Commemorating the 1974 Dunedin earthquake to encourage community resilience

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ABSTRACT

On April 9th 1974, a M_L 4.7 earthquake struck near Dunedin, causing the most significant damage to the city up to that date. While there have been no earthquakes causing more damage since 1974, scientific investigations over recent years have advanced the understanding of seismic hazard and risk to life safety and buildings. Studies reinforce that although the city is relatively quiescent, much stronger ground motions should be expected and planned for, particularly from local earthquake sources and distributed seismicity. The New Zealand National Seismic Hazard Model (2022 NSHM,) was updated accordingly. The year 2024 marked the 50th commemoration of the 1974 earthquake, providing an opportunity for a collaboration between scientists and emergency management practitioners to support the Dunedin community learn more about their local hazard and risk context. Prior to a commemoration event, information about the 1974 earthquake and its impacts was collated using archives, insurance data, and interviews with people with living memory of the earthquake. A summer scholarship project developed a 9 min short film based on this information called "Are you ready to shake, Dunedin?". Then, on the evening of April 9th, exactly 50 years since the 1974 earthquake, a public commemoration event and media articles shared the science about the earthquake, to encourage community preparedness for a future damaging earthquake in Dunedin. Evaluations of participant experiences of the commemoration demonstrate the value of using the experience of past natural hazard events to encourage and support community awareness, preparedness and resilience.

1 INTRODUCTION

This paper reports on a multi-agency collaboration aimed at using the 50th anniversary of the 1974 Dunedin earthquake to improve community awareness about seismic hazard and risk. The project brought together scientists, emergency managers and science communication specialists to develop a public commemoration event with two main goals; first, to share historical perspectives of the 1974 earthquake and outline the damage done by the M_L 4.7 earthquake, and second, to improve public awareness about seismic risk and encourage preparedness and resilience in Dunedin.

2 EARTHQUAKE HAZARD AND RISK IN DUNEDIN

While the 2010 M_W 7.1 Darfield earthquake, centred ~35 km from the Christchurch CBD, was devastating locally, the 2011 M_W 6.2 earthquake located much closer to the city caused far greater damage (and loss of life), the wider population of New Zealand were served a timely lesson that 'both proximity and size matter'. In Dunedin, residents have in recent decades learned of the dangers of 'A Big One' - being a very large (or great) earthquake on the Alpine Fault – but the Canterbury Earthquake Sequence (CES) has aided the promotion of awareness that nearby local faults can also produce significant shaking and there are multiple sources of hazard. The CES provides exemplary evidence that Dunedin is by no means immune to events like those in Christchurch in 2010-2011.

Dunedin lies at the eastern edge of the Otago Range and Basin province, part of the wider deformation zone associated with the boundary between the Australian and Pacific plates (Seebeck et al. 2024, Figure 1). Plate boundary deformation in southern New Zealand is highly asymmetric, with over 75% of the relative motion accommodated in the west on the transpressional Alpine Fault (Cox & Sutherland 2007; Litchfield et. al., 2014). The current tectonic regime in Otago is largely utilising pre-existing geological structures, including contractional reactivation of normal faults formed during a previous extensional regime.

Paleoseismological investigations over recent years have advanced the understanding of activity and movement of faults near Dunedin that could generate large future ground motions, with particular focus on hazard from the nearby Titri, Akatore and Hyde faults (Lichfield & Norris 2000; Barrell et al. 2020; Taylor-Silva et al. 2020; Griffin et al. 2022a). Slip rates for faults in Otago tend be relatively low (0.05-1.5 mm/yr) and with ever-improving evidence for episodically varying return periods between large earthquakes (e.g. Griffin et al. 2022b; Morgenstern et al. 2024). An increasingly broad perspective on seismic hazard has shifted focus from distributed seismicity with a strict, narrow, definition of active faults, to encompass a much larger number of "potentially active" faults as seismic sources (Nicol et al. 2016; Seebeck et al. 2024).

The annual probability of different levels of earthquake shaking across New Zealand are provided by the National Seismic Hazard Model (NSHM). This shows Dunedin City to be in a relatively low seismic hazard area with a lower annual probability of damaging shaking levels compared with much of the country (Stirling et al. 2012), although these probabilities have been increased somewhat in 2022 NSHM through paleoseismic investigations and recent seismic hazard modelling (Gerstenberger et al. 2023; Horspool et al. 2023). Dunedin's ground motion hazard is dominated by an Akatore Fault earthquake, due to its close (<15 km) proximity to the city, and nearby earthquakes produced by distributed seismicity (Stirling et al., 2012).

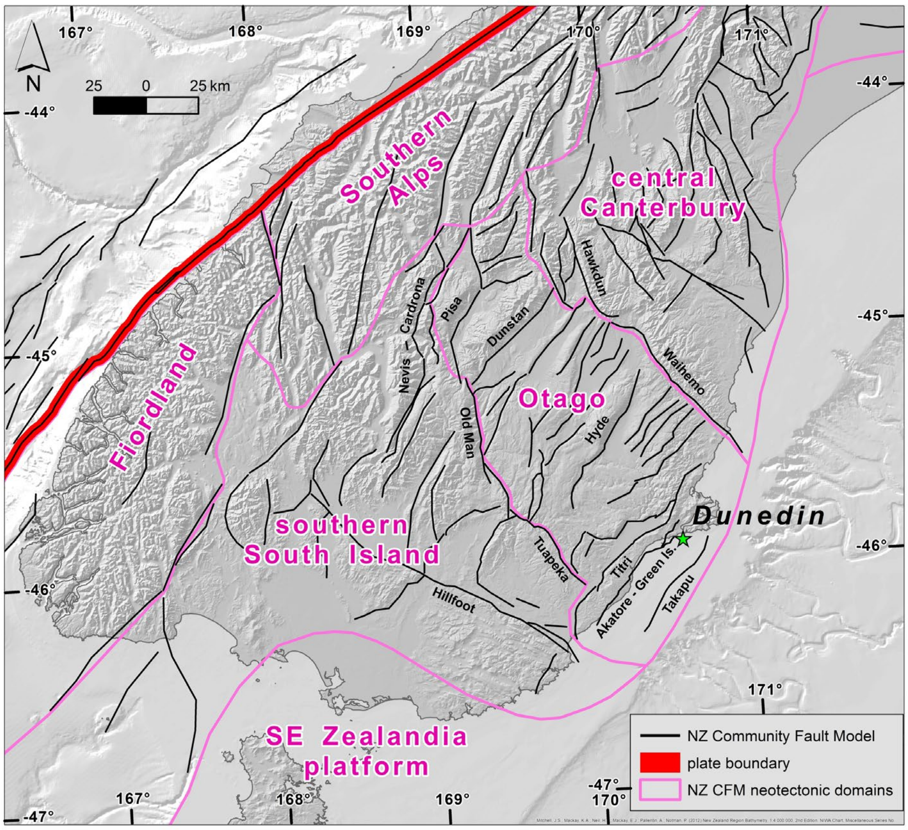

Figure 1: A. Neotectonic setting of Dunedin and the southern South Island. Faults and neotectonic domains from the NZ Community Fault Model (NZ CFM) version 1.0 (Seebeck et al. 2024). Selected faults named, with names placed on the upthrown side. Digital elevation shade models are LINZ 8 m resolution (onland) and NIWA 1:4 million-scale (offshore). Green star marks the epicentre of the Dunedin 1974 M_L4.9 earthquake, offshore 7 km southwest of Dunedin..

2.1 The 1974 Dunedin earthquake

2.1.1 Event

On 9 April 1974 at 7.49pm NZST, a local magnitude (M_L) 4.9 (equivalent to a moment magnitude, M_W, 4.7[1]) earthquake occurred at a shallow (default) depth of ~10-12 km around 7 km offshore and south of Dunedin (45.97°S; 170.52°E, Event ID:1555709 GeoNet 2025), with a magnitude uncertainty of ±0.2. A small foreshock preceded the main shock by a few seconds and it was followed by M_L=3.7 aftershocks at 8.20pm and 9.50 pm (Bishop et al. 1974). Many observers reported a strong vertical movement (Bishop et al. 1974). Shaking intensities reached MMI V-VI across Dunedin, locally reaching VII. Peak ground accelerations of 0.27g to the NE were recorded at St Clair Telephone Exchange, and 0.12g to the SW at the Central Post Office. There were no landslides attributed to the earthquake. Power line switches in the foreshore substation were tripped, which also set off a series of fire alarms, and power supplies in the suburb of Corstorphine were interrupted for ~45 minutes. The public submitted 49 felt reports by post, which record that shaking was felt as far away as in Oamaru, Roxburgh and Balclutha, with isolated reports from as far away as Waipapa Point in the Catlins and Gore in Southland. Assessment of felt reports suggested isoseismal patterns had a reasonably regular configuration and attenuation with distance for a shallow earthquake (Adams & Kean 1974; Downes & Dowrick 2014).

The earthquake mainshock registered first-motion polarities indicative of primarily strike-slip movement on a steeply dipping fault, involving dextral slip on an ENE strike or sinistral slip on an NNW-strike (Adams &

[1] At the time of the 1974 earthquake earthquakes were most commonly measured with local Richter magnitude M_L, but the more recently adopted moment magnitude M_w gives better representation of larger earthquakes. This paper uses the assigned M_L 4.9 (± 0.2) local magnitude (GeoNet 2025), as it in part reflects the relatively low number of seismometers (7) that recorded the earthquake, and was used in the media at the time of the earthquake. A moment magnitude M_w 4.7 has been subsequently determined.

Kean 1974). By contrast, faults mapped close to Dunedin, which by definition are large enough to have repeatedly experienced surface rupture, are predominantly NE striking reverse faults (Figure 1, see also Gorman et al. 2013; Holt 2017). Although the earthquake was once assumed to have occurred on the Akatore Fault (Bishop et al. 1974), it is now more commonly considered to be a background seismicity event, given its small size, and lack of clear association with any known active faults.

2.1.2 Damage

Damage was almost entirely confined to Dunedin, where residents experienced one of the first earthquakes to cause widespread shaking damage in the city. The Earthquake and War Damage Commission (EQWDC, now Natural Hazards Commission Toku Tū Ake) received 3000 claims, which was relatively high for the moderate size of the earthquake. At least half involved chimney damage, whereas others were due to cracking of interior plaster, cracking of external masonry, damaged plumbing and fallen household items. Damage cost approximately $250,000 (Adams & Kean 1974). This was equivalent to an inflation adjusted 2024 value of over $3.5M (using RBNZ 2025), more than any single New Zealand earthquake since the 1968 M_L=6.9 in Inangahua, yet an order of magnitude lower than cost of flood damage in 2015 ($28M, Goldsmith et al. 2015). A contour map shows highest densities of claims on the coastal plain of South Dunedin, where the density of housing was high, but damage also occurred throughout the hill suburbs (Figure 2A).

A unique isoseismal map was also constructed based on the number of items that fell from shelves in 105 grocery stores (Figure 2B; Bishop et al. 1974). Greatest number of fallen items were along the southwest edge of the South Dunedin coastal plain. Where known, the direction in which items fell was also recorded, showing a pronounced northwest-southeast concentration. There is broad consistency between seismometer accelerations, claim densities and the isoseismal maps (Figure 2; Bishop 1974). The map was one of the first to show the effect of amplification and/or directionality as seismic waves pass from underlying mid-Cenozoic volcanic and sedimentary rocks into unconsolidated Quaternary sediments of South Dunedin. Strong site effects in Dunedin were subsequently measured in seismometers across Dunedin during the 2003 Fiordland earthquake (Reyners et al., 2003).

3 COMMEMORATING PAST NATURAL HAZARD EVENTS

Commemorations of past earthquake disasters have been described in the academic literature as an opportunity to reflect, and for supporting long term community recovery and resilience. Marreiros et al. (2019) used the 50th commemoration of the 1969 Cape Saint Vincent earthquake in Portugal to collect and preserve community observations of the event. Zavar et al. (2019) describe how commemorating past earthquake impacts can help to 'recast sites scarred by devastation as inviting spaces to collectively mourn and reflect' (p. 157). Commemorations can be opportunities to express grief, to aid community healing and psychosocial recovery. Activities to remember past events may be tangible, such as memorials, museums or monuments, or intangible, including public gatherings and other forms of remembrance. Boret and Shibayama (2017) note the importance not only of monuments to acknowledge past events, but also the need for practices like storytelling and disaster education, to support a culture of disaster awareness and preparedness. For example, high water flood and tsunami markers are used to capture the extent of past events as a reminder of what could happen again in future.

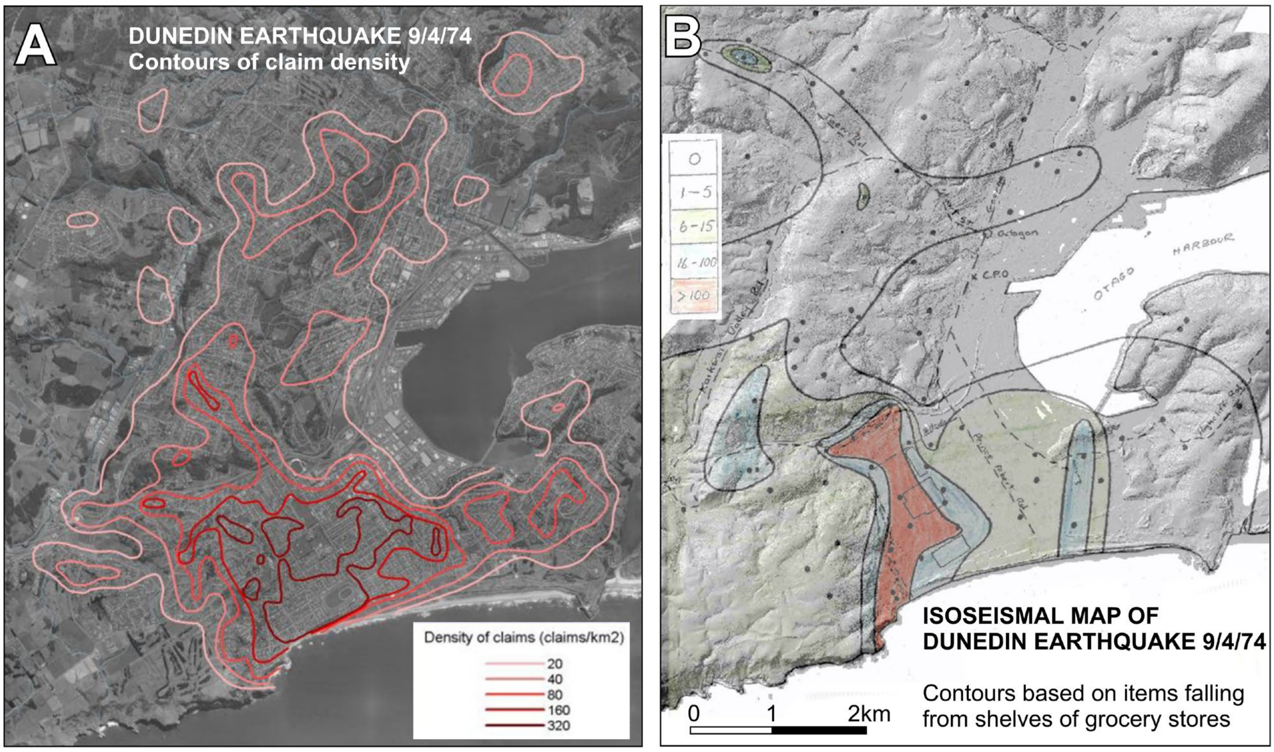

Figure 2: The 1974 earthquake damage. A. Density of claims received by the Earthquake and War Damage Commission, reproduced from Bishop (1974). B. An isoseismal map from Bishop et al. (1974), mapping the number of fallen items from the shelves of grocery stores, geo-registered and overlain on a modern, shaded digital elevation model of Dunedin.

3.1 Commemorating the 1974 Dunedin earthquake

To date, few studies have described commemorations related to past earthquakes that were moderate in their level of damage and disruption. This paper applies lessons from earthquake disasters elsewhere to memorialising the M_L 4.9 1974 historical earthquake in Dunedin as a way to encourage the local community to understand and prepare for future damaging earthquakes. Because Dunedin has historically experienced very few earthquakes, the public perception of earthquake risk is low. Johnston et al. (2017) conducted a public awareness survey in Dunedin, showing that fewer than 10% of respondents had experienced a significant earthquake before, and many had an elevated perception of risk following the Christchurch earthquake disaster in 2012. 86% of respondents agreed or strongly agreed there is potential for future earthquakes to significantly damage heritage buildings in the city. However, preparedness was observed to be generally low.

3.2 Commemoration activities

To prepare for the public commemoration event, archival materials, including media and historical stories, were collected by the research team, including images of damaged property and falling masonry. A summer scholarship student at the University of Otago worked on collating this information, together with stories from local people who remembered the earthquake in 1974. A 9 min video called “Are you ready to shake, Dunedin?” was produced that outlined the impacts and implications of the Dunedin earthquake in an accessible way for a general public audience (Latton, 2024).

The public commemoration event was held on April 9th 2024 at the Hutton Theatre, Tūhura Otago Museum, on the exact 50 year anniversary of the earthquake. A communication plan was developed by Emergency

Management Otago to share and promote the anniversary event information widely, including a media release for the Otago Daily Times (https://www.odt.co.nz/news/dunedin/information-event-commemorate-earthquake), and advertising for local radio, social and print media. An event poster was printed and placed in numerous locations across the city. A total of 110 people attended, which exceeded expectation. The evening began with the short film to set the scene, and was followed by a presentation about the 1974 earthquake and its impacts. Representatives from the Property team at Dunedin City Council outlined their work to improve heritage building resilience, which was followed by emergency management preparedness and resilience information. The evening concluded with a question-and-answer session, which generated many questions about heritage buildings in Dunedin, local emergency management arrangements and personal preparedness actions. Attendees were invited to click a QR code link to share feedback on the event, and the data from the survey is presented below.

An article about the event was published in local newspapers the following day, and some survey forms were distributed at three other lectures about the earthquake given for local clubs and societies that week - including the Otago Branch of the Geoscience Society who experienced the earthquake first hand during their inaugural meeting on 9th April 1974 (H. Campbell pers comm.)

3.2.1 Evaluation data

The evaluation survey was developed and hosted on the online platform Qualtrics. A range of questions covered experience of earthquakes generally, preparedness, and risk perception, as well as whether participants or someone they know had experienced the 1974 earthquake.

3.2.2 Participants

Seventy-eight people followed the survey link, with 62 proceeding to complete at least most of the survey. Most respondents (77%) did not attend the commemorative event. The majority of participants (70%) were women. Year of birth ranged from 1948 to 2003, with most being born in the 60s (10), 70s (10), 80s (12), and 90s (11). The most common living situation was in a family without children (40%).

3.2.3 Earthquake experience

Most participants (68%) had not been affected by a significant earthquake in the past, although over half had someone they knew very well or a family member directly (48%) or indirectly (13%) impacted. Few (13%) survey participants personally experienced the 1974 earthquake, although over a third (38%) knew someone who had experienced it, suggesting that this earthquake is at least known about by a meaningful proportion of the Dunedin public.

3.2.4 Earthquake perceptions and preparedness

The majority of survey participants felt that they were informed enough to be able to adequately plan or prepare for earthquakes (84%). No participants reported thinking that a big earthquake near their community in the future was "Not at all likely", although the mean score for this item on a scale from 1 to 5 was 3.66, suggesting that while participants acknowledge that a future big earthquake is possible, many do not see it as very likely. Similarly, most participants think about earthquake issues in their community a few times a year (41%) or rarely (25%). Similar proportions talk about earthquake issues with their community a few times a year (34%) or rarely (34%), with 13% saying they have never done so.

Most potential barriers to earthquake preparation were rated around the midpoint of the 1-5 scale (mean scores ranged from 2.23 to 3.10), but there was a general trend where the strongest barriers were cost (M = 2.89), the need for co-operation with others (M = 3.02), and having other things to think about (M = 3.10).

4 CONCLUSION

The city of Dunedin is exposed to infrequent, yet potentially damaging earthquakes from local active fault sources, including the Akatore Fault less than 15km from the city centre. The most recent damaging earthquake to affect Dunedin was in 1974, and led to $250,000 of insurance claims. A collaboration between scientists, emergency managers and communication experts (film-makers) was developed to leverage this historical earthquake as a means to engage with the public on disaster risk reduction and preparedness messaging. The commemoration event held on April 9th 2024 shared the impacts and consequences of the earthquake 50 years ago and outlined efforts by Dunedin City Council to improve resilience in the built environment. Ideas and initiatives to support personal preparedness were shared by Emergency Management Otago. Evaluation survey data highlight the value of commemorating past hazard events as a means to encourage community efforts to build personal preparedness, towards enhancing local resilience.

Dedication

This paper is dedicated to co-author Distinguished Professor David Johnston, who tragically passed away in January 2025. David's commitment to safer communities through education and memorialising natural hazards was well known to all his colleagues and friends. In publishing this paper, we hope to continue David's legacy, and contribute to the knowledge base of natural hazards for the education and safety of all communities.

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