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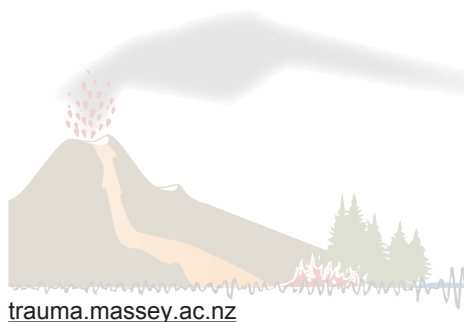
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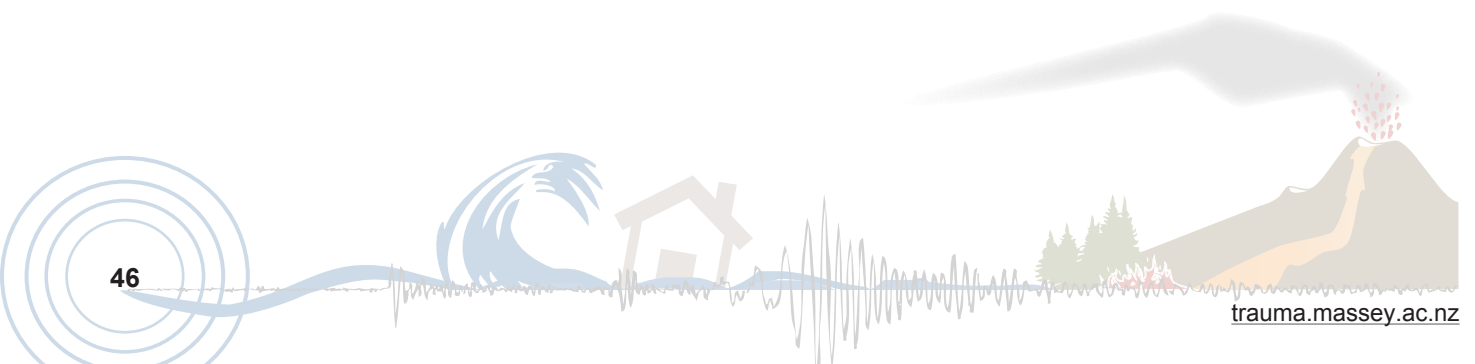
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The experience and future of businesses displaced by earthquake from central Christchurch, New Zealand.

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Abstract

A large number of businesses that used to be in the centre of Christchurch relocated after the earthquakes. Are they satisfied with their new locations and do they intend to return to the central city? We questioned 209 relocated businesses about their relocation history, present circumstances and future intentions. Many businesses were content with their new premises, despite having encountered a range of problems; those businesses that were questioned later in our survey period were more content. The average business in our sample rated the chances of moving back to the central city as around 50 %, but this varies with the type of business. Building height did not emerge as a major issue, but rents may be. The mix of types of business is likely to be different in the new city centre.

Keywords: *Business decisions, Earthquake, Relocation*

Disasters have a vast variety of effects on people. There are the obvious immediate physical effects: People die and are injured; property is destroyed; people may need rescue, food, shelter and water. A good deal of research has gone into such effects and into effective ways to prepare for them and mitigate them (e.g. Lindell, Prater, & Perry, 2007; Spittal, McClure, Siegert, & Walkey, 2008). There has also been considerable research into longer-term effects, such as the effects of relocation on individuals and families who flee or are removed from the devastated area (e.g. Najarian, Goenjian,

Pelcovitz, Mandel, & Najarian, 2001; Blaze & Shwalb, 2009), the development of psychological disorders such as post-traumatic stress disorder in the survivors (e.g. Neria, Nandi, & Galea, 2008), and the difficulties of managing the reconstruction or repair of housing (e.g. Chang, Wilkinson, Brunson, Seville, and Potangaroa, 2011). One such longer-term effect is on the business community, and one aspect of this effect was the subject of the present study. Businesses have been forced to relocate following an earthquake. Some have survived this relocation and the attendant disruptions. What plans for the future do they now have?

Zhang, Lindell and Prater (2009, p. 38) comment that “in the disaster literature, research on business impacts has been less developed compared to the extensive literature on community impacts of environmental disasters”. Yet, clearly, these impacts are also of critical importance, both for the business world and for the rest of the community. Much reconstruction is undertaken by businesses; community recovery depends in part on the ability of businesses to employ people; the decisions that businesses make about where to locate or relocate themselves are important in determining where communities will be relocated. If all business were to forsake a devastated area, the community would be forced to leave it too.

Petak and Elahi (2001) estimate losses suffered by business in the Northridge Earthquake as about US \$6.4 billion (excluding damage to buildings). About 15-30% of businesses closed immediately, and small business closures continued for at least 2 years afterwards. Studies of Indian (Amirthalingam & Laksham, 2009) and Sri Lankan (Ray-Bennett, 2009) disasters point up the importance of short-term finance, via gold jewelry or microcredit, for households adapting to disasters. Wasileski, Rodrihuez, and Diaz (2010) surveyed businesses that had survived either the Loma Prieta earthquake (1989) or Hurricane Andrew (1992). Many reported infrastructure damage and business disruption and temporary closure of the business. Few of the Loma Prieta businesses (6.2 %) relocated after the earthquake, but 29% of those affected by Hurricane Andrew relocated. However, more than half of these had returned to their original location at the time of the

survey six years later. In neither case did the disaster lead to a shut-down of a large central business district, so it is not easy to compare these situations with that of businesses following the Christchurch earthquake.

The relocation of businesses is a normal phenomenon in the absence of any disaster, and business decisions to relocate have received some previous attention, although most of this has been directed at rather larger firms than were affected by the Christchurch earthquakes (Greenhalgh, 2008; Mazzarol & Choo, 2003). In general larger and older firms are less willing to relocate (Nguyen, Sano, Tran & Doan, 2013). Greenhalgh (2008) suggests that small businesses are less likely to make fully considered relocation decisions larger ones, and that small business owners often look to locate their businesses near their own homes. Sletjes and Völker (2012) point out that usually businesses are reluctant to move at all, and that factors in a decision to move include not only business costs and the size and suitability of new premises but also the desirability of the neighbourhood. Some of these previous findings might apply to the present study, but it is important to note that the questions asked are different. In particular, all of the businesses we studied had already been forced to relocate and the question they now face is whether to stay in their new locations or to move back.

This paper focuses on businesses forced to relocate after earthquakes in Christchurch, New Zealand in 2010 and 2011. The sequence of earthquakes was initiated on September 4, 2010 by a magnitude 7.1 event. A further earthquake on 22 February, 2011 was smaller in magnitude (6.3) than the September one, but its shallow epicentre was within the Christchurch city limits. In consequence, 185 people died; many were injured; the central city was devastated; and there was enormous property damage in the suburbs. In addition to these major events there were a number of aftershocks: As at 11 November, 2013, there had been 12774 recorded quakes in the area (<http://www.christchurchquakemap.co.nz/>). Although many of these were unnoticeable, others were substantial enough to produce further property damage.

After the February 22 earthquake, most of the centre of Christchurch, the area that lies within the "Four Avenues", was closed down. Some buildings were obviously ruined, many were later discovered to be ruined, and almost all seemed dangerous. Before the September 4 earthquake, over 6,000 businesses

employed over 50,000 people in the central city (The Field Connection, 2012). The vast majority of these businesses were forced out of the central city. There are no good statistics concerning the immediate fate of these businesses, but certainly some have not reopened since their enforced closure. It is likely, in line with findings from Alesch, Holly, Mittler and Nagy (2001), that small businesses were particularly likely to close permanently. On the other hand, others relocated quite quickly outside the central city.

The period since the February earthquake saw a slow transfer of focus from day-to-day survival to the more medium-term future. Plans to rebuild the central city have been developed (e.g. Christchurch City Council, 2012). Firms that relocated might look either to move back to the city or consolidate their businesses in new locations. Our aim in the present survey was to shed some light on how the relocated firms are faring (see, also, The Field Connection, 2012) and what they might do next. In particular, are they likely to return to the central city?

It is not difficult to think of reasons why business owners and managers might either favour returning to a location in the central city or prefer to remain at a location outside of it. The central city might offer a more identifiable location for customers, easier access to complementary businesses (for example, lawyers would often be closer to the central courts), and a more varied range of facilities for the workers. During the piloting of the survey, one business manager commented that everyone in his organisation disliked their new suburban location because there was no one to talk to except for each other. On the other hand, central city rents are likely to be more expensive, and parking for workers and customers more difficult.

Workers and owners alike might be reluctant to return to medium or high rise buildings within the city because of the perceived continuing danger. Moreover, once a business has been forced to move to the suburbs and necessary adjustments to the new premises have taken place, the owner might be reluctant to move back. Finally, as already remarked, business locations are never static in any city. For example, shopping malls, dentists, restaurants and bars were already proliferating in the suburbs of Christchurch before any of the earthquakes (Christchurch City Council, 2011). The earthquakes drove many businesses out of the central city, but some may have gone anyway.

Method

Respondents and recruitment

The respondents were 209 people responsible for businesses that had moved from the centre of Christchurch City and set up business again in other areas of Christchurch. Seventy-six respondents said that they owned the business, 39 were managers, 76 were directors (76); and the remaining 18 had some other relationship to the concern. We found no single, reliable register of such businesses, and recruitment was lengthy and drawn-out.

Some respondents completed questionnaires online in response to our request or that of another organisation (for example, the Canterbury Employers' Chamber of Commerce). Some respondents completed paper questionnaires available through the Westpac Hub; some completed paper or online questionnaires in response to door-knocking in areas such as Riccarton, Addington, or Harewood.

Fifty questionnaires were completed in December, 2011; 26 in January, 2012; 12 in February; 27 in March; 8 in April; 35 in May; 37 in June; and 14 in July. The lengthy recruitment period creates difficulties of interpretation but does provide an opportunity to examine change over time, and in some subsequent analyses results for the 115 early (December 2011 until the end of March 2012) and 94 late (beginning of April 2012 until July 15) questionnaires are compared. The businesses were companies (146), partnerships (21), not-for-profit organisations (14) and other, mostly sole traders (28). One hundred and four businesses had 5 or fewer employees, 37 had between 6 and 9 employees, 37 between 10 and 24, 15 between 25 and 49, 7 between 50 and 99, and 9 had 100 or more. Note that these numbers refer to the particular workplace (e.g. a branch of a bank) rather than the organisation as a whole.

Figure 1 shows the principal activities of the different businesses in the sample. The coding scheme was devised after we had read through the descriptions given by our informants and two independent coders achieved 82% initial agreement and resolved discrepancies after discussion. It turned out that whether a business responded early or late varied with the principal activity. For example, all the legal businesses were in the early sample.¹

¹ The analyses that follow do not make use of the principal activity of the business in consequence of this relationship.

Of the 181 businesses who gave us information about the suburb they had relocated to, 15 had already moved back to the CBD. Of the rest, 116 had relocated to suburbs that were relatively near to the central city (Defined as Riccarton (incl. Church Corner, Addington, Blenheim Rd, Merivale, St. Albans, Bryndwyr, Strowan, Sydenhamd, Spreydon, and Beckenham), while 50 had moved further out. Ninety-two had relocated to the west of the city, and 644 had gone south or north, and 10 had gone east. Thus, our businesses tended to have moved west of the city, but not very far west. As the effects of the earthquakes were generally milder in the west of the city, this pattern is unsurprising.

The majority of the businesses (129) had made only one move at the time of surveying, but 57 had made two moves, 13 had made three, 7 had made four, and 3 an unknown number. Twenty-six businesses owned their land and building within the city, and 33 owned the land and buildings of their current premises.

Questionnaire

The same standardised questionnaire was used for all surveys. The online version of the questionnaire was written in Qualtrics, hosted on a University of Canterbury web-site, and used the same ordering and wording as the paper one. The questionnaire was divided into sections with different themes.

The first part of the questionnaire asked for details about the business, such as the type of business, number of employees, etc. The second set of questions concerned the relocation history, and the "most important component for the survival of your business to this point". The third section asked about changes to the business. Respondents were asked whether electronic transactions, the proportion of business conducted online, home delivery, staff working from home, breadth of customer base, storage space, overall profitability

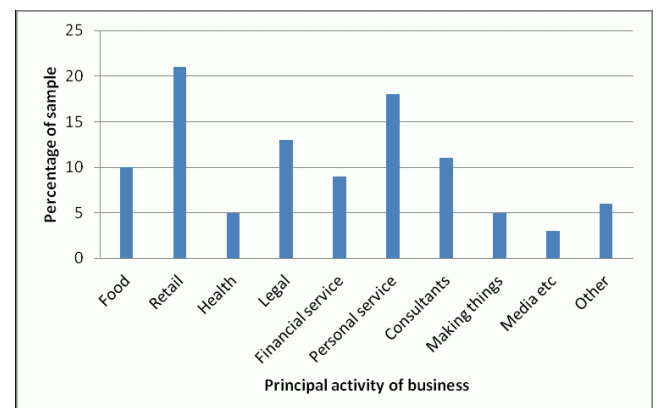


Figure 1. Principal activities of the businesses sampled.

and size of staff had decreased, stayed the same or increased. They were also asked whether customers finding the new premises, transport to the new premises and parking, were easier, the same, or more difficult at the new premises. Questions were included about alterations to the new premises, and, finally, overall satisfaction with the new premises rated on a scale from 1 (very unhappy) to 5 (very happy).

The next set of questions, called “general issues facing your organisation”, asked respondents to rate the importance using a five-point scale (1 = no importance to 5 = utterly necessary) of being near organisations similar to your own, being near organisations complementary to your own (e.g. courts for law firms), having customers come to your workplace, and being near facilities for staff welfare.

The final section concerned issues “you might consider when the central city is open again”. We asked whether, if the business moved back to the central city, some of it might remain in the present premises, and the amount of rent or lease that the business might pay in the central city compared with previous and present rentals. We asked about the maximum height of building that businesses would move back to and the maximum height they would like their own offices to be. We also asked whether moving elsewhere but not within the Four Avenues was under consideration. Finally, respondents were asked whether they would move back to the city.

Results

Respondents were asked to give the principal reason for their business’s survival to date. The question was open-ended and subsequently categorised by two coders who reached 82 % initial agreement and then resolved the discrepancies after discussion. Results are shown in Figure 2. Maintaining customer support

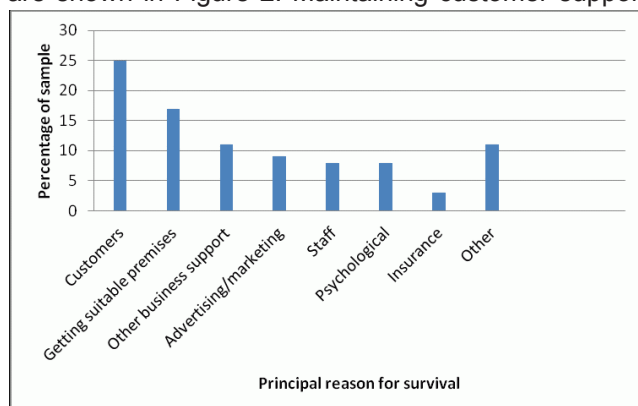


Figure 2. Different principal reasons given by respondents for the survival of their business.

was the most important factor respondents identified for the survival of their business to date. The results, incidentally, are generally in line with those previously reported after both the Christchurch earthquake (The Field Connection, 2012) and the Northridge, California earthquake (Petak & Elahi, 2001).

The relocated businesses have often changed the way they do things and Table 1 summarises these changes. All the variables show a mixed pattern. So, for example, some businesses reported increased profitability, some decreased profitability. Overall, however, the general pattern is that businesses have found it tougher. In particular, the tendency is to report smaller customer bases (and more difficulty for customers in locating the business), reduced storage space, reduced profitability and staff shrinkage.

Table 1
Percentages of Sample Reporting Changes in Different Aspects of the Business since the Move

	Decrease	No change	Increase
Electronic transactions	18	49	33
Proportion of business online	8	63	29
Home delivery	5	75	18
Staff working from home	3	52	44
Breadth of customer base	37	35	27
Storage space	59	18	22
Overall profitability since pre-earthquake	53	23	23
Workforce size since pre-earthquake	44	40	15

	Easier	No change	More difficult
Customers finding you at new premises	28	26	46
Transport to new premises	37	22	39
Parking at new premises	66	12	21

Businesses have not only experienced change in their new surroundings, they have often initiated it, in particular by altering their new surroundings. While just over a third of the businesses (38 %) had made little or no change to the new premises at the time of the survey, 21 % had made or at least begun changes that require a building permit, 4 % had subleased part of the premises to some other organisation, and 35 % had initiated major changes that did not require a building permit.

Table 2 shows the overall satisfaction levels with the new premises. As the table suggests, there is a significant difference between early and later respondents (Mann-

Whitney U, $z = 3.71$, $p < .001$): Respondents later in the survey period were more satisfied than earlier ones. Statistical tests (Mann-Whitney U, $\alpha = .05$) were also performed to see if there were differences in satisfaction level between small (1 - 5 workers) and larger (6 or more workers) businesses, between businesses relocating in the west or elsewhere, and between businesses relocating near to the city or further out, but no differences were found. Pearson correlations were calculated between satisfaction levels (1 = very unhappy to 5 = very happy) and all the change variables shown in Table 1 (1 = decrease or easier to 3 = increase or more difficult). Respondents were significantly ($p < .05$) more satisfied if they had increased storage space ($r = .33$), reported less difficulty in being found by customers ($r = -.31$), less difficulty with transport to the new premises ($r = -.28$), had increased profitability ($r = .19$), found parking easier ($r = -.17$), and where there was a lower tendency for staff to work from home ($r = -.15$).

Table 2
 Percentages of Early and Late Respondents Choosing Different Categories of Overall Satisfaction with new Premises

	Early %	Late %
Very unhappy	15	6
A little unhappy	22	15
Neutral	25	10
A little happy	14	27
Very happy	25	43

Taken over all the businesses, customer access ($M = 3.6$, $SD = 1.3$) was rated the most important of four location issues, followed by the ability of staff to access facilities ($M = 2.8$, $SD = 1.1$), being near complementary businesses ($M = 2.6$, $SD = 1.2$) and being near similar businesses ($M = 2.3$, $SD = 1.3$).

An important practical concern in Christchurch is whether relocated businesses are likely to want to move back to the central city. However, a currently relocated business might want to move from its present location but not back to the central city. At the time of the survey, 27 % of the businesses indicated they had already given "a little consideration" to another location outside the central city and 17 % were "taking this possibility very seriously". Moreover, if suitable premises were available in the central city, 19 % of the sample would still wish to retain part of the business at the present location.

Two issues that have emerged as possible concerns for businesses that might relocate back to the city centre are the prices of the rents or leases in a central city building and the height of the central city building. Table 3 shows

the results relevant to the pricing issue. The general result is that the average business is currently paying less for its present location than it paid in the previous inner city location. Respondents generally say they would be prepared to pay more than at present to move back, but not more than they previously paid in the central city.

Table 3
 Percentages of Businesses either Paying or Prepared to Pay less, the same, or more Money to Rent or Lease in Comparisons of the Present Premises and Past and Future Central City Premises

	Present and past city	Future city and present	Future and past city
Less	42 %	12 %	18 %
About the same	22 %	39 %	50 %
More	21 %	30 %	20 %
Not applicable	14 %	16 %	11 %

Note. Recall that businesses may own either the land and buildings (or both) on their present premises (16 %) or in the city (12 %)

Table 4 shows results related to the height of buildings that businesses are prepared to move back to. There were two pairs of questions. The first pair asked the maximum *height* of building that the business would be prepared to move back into and the height of the building it was housed in previously. The second pair of questions asked the highest *level* in a building that the business would now be willing to occupy, and the level in the building previous occupied (taking the highest when the business occupied more than one level). Note that the two pairs deal with related but not identical issues: A business may, for example, be located on level four of a twelve-storey building.

Table 4
 Maximum Height of Building Overall and Maximum Level in a Building that Businesses would be Prepared to Move back to in the Central City. Level of Previous Building and Highest Level of Previous Occupancy are also Shown

Level	Max height of future building	Height of previous building	Max level of future occupancy	Previous level of occupancy
1	14 %	13 %	21 %	38 %
2	23 %	35 %	25 %	28 %
3-4	22 %	22 %	18 %	14 %
5-22	14 %	19 %	14 %	19 %
Not concerned	25 %		20 %	

The results shown in the table are at first sight surprising. On average, businesses are prepared to move back to buildings or levels in a building that are similar in height to those they occupied previously. Initially, these results imply that from the point of view of finding tenants the

height of future buildings is unimportant. However, the matter is not quite so simple. As the table also shows, most businesses that moved out of the central city did not previously occupy medium or high rise. If the future city were to have a similar height profile to the previous city, that is, a mixture of high, medium and low rise, then willing tenants could probably be found for all levels. But willing tenants may be harder to find if the buildings in the new city were mostly medium or high rise.

The final question asked about the overall chance of returning to a site within the Four Avenues. Twenty-six percent of the businesses rated their chance of return as "about zero", 14 % as "about 25 %", 20 % as "50/50", 13 % as "about 75 %" and 24 % as "nearly 100 %". In order to facilitate analysis of the chances of return an average chance was calculated by taking the different ratings as a percentage estimate ("about 0 %" = 0 %; "about 25 %" = 25 %; and so on). The average estimated chance of return was then 48 % (SD = 38 %).

A number of variables affected the estimated chance to return. Businesses with five or fewer workers have a lower average chance of return (42 %) than larger ones (55 %; $t(201) = 2.63, p < .01$). Businesses that have moved west estimated a higher average chance of return (55 %) than the rest (38 %; $t(159) = 2.77, p < .01$). Unsurprisingly, businesses that owned land within the central city were estimated more likely to return (72 %) than those that did not (45 %; $t(199) = 4.43, p < .001$). Early respondents estimated a higher average chance of return (55 %) than those responding later (41 %; $t(201) = 2.63, p < .01$). There was no significant relationship between the estimated chance of return and whether the business had relocated near or further away to the central city or whether the business owned the land of their current premises.

Correlations were calculated between the estimated chance of return and all the variables listed in Tables 1 to 4, and a number of significant ($p < .05$) results obtained. The respondents said they were more likely to return to the central city if they were happy to move back to higher building ($r = .38$), a higher level in a building ($r = .35$), they were less satisfied with their present premises ($r = -.31$), transport to the new premises was more difficult ($r = .30$), they saw it as important to be near complementary businesses ($r = .31$) or facilities for staff ($r = .29$), they reported more difficulty in customers finding them ($r = .28$), they saw it as important to be near similar businesses ($r = .25$), they were prepared to pay more rent than they pay in the new premises ($r = .19$),

they paid less rent in the present premises than they paid previous ($r = -.18$), they were prepared to pay more rent in the inner city than they paid there previously ($r = .17$), they were previously in a higher building in the central city ($r = .17$), more of the staff were working from home ($r = .17$), they had less storage space in the new premises ($r = -.14$), and they were in a higher level in the previous inner city building ($r = .14$).

An initial multiple regression (ordinary least squares) was calculated regressing the estimated chances of return to the central city as a function of all the significantly associated variables listed in the previous two paragraphs. This multiple regression found significant beta-weights for just three variables. A multiple regression on just these three independent variables produced a significant overall R^2 of .18 ($n = 197$) and significant effects of satisfaction level in the new premises ($\beta = -.28$), owning land in the central city ($\beta = .25$) and paying lower rent in the new, relocated premises ($\beta = -.21$).²

Discussion

Both common sense and the results of previous work (e.g. Ray-Bennett, 2010; Zhang et al., 2009) suggest that the Christchurch businesses surveyed here would report that they still face many difficulties a year or so after the February event. Table 1 shows that they have been adversely affected in a number of different ways. Most important perhaps, the majority of businesses reported reduced profitability and more have reduced than increased staff. To some, unknown extent, such results may reflect the wider picture of subdued national and world economies over the period 2011-2012. On the other hand, it is worth remembering that the present survey respondents were businesses that had survived this period.

On the optimistic side, many of the results indicate that businesses have often adjusted to their new circumstances and surrounding. Indeed, as shown by their rebuilding plans, many are adjusting their surroundings. Business owners reporting later in the survey period were generally more satisfied with their new premises, suggesting that the longer they spend in their new environments in the future, the more satisfied they will become with them and the less likely they

² Clearly, there are a number of different multiple regressions that could be done here, but, because a number of the variables have naturally missing values, analysis with large numbers of variables entails a reduced sample size. For example, the initial multiple regression described was based on only 109 respondents.

are to return to an inner city location. One would also expect that some of the specific problems reported at present – for example, difficulty for customers in finding the relocated business – would decrease with time. Presumably, too, the longer they stay in their new locations the greater the commitment to this location and the less the commitment to the original central location (Greenhalgh, 2008).

Much of the practical value of the present survey derives from extrapolating the results to make tentative predictions about how businesses might behave in the future. Such extrapolation is useful because decisions are actually being formulated now about the shape of the inner city, even though its construction is still some way off (e.g. Christchurch City Council, 2012). However, it is also true that the present results are limited in at least two important ways.

Firstly, the present sample cannot be regarded as representative of all the relocated businesses. It was probably impossible to obtain such a sample. Most surveys have difficulties with the non-participation of potential respondents, and the respondents required for the present one were busier than most. More seriously, there was no single register of eligible businesses or any real possibility of creating one. Indeed, basic questions like how many of the original inner city businesses remain or how many of their workers are still in Christchurch were not answerable. In effect the surveying suffered from the problems of disruption faced by the city as a whole.

Secondly, surveying intentions is notoriously unreliable (e.g. Neuman, 2000, ch. 10). We attempted to mitigate this problem by including questions that dealt with present or immediate past behaviour. Hence, for example, the analysis of predictors of satisfaction with the new premises and the inclusion of items regarding what is important for the operation of the business. However, some direct questioning of intentions seemed unavoidable in a survey whose main practical value is the insight it might offer into future behaviour.

Bearing these limitations in mind, we draw some very tentative conclusions. Overall, it seems that some businesses will move back to the central city, particularly, for example, if they own land there or need to be near complementary businesses that are located there. Others will not. Overall the chances of return were about 48 %. A somewhat differently conducted survey by CBRE and Lincoln University (2012) found 32 % of

businesses wishing to return. Thus, according to both studies, it seems likely that many relocated businesses will continue to remain outside the central city.

Such an outcome would have a number of implications for the Christchurch community. In the first place, we should note that the current intention of the Christchurch City Council (2012) is actually to have a smaller and perhaps greener central city. This plan might fit rather well with the overall intentions of relocated businesses. Secondly, between now and the time when large-scale re-occupancy of the inner city takes place, there will be a good deal of turnover of businesses themselves. Some existing businesses will no longer exist in their present form. Other new businesses will have been set up. Thirdly, it is possible that the future will see the development of new business hubs outside of the central city and most likely somewhat to the west of it. Christchurch has traditionally had a transport system with a strong central hub, but this arrangement may not be ideal in the future.

It is worth remarking that the pattern of immediate relocation, close to the central city and to the west of it nicely follows previous research suggesting that business owners tend to relocate in relatively up-market neighbourhoods and try not to move too far from the original locations (Greenhalgh, 2008; Sleutjes and Völker, 2012)³. Also in line with previous research on business relocation as well as common sense are the evident concern about rentals, and the finding that those businesses more likely to move back already own land in the central city (Nguyen et al., 2013; Sleutjes & Völker, 2012).

Although, as outlined in the introduction, there has been some previous research into the effects of disasters on business, no previous research to our knowledge has looked at the experiences and intentions of businesses that have been forced to relocate. Yet this research is important because the aggregate of the business decisions made by the businesses is of crucial importance for the community as a whole. For example, if virtually all the relocated businesses were unwilling to return to the former central city, then the central city would effectively be forced to relocate. The present findings, however, suggest that parts of the former central city will relocate and this process will lead to a less centralised city. Future research on the

³ The west of Christchurch generally has higher property values than the east, north or south. It is also likely that relatively more business owners live there.

development of Christchurch will lead to the confirmation or otherwise of this expectation.

If one gained all one's knowledge of disasters through the media one could get the impression that disasters like earthquakes occur as terrifying but brief events which can be quickly followed by rapid recovery, and, if recovery is not rapid, then this is essentially the fault of mismanagement or lack of political will. Those who work with or research disasters know this impression to be false, and that there are a variety of reasons why recovery is slow. To take just two reasons: earthquakes are not single events and ruined buildings must be removed before new ones are constructed on the old sites. The research presented in this paper presents yet another reason for delay. At least at a collective level, the business community is made uncertain about where they should locate for the medium to long term.

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The 2009 New Zealand West Coast ShakeOut: Improving earthquake preparedness in a region of high seismic risk.

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Abstract

New Zealand is geologically active and has significant seismic potential resulting from its position astride the Pacific-Australian plate boundary. The Alpine Fault transects 495 km of the South Island, west of the Southern Alps. It produces large (ca. M8) earthquakes, and is late in its average seismic cycle. Recent studies have shown that the West Coast would suffer extensive damage and isolation in the event of a large earthquake. Current levels of organizational, business, and community awareness and preparedness for dealing with the outcomes of a future major earthquake are considered less than optimum, even following the recent Canterbury earthquake sequence (2010-2011). The 2009 ShakeOut exercise was an opportunity for West Coast Civil Defence organizations to assess the status quo and develop resilience in order to improve physical and economic recovery outcomes. The exercise was based on the Californian ShakeOut event, and despite many differences in geography and population density, comparisons between the West Coast ShakeOut and California ShakeOut registration data show very similar participation profiles.

Keywords: earthquake hazard, ShakeOut, New Zealand, Alpine Fault, preparedness.

Introduction

The South Island of New Zealand lies across the Australian and Pacific tectonic plate boundary. It forms part of the “Ring of Fire”, the margins of the Pacific Plate that generate most of the world’s seismic activity each year. The Alpine Fault makes up part of the plate boundary west of the Southern Alps in the South Island (Figure 1).

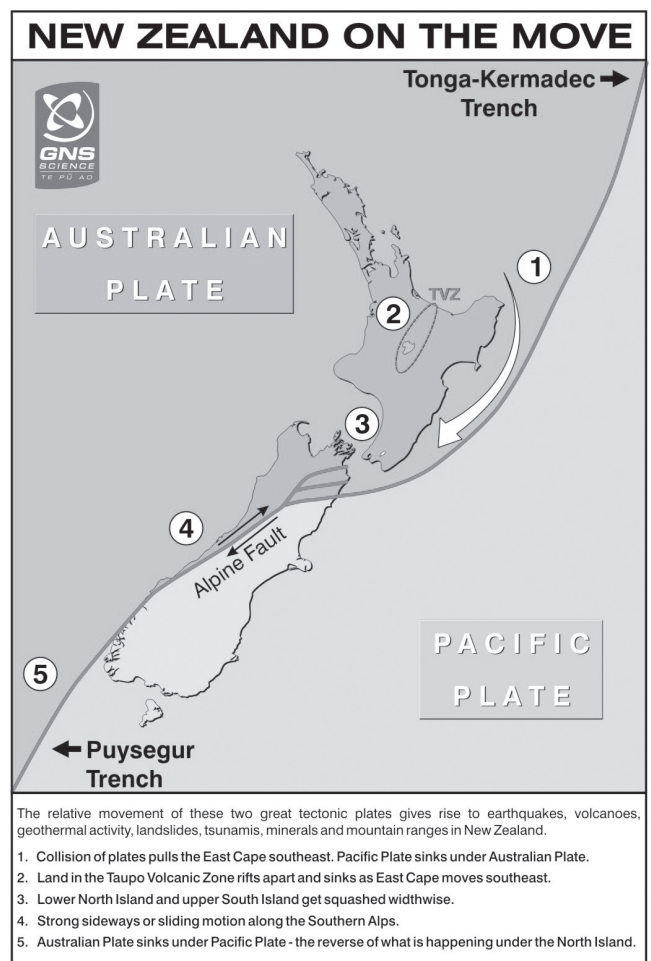
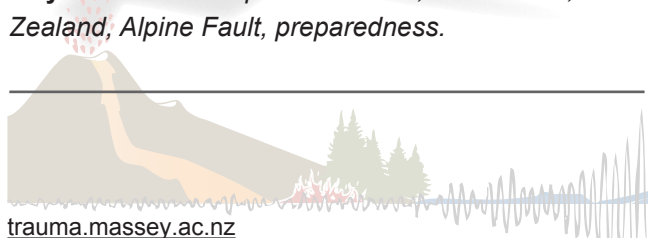


Figure 1. The Australian and Pacific tectonic plate boundary. Source: GNS Science

Most of New Zealand has a significant exposure to earthquake hazard, demonstrated by the recent Canterbury earthquake sequence (2010-2011). However, this study is concerned with the potential for rupture of the Alpine Fault. The Alpine Fault is a 495 km long mature dextral reverse fault that generates periodic earthquakes approximately every 300 years, with the



last known event taking place in 1717AD (Berryman, Cochran, Clark, Biasi, Langridge, & Villamor *et al.*, 2012, Figure 2).

The West Coast region is situated to the west of the Southern Alps, and is at risk from significant ground shaking generated by a future large Alpine Fault earthquake. The population of 31,000 is widely dispersed throughout the region, with Greymouth (pop. 9,500) Westport (pop. 3,800) and Hokitika (pop. 3,500) the most significant centres and district capitals. The region is isolated as a result of its geographical situation, and linked to the east coast by only three alpine passes, all of which cross the Alpine Fault.



Figure 2. Snow lying on the Southern Alps, New Zealand revealing the straight line of the Alpine Fault. Source: NASA

The three local authorities (Buller, Grey and Westland District Councils) and the West Coast Regional Council are required to assess the risk posed by natural hazards, and have produced Lifelines scenario reports that describe the main natural hazard threat to roads, rail, electricity supply and water reticulation (McCahon, Dewhurst, & Elms, 2006a). The reports prioritize the risk posed by various natural hazards, with the Alpine Fault considered the highest risk regional hazard (McCahon *et al.*, 2006a). The Canterbury earthquake sequence

(2010-2011) confirmed the serious consequences of major earthquakes for New Zealand, and focused the national consciousness on seismic risk. This paper, however, reports on community-based efforts to improve local resilience and preparedness *before* the Canterbury earthquakes.

The consequences of a major Alpine Fault earthquake to the West Coast region are expected to be significant. Anticipated strong, Mercalli shaking intensities throughout the region will cause substantial damage to buildings, infrastructure and communities (Robinson & Davies, 2013; McCahon, Dewhurst, & Elms, 2006b). Building codes to ensure the construction of earthquake resistant buildings help reduce loss of life and lessen physical injury figures, but the isolation of the West Coast region would present significant long-term issues for a population whose economy is based upon a functioning transport infrastructure. The main transport link from the West Coast to Christchurch, the South Island's largest city, is through Arthur's Pass, a route that travels adjacent to the Alpine Fault for 10 km and then crosses a series of deep landslide prone valleys. It is anticipated that Arthur's Pass could be closed for more than 6 months after an Alpine Fault earthquake (Orchiston, 2012; McCahon *et al.*, 2006a).

Christchurch is the largest city in the South Island, 200 km east of the Alpine Fault. Iseismal modeling of a future Alpine Fault event indicates that Christchurch could experience intensities (MMVI+) sufficient to cause non-structural damage to buildings due to the underlying alluvial soils on which the city is largely built. Emergency managers gained significant experience in responding to major earthquakes during the Canterbury earthquake sequence. However, damage to airport and roading infrastructure in Christchurch under this scenario could potentially lead to a delay in the arrival of disaster response teams and deployment of resources to the West Coast region.

The economic future of the West Coast region following an Alpine Fault earthquake will depend to a large extent upon damage to roading infrastructure, and the resilience of West Coast businesses. The local economy is mainly based on farming and tourism, and prolonged closure of the roading network would cause a severe regional economic downturn. It could take up to six months to repair Arthur's Pass and Haast Pass highways to a single lane (Orchiston, 2012; McCahon *et al.*, 2006b). A lack of road access would place a significant strain on West Coast businesses, both in

terms of delivery of supplies, and for the mobility of tourists. The popular tourist circuit of the West Coast from south or north would not be possible, and for tourism operators located in South Westland it may be many months until tourists return (Orchiston, 2012). Power outages and road damage would also impact the dairy industry, with farmers unable to milk their cows and transport milk products to factories.

This article reports on efforts by community leaders in the West Coast to build local preparedness and resilience for a future Alpine Fault earthquake by using the 2008 Californian ShakeOut exercise as a template. First, the Californian ShakeOut is described in terms of its nature and intent. The article then outlines the development of the West Coast ShakeOut and compares the two events in terms of participation data and community outcomes. Finally, official observations recorded in schools during the West Coast ShakeOut exercise are described.

The Californian ShakeOut

In November 2008 an earthquake exercise and drill event, entitled the Great Southern Californian ShakeOut was held in southern California (United States Geological Survey (USGS), 2013). The exercise and drill was developed by the USGS based on an earthquake scenario for the San Andreas Fault. The scenario took the form of a magnitude 7.8 earthquake, typical of an event that may strike southern California in future (Perry *et al.*, 2008). The aim of the drill was build community resilience, and to create a sense of urgency to motivate preparedness in individuals, communities and organisations (Jones & Benthien, 2011). It utilized “lessons learned from decades of social science” to help improve preparedness in areas of high seismic risk (Jones & Benthien, 2011). Several New Zealand representatives visited California during the exercise to observe the events that took place (Becker, 2009).

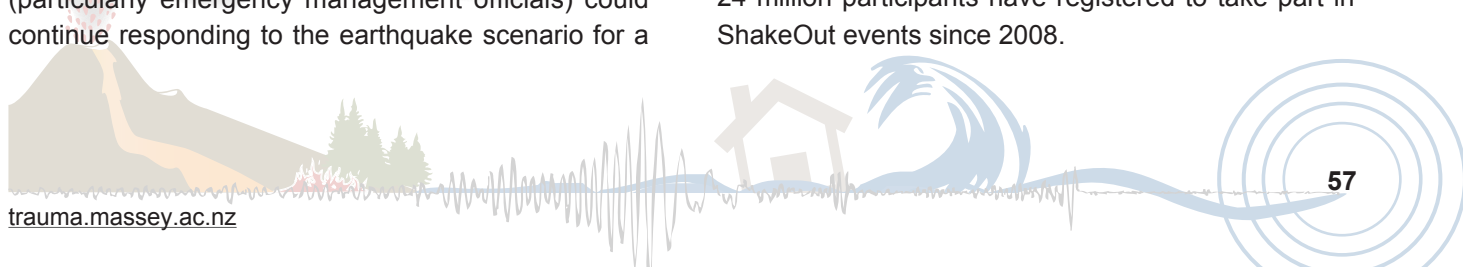
The Californian ShakeOut capitalized on the widespread use of the Internet by developing a website to act as a portal for public involvement. It provided a countdown to the ShakeOut drill and a large number of links and resources available for download. Participants were encouraged to get prepared in the build-up to the event by making emergency plans, and reminded to “drop, cover and hold” during the drill to protect themselves during shaking. Following the drill itself, participants (particularly emergency management officials) could continue responding to the earthquake scenario for a

period of time (e.g. evacuate buildings, check utilities, apply first aid, etc). This exercise continued for two days after the earthquake drill, and allowed responders to test their reaction to a large earthquake.

Communication to the public before the event was focussed on three key areas, designed to maximise levels of participation and generate as many positive outcomes as possible (Jones & Benthien, 2011). Earthquake scenarios and preparedness messages were presented to communities, repeatedly and consistently. Organisers provided visual images of people preparing for earthquakes to highlight the specific actions being undertaken. Organisers encouraged the “milling” principle whereby people talk about the drill and preparedness with the people they care about (e.g., families) and also with others who may have taken action (Becker, 2009).

In evaluating the effectiveness of the ShakeOut exercise, the event was seen to have generated a significant level of participation by Southern Californian communities. Organizations and local authorities participated in emergency management planning, the earthquake drill and other ShakeOut outreach activities. In total over 5.2 million people registered on the ShakeOut website to take part in the drill, with approximately 3.6 million of those school attendees or graduate students. Home Depot stores registered a 260% increase in sales of products used in earthquake preparedness during the weeks around the ShakeOut ((L. Jones, personal communication, 2009).

The Californian ShakeOut demonstrated that emergency exercises and drills have the potential to improve community awareness and involvement in preparedness and planning for future earthquakes. Traditionally, earthquake exercises have focused solely on planning from an emergency management perspective, but the ShakeOut effectively targeted the wider community, creating greater visibility of the problems and potential solutions in preparing for major earthquakes. Since 2008, the Californian ShakeOut participation has grown significantly, and other seismically active regions have developed their own ShakeOut events using the Californian template, including Japan, southern Italy, Puerto Rico and New Zealand. Globally more than 24 million participants have registered to take part in ShakeOut events since 2008.



The 2009 West Coast ShakeOut

Largely through the efforts of Chris Manuel, a local teacher and Royal Society teaching fellowship recipient, the Californian ShakeOut was brought to the West Coast of New Zealand in September 2009, the first event outside the United States. The event was constructed around the Ru Whenua Civil Defence exercise on September 18th 2009, which was based on an Alpine Fault earthquake scenario. As a result of collaboration with Mark Benthien, Director of the Southern California Earthquake Centre, a web-based public information portal for the West Coast ShakeOut was developed and hosted by the Californian ShakeOut administrators (ShakeOut, 2009). This gave the Californian team the opportunity to trial a global version of their product on a small scale compared with the design capability of the Californian ShakeOut. The budget for the West Coast ShakeOut was very limited, but allowed for some publicity material and visits to each significant settlement in the region to inform local stakeholders about the event. The design and implementation of the West Coast ShakeOut took five months.

The West Coast ShakeOut used the same procedures and formatting as the Californian event except for some significant simplifications because of limited timeframe and budget. For example, the number of registration categories was significantly reduced. The main categories were individuals and families, schools and education providers, organizations and businesses, and community groups. Sub-categories were used to identify types of schools, businesses and government agencies. Other simplifications included changing the weblinks to external resources on the website to reflect the New Zealand perspective and growing local information base, although some existing links were left if no equivalent source existed (e.g. disabled persons earthquake advice and business resiliency planning). No shaking propagation simulation maps were included because none existed for seismic scenarios based on the Alpine Fault at the time. No large rallies were planned because of the geographic isolation of the population. However, GNS Science hazard specialists Mauri McSaveney and Rob Langridge spoke at each of the three district centres about the nature of the Alpine Fault and the potential consequences of its rupture.

The West Coast ShakeOut exercise used a promotional video produced as an "Education for Enterprise" project by local Year 12 high school students as part of their media studies course. The script was an adapted

version of the 2008 ShakeOut video, to maintain the character of the message. Information sources focused on explaining the nature of the risk in an accessible but scientific manner and included a description of the likely consequences for the region based upon previous events. The provision of information to participants was via a series of e-mails, using language that was generally less formal than the Californian material to reflect cultural differences and the smaller audience for the event.

The West Coast ShakeOut was promoted throughout the region, principally using schools as a conduit to the communities, but also targeting supermarkets and retailers to attract the widest audience. Information brochures were produced, again as an "Education for Enterprise" school project using a local education provider to produce the design from a predetermined script. Ten thousand brochures were printed, and distributed mainly through schools and supermarkets and also through health promoters and libraries. The brochures included a significant description of the risk profile and consequences so those without Internet access could still be informed. Significant media attention was encouraged by sending regular press releases. Local newspapers covered the stories thoroughly, and the ShakeOut exercise was reported in many other newspapers throughout the country. Radio coverage by the two main West Coast stations, and one local Hokitika station was an important aspect of the exercise. Both played the drill broadcast on the day and one followed the story with interest, interviewing the organizer live on three occasions over a period of a month.

The Californian ShakeOut was reported by Green & Petal (2010) to have had positive outcomes on improved school disaster planning. The event was found to improve dialogue on earthquake preparedness and offer students an opportunity to "rehearse frightening events in a less threatening environment." (Green & Petal, 2010, p.3). Westland High, Paroa and West South Schools used ShakeOut to reinforce key earthquake safety and preparedness messages by either developing a series of earthquake lessons preceding the ShakeOut event, or using ShakeOut to raise staff and student awareness. Involving schoolchildren in disaster education can prepare children both physically and psychologically for future disaster events (Ronan and Johnston, 2005). In addition, children act as a conduit to passing on the preparedness message to their families, and are a

valuable means of disseminating key preparedness messages into the community (Green & Petal, 2010).

The West Coast ShakeOut 2009 exercise was run concurrently with Operation Ru Whenua (West Coast CDEM exercise), from 6am till midnight on 18th September. Ru Whenua involved both volunteers and paid council staff operating in 6-hour shifts in the Westport Emergency Operations Centre (EOC). The scenario included setting up welfare centres, and in Greymouth approximately 50 people including Civil Defence and Emergency Management (CDEM) representatives, Red Cross, Child, Youth and Family (CYF), Victim Support, SPCA, Work and Income New Zealand (WINZ), Search and Rescue, and local residents took part in the exercise. School children and local residents presented with a range of “injuries” and disaster related needs (e.g. food, clothing, shelter) and new arrivals were registered and assessed as if in an actual event.

Emergency managers were unaware of the scripted scenario and were fed information minute by minute throughout the exercise. The scenario was designed to identify gaps and needs in current planning and highlighted the fact that issues or a lack of resources in one area could create problems in other areas. For example, the EOC compiled incoming disaster information using computers rather than traditional paper-based systems, which was found to be much more time-efficient. However, because of the increased power usage during the exercise the EOC generator required fuel supplies additional to those available in the town, demonstrating the need for careful planning of resources and storage facilities specifically dedicated to the EOC.

Comparison of ShakeOut participation rates

The implementation of the West Coast ShakeOut exercise was found to be successful, with more than 1

in 4 people in the West Coast region taking part (27.5% of the 2006 census population). Table 1 illustrates the participation figures for the region. Some registrations also came from neighbouring districts interested in being part of the process. Internet availability may have been a factor in limiting the potential success of ShakeOut with only 63% of New Zealand households reportedly having access to the Internet and 33% having broadband access in December 2006 (Statistics New Zealand, 2006).

In evaluating of the 2009 Californian ShakeOut three counties in California were chosen for comparison of participation data, shown in Table 2 alongside data for the West Coast event. The West Coast ShakeOut attracted very similar participation rates, both as a proportion of the population and as a distribution between the main registration categories. The similarity of participant distribution between the West Coast and California reflects the emphasis placed upon targeting schools and other education providers in the first instance. Schools represent not only a means of attracting large numbers of participants for a minimal input of resources, but also act as a conduit to both the wider community. The relatively poor involvement of government agencies in the West Coast region may well reflect the reduced presence of these agencies in the region and also fewer layers of governance in New Zealand compared to California (State and Federal Governance). The higher percentage of individuals, families and businesses in the West Coast ShakeOut is partially a reflection of the relatively small numbers in these categories, but may also reflect the ability of the local promoter to access the communities on a more personal level given the small population. Each district on the West Coast has a business forum that allows ready communication with small businesses without the need to make personal visits.

Table 1
The distribution of ShakeOut participants by main registration categories.

District	Participants	Individuals and families	Education	Business	Govt agency
Buller	1895	17	1739	51	80
Grey	3761	206	3124	126	166
Westland	1916	144	1350	186	127
Other	758	30	706	14	8
Combined (% of total participants)	8330	397 (4.8%)	6919 (83.1%)	317 (4.5%)	381 (4.6%)

Table 2

Comparison of ShakeOut participation between the 2009 West Coast region and three partially randomly selected counties in the 2008 Californian ShakeOut, shown as percentage of the total population.

County/Region	Total participants	Individuals and families	Education	Business	Govt. agency
San Diego	580,243 (19.3%)	717 (0.12%)	492,734 (84.9%)	11,980 (2.1%)	64,575 (11.1%)
Los Angeles	2,621,892 (26.6%)	1,611 (0.44%)	2,274,434 (86.7%)	80,258 (3.1%)	134,377 (5.1%)
Sacramento	112,005 (9.2%)	131 (0.12%)	98,161 (87.6%)	503 (0.4%)	12,080 (10.8%)
West Coast	8,330 (27.5%)	397 (4.8%)	6,919 (83.1%)	377 (4.5%)	381 (4.6%)

Review and evaluation of the West Coast ShakeOut

The West Coast ShakeOut was the largest ever earthquake drill in New Zealand at the time and most schools on the West Coast participated in the exercise. The process was subject to an internal review, presented to the communications executive group of the supporting district and regional councils, and forwarded to the Ministry of Civil Defence and Emergency Management (MCDEM) for consideration in any future events of this type in New Zealand. In addition, the organizer requested the support of an external review team, who followed the process and visited the region on the day of the exercise. The external review team formed part of the authorship for this paper. Thus, while attempts were made to review the process of developing and implementing the ShakeOut exercise, no evaluation in terms of measuring the effectiveness and lasting benefit of the event has been conducted.

The goal of the external review panel in visiting Westland High and Paroa and Westport South Primary Schools was to observe staff and children undertaking an emergency response drill, and to join discussions of earthquake related issues. The observers also visited the Greymouth Welfare Centre and Westport Emergency Operation Centre where CDEM personnel were coordinating the earthquake response during Operation Ru Whenua.

Observations of school student understanding, preparedness and awareness

At the ShakeOut time of 10.10am observers were in three classrooms at Westland High School, Hokitika (Year 7 – 15). The students were aware that the earthquake simulation was going to happen. “Drop, cover, hold” was written on blackboards, and all students and staff understood that they must get under the desks

and hold on during the simulation (Coomer, Johnston, Wilson, Becker, Orchiston, & Page, 2009).

After the exercise observers joined a Year 12 class for a discussion of earthquake issues, and to discuss impacts or implications of a possible Alpine Fault rupture. Students showed some interest in the geomorphic response and were generally knowledgeable about physical earthquake processes and the likelihood that West Coast communities would be isolated from each other and from the rest of the South Island. They asked about the possible size and timing of the Alpine Fault rupture, about the extent of building damage, whether a tsunami could happen, and where outside help would come from. Students living out of town were concerned for their families and the possibility of being isolated from their homes for many days. They wondered what would happen to those trapped in Hokitika and if they would have to stay at school rather than make their own way home to be with their families. Communication with their families, friends, and with the outside world, was a major issue, particularly regarding access to cell phones. Students wanted to know about shelter, food and water supplies both at school and home. Only a few families had emergency supplies at home. Some students were concerned about post-event recovery and whether they would retain their part time jobs. Most students were realistic about an Alpine Fault earthquake happening, however only a minority thought it would take place during their lifetime.

Students at both Paroa and West South Primary Schools (Year 1-6) had been taught the “Drop, cover, hold” procedure, and learnt about safety at school and at home in preparation for ShakeOut. Around one third of children said they had an emergency kit at home with water, food, toilet paper/buckets and a first aid kit. Some children had experienced earthquakes and

knew what to expect, while some younger children were clearly anxious about what to do during a big shake, and questioned the safety of the school buildings. They discussed the local sandy soils and liquefaction and whether the school buildings would sink during an earthquake. One child spoke about the risk of fire and some mentioned the likelihood of tsunami and whether the earthquake would kill people “like on TV”.

Some of the children asked when the next Alpine Fault rupture is likely to occur and if the lower South Island earthquake (Resolution Island, M7.8 July 2009) was ‘the big one’ we were worried about. There was concern about isolation following road damage but all seemed confident that they would be looked after whether at school or at home. The children talked about the earthquake information in the school newsletter, with some developing earthquake and fire escape plans at home as a consequence of the ShakeOut event.

Conclusions

The ShakeOut exercise and Operation Ru Whenua generated substantial community interest and involved large numbers of local participants. The publicity generated by the event raised awareness of future Alpine Fault earthquakes, the likelihood of such events taking place, and the need to prepare for such an event. For school children, the exercise provided an opportunity to ask questions and build their understanding of how a future earthquake will impact on themselves, their families and their communities.

Since 2008, the Californian ShakeOut has been applied in other seismic regions throughout the world, including New Zealand in 2012. The West Coast ShakeOut was the first outside California, and generated similar participation rates and registration profiles. Beyond earthquakes, the concept could be developed to include other hazard types such as tsunami, volcanic eruption, flooding and landslides. Initial costs of setting up such a system may be offset by the ongoing and multi-hazard applicability that it could deliver as a means of promoting community resilience. Events like this act to reduce post-disaster losses and improve the culture of earthquake preparedness in areas of high seismic risk.

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