing these limited stretches of road, the scale of the problem should be substantially reduced.

The hotspot persistence analysis showed a clear shift in the focal area of NZFS hotspots. Prior to the earthquake, 70% of the significant road segments were north of Kaikōura, whereas, post-earthquake, 63% were south of Kaikōura. Considering the south coast of Kaikōura in isolation, it is likely that the growth in incidents here is the result of local population growth. Pre-earthquake, the only recorded breeding in this area was on an nearshore islet, whereas, today, several breeding sites exist along the mainland coastline. However, there are still substantially more pups produced to the north of Kaikōura than to the south. Thus, in the absence of other factors, it would be expected that the north coast would continue to experience the bulk of NZFS incident hotspots.

The best explanation for these changes is the post-earthquake modifications to SH1. The most obvious of these is the construction of 2.5 km of non-contiguous seawall north of Kaikōura, with the majority situated around the established Ohau Point NZFS colony. In segments of SH1 now abutting the sea wall, the number of NZFS incidents have noticeably reduced since its construction, suggesting that it effectively excludes NZFS from the road. In addition, some sections of road north of Kaikōura where motorcycle protection railing (MPR; double guard rail) has replaced single guard rail, these sections have also seen reductions in NZFS incidents. This makes sense, particularly as pups make up the bulk of NZFS incidents and these smaller animals could easily fit under barriers that do not reach the road surface, such as single guard rails, but would not be able to get under MPR. By contrast, there have been increases in NZFS incident numbers in sections of road, particularly south of Kaikōura, where additional single guard rails and plastic mesh safety fencing have been installed. This suggests that these barrier types do not effectively exclude NZFS from the road.

Of the temporal and environmental variables, season had the greatest effect on NZFS incidents, with autumn experiencing substantially more incidents than any other season. This is likely tied to pup development as, during autumn, NZFS pups are still largely confined to land, but are mobile, inquisitive and feeding less frequently than in summer. Together, this means pups have the ability and time to explore their terrestrial environment. If the colony is close to SH1, this may lead them to access the road. Greater traffic volumes and higher wind speeds were also significantly associated with more NZFS incidents. It is unsurprising that months with heavier traffic volumes experience more NZFS incidents, and the relationship between windspeeds and NZFS incidents may be tied to animals escaping windy conditions on the coast by moving inland and thus onto roads. By contrast, higher temperatures and heavier rainfall were significantly associated with fewer NZFS incidents. In both cases, the relationship is likely associated with NZFS seeking shelter from high temperatures or prolonged/heavy

Seal pup and mother resting next to State Highway 1 (left), and a new pup at home among the rocks (right) (Photos: Alasdair Hall).

rain. Pups are vulnerable to both over-heating and soaking to the skin, as their juvenile coats are not waterproof, and therefore are likely to escape to verges and onto roads during these conditions.

The analysis of spatial features showed that the presence of road abutting NZFS breeding sites was so predictive of NZFS incidents that a full logistic regression was not required. This finding fits with our other results indicating the prevalence of pups in NZFS mortalities, and is logical, as breeding colonies contain the greatest year-round densities of NZFS. There are, however, important management implications of this finding, as it suggests that breeding sites should be prioritised when it comes to road protection mitigation, even if, as in Kaikōura, a coastline also features non-breeding aggregations of NZFS.

Overall, these results indicate that SH1 can be a threat to Kaikōura's NZFS, and one that has worsened in recent years. However, it appears that, if appropriate mitigation measures are taken at the identified areas where incidents occur, it may be possible to significantly reduce the number of NZFS deaths. Although our study did not explicitly test different barrier type efficacy, it appears that the most effective long-term solution would be the addition of more motorcycle protection railing at the identified hotspots. As autumn is the worst time of year, and high winds and increased traffic volumes also lead to increased NZFS incidents, a next-best solution would be temporary mitigation measures during such periods – for example, autumn holidays such as Easter and ANZAC day, or when storms are forecast.

It is also worth considering that continued growth of the nationwide NZFS population, combined with sea level rise and the predicted increased intensity and regularity of storms, which will likely drive coastal species further inland, may mean that this problem becomes replicated elsewhere. As such, proactive response planning is needed to minimise the risks to both wildlife and humans.

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Novel numerical modelling of tsunamis from volcanic explosions

Matty Hayward, University of Auckland

The highly explosive eruption at Hunga Tonga-Hunga Ha'apai and subsequent tsunami in January 2022 has reinforced the necessity to explore and quantify volcanic tsunami sources. However, a lack of previous field data and modelling effort means that volcanogenic tsunami and wave hazard remains less understood than that of other tsunami sources. Numerous localities across the Pacific, including the northern shores of New Zealand, may yet be found to be exposed to such events in the future. Caldera lakes, such as Lake Taupō, may also experience tsunami-like hazards from volcanic eruptions.

The study simulates 20 volcanic explosion scenarios across Lake Taupō of varying magnitudes to explore the scope and scale of potential wave hazard on the foreshore of the lake from such eruptions. To do this, a non-hydrostatic multilayer numerical method is used to reliably capture the higher dispersivity of waves generated from an explosion and simulate their propagation through to their interaction with the shores, including that of the built environment. The outputs from simulations include mapping of significant wave amplitudes, any inundation near built areas and roads, and a more targeted hydrographic analysis of incident waves flowing towards the Waikato River control gate.

Results from the scenario suite indicate that locally significant waves start being generated in the lake at an eruption size approximately equivalent to one at 5 on the Volcanic Explosivity Index – a large eruption. In addition, the most hazardous inundating waves were often found on shores most directly exposed to the eruptions, including the eastern shore where State Highway 1 often runs nearby or alongside. Given the location, little resilience to this hazard is likely present and may be a compounding factor to the many hazards present during a volcanic eruption.

While the event at Tonga showed the effectiveness of a community-driven response, many other coastal areas within proximity of volcanoes may currently be less prepared for tsunamis of this type, even when considering current tsunami warning systems. The current opportunity of incorporating field data from Tonga into further experimentation and hazard investigations should not be missed; exposed coastlines around the Pacific should be aware to incorporate this mechanism into hazard studies.

To read the full paper on modelling volcanogenic tsunamis, go to https://doi.org/10.5194/nhess-23-955-2023

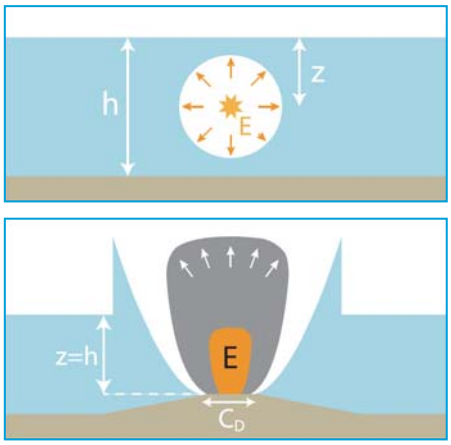

Figure 1 (right): Illustration of the submarine explosion problem (above); and an explosion of yield E and depth z in water of depth h (below). Schematic of a volcanic scenario in which such an explosion would occur where z=h, and crater diameter C_D can be measured or calculated using estimated ejecta volume V.

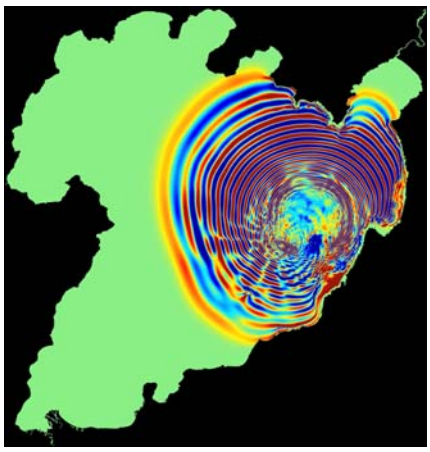

Figure 2 (above): Snapshot of wave amplitudes from a simulation of waves generated by a possible volcanic eruption within Lake Taupō, where the maximum amplitudes were approximately 2 m.

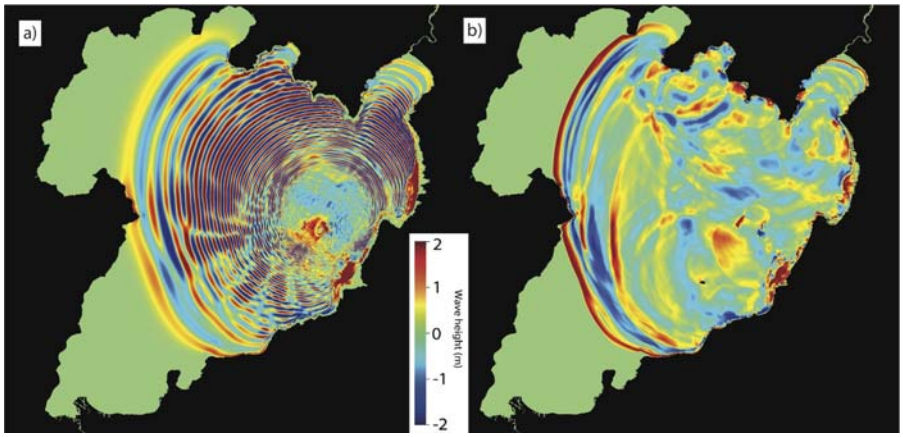

Figure 3 (left): Simulation snapshots of waves generated by a volcanic explosion in Lake Taupō using (a) the multilayer non-hydrostatic model, and (b) the usual shallow water equations model.

Recent regional events

Bay of Plenty

A regional networking event was held in Tauranga in May featuring coastal scientist and consultant Dr Peter de Ruiter. Peter gave a well-received presentation on his recently completed PhD thesis, titled *Hypsometric and geometric controls on hydrodynamics, tidal asymmetry, and sediment connectivity in shallow estuarine systems*.

For his research, Peter combined field observations (in Tauranga Harbour) with numerical simulations to explore how geometry and morphology modulate tidal asymmetry and sediment transport in shallow estuaries.

Presentation at the Bay of Plenty regional event (Photo: Alison Clarke).

A longer description of the project and a download link to the thesis are both available at https://hdl.handle.net/10289/15403

Peter's talk was followed by pizza and drinks and networking opportunities. The event had a very good turnout of local coastal scientists, engineers, planners, ecologists and geologists.

Canterbury

New Canterbury reps Kate MacDonald and Tommaso Alestra held a successful regional get together at the end of March, with close to 30 attendees from the two local universities, local consultancies, NIWA, the Christchurch City Council and Environment Canterbury.

Attendees appreciated both the networking opportunities, and the science side of the event, which featured six short presentations on a range of topics: whitebait, marine heatwaves, saltmarsh restoration, coastal groundwater, beach geomorphology, and youth engagement as part of managed retreat.

Most people in the crowd were familiar with the New Zealand Coastal Society, but there were definitely a few new faces, so we took the opportunity to say a few words about the Society before the talks began. Overall, the event was very well received and we have already received enquiries about the next one.

Attendees at the Canterbury regional event (Photo: Tommaso Alestra).

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Accessing weblinks in the printed newsletter

Web links are an invaluable source of further information for readers, but in the printed version of *Coastal News* we can't include active links as we do in the pdf version.

We realise that manually copying long strings of seemingly random characters can be frustrating for readers, so for each issue we now produce a pdf file of live links – this can be found on the NZCS website at www.coastalsociety.org.nz/publications.

To make things even easier, you can access the pdf file by using the QR code to the right. The file contains every link published in each newsletter, organised by the pages where they appear, and all are active (clickable) links.

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The submission deadline for the next issue is 30 September 2023.

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