

ABSTRACT

Towards tsunami-safer schools in the Wellington region of New Zealand: evaluating drills and awareness programs

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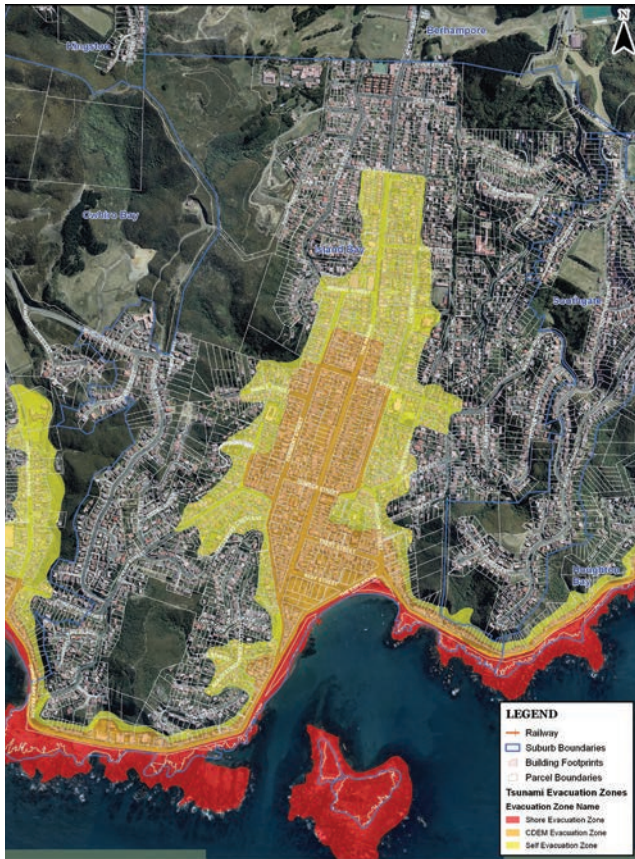
Introduction

The Wellington region of New Zealand (NZ) is susceptible to both earthquakes and tsunami, with tsunami being one of the greatest threats to life. For example, the Hikurangi subduction margin north-east of the North Island of NZ is capable of generating earthquakes in excess of Mw 9.0 (Power *et al.* 2016, Wallace *et al.* 2009). If a major rupture were to occur at the southern end of the margin it could generate tsunami similar to those observed in Japan in the Mw 9.0 Tohoku event in March 2011 (Power 2013), reaching Wellington within tens of minutes (Fraser *et al.* 2014). In addition, the many fault lines that cross Cook Strait, adjacent to Wellington, also pose a potential tsunami threat. Tsunami evacuation maps produced by the Crown Research Institute GNS Science and Wellington Region Emergency Management Office (WREMO) (Figure 1) have enabled the identification of 46 schools within the Wellington region that are located in potential tsunami inundation zones.

Under NZ health and safety legislation (New Zealand Government 2015) schools are required to develop plans and procedures for all foreseeable emergencies including earthquakes and other natural events. In addition, it is necessary for schools to provide staff and students with the education and training necessary to implement the emergency plans and have the knowledge and skills to assist in their own safety. Plans and skills such as moving students to an evacuation zone, and the efficacy of 'drop, cover, hold' drills have been evaluated in two single school studies (Johnston *et al.* 2011, Tipler *et al.* 2016), but there are no known systematic studies that have evaluated plans and skills in NZ schools. Existing research in NZ schools (e.g. Coomer *et al.* 2008, Tipler *et al.* 2015) has found differences across schools in the types of emergency preparedness activities undertaken (e.g. planning for students and staff with disabilities, engaging with emergency management professionals, developing reunification plans). Such differences in preparedness are also common throughout the international literature (e.g. Graham *et al.* 2006, Kano *et al.* 2007).

For example, research conducted after the 2011 Japanese earthquake and tsunami found that regional differences in school preparedness levels directly influenced child mortality rates (Nakahara & Ichikawa 2013). Only half of schools impacted by the tsunami had developed evacuation plans, with plan-

The Wellington region of New Zealand is exposed to a wide range of potentially damaging impacts from various hazard events (e.g. earthquakes, tsunami, storms and floods). Wellington is situated in one of the most active seismic regions in New Zealand, creating a significant earthquake and tsunami risk. Given the variety of hazards Wellington faces, consideration needs to be given to how the risks are managed within schools. The purpose of the present study was to investigate tsunami preparedness activities undertaken in schools in the region in association with the New Zealand 'ShakeOut' exercise. In November 2015, a survey was carried out in 17 schools from several Wellington tsunami evacuation zones. Results revealed that the sample schools had undertaken at least some tsunami preparedness activities, and some schools reported formal planning, and practice-drills. Importantly however, not all at-risk schools are fully prepared for a tsunami; one of the greatest life-safety risks for students attending school within the Wellington tsunami inundation zones. It is expected that results of the present study will help inform school-based tsunami preparedness guidelines for New Zealand schools.



Source: Wellington Region Emergency Management Office, www.getprepared.org.nz/tsunami-zone-maps.

Figure 1: Tsunami evacuation zones for Island Bay.

Wellington region tsunami evacuation zones are defined using the methodology developed by GNS Science (Leonard *et al.* 2008).

content varying across schools. Nakahara and Ichikawa surmised from anecdotal evidence that although it was standard practice for schools to return students to their parents immediately after the disaster, schools that evacuated to safe sites saved students. This highlights the importance of planning, preparedness, exercising, and reviewing best practice for tsunami in the school context, and for the wider community.

Given the importance of whole school tsunami planning, and participating in hazard education activities, the present study aimed to run a pilot to explore tsunami preparedness in schools within the Wellington tsunami inundation zone.

Background to the present study

On 15 October 2015, NZ conducted its second nationwide 'ShakeOut' earthquake drill, with participants practising 'drop, cover, hold'. The ShakeOut drill originated in California (Jones *et al.* 2008) and promoted appropriate response actions during an earthquake (e.g. 'drop, cover, hold'), as well as promoting preparedness and planning for earthquakes prior to an event. More than 1.36 million people throughout NZ participated in the 2015 ShakeOut exercise (Becker *et al.*

2016). In the Wellington region, 214 schools, representing 85,105 participants (students, staff and visitors), registered their participation in the drill on the ShakeOut website. For schools in tsunami inundation zones, the ShakeOut exercise presented an opportunity not only for the earthquake 'drop, cover, hold' drill, but also for undertaking tsunami planning and preparedness, and for practising tsunami response actions.

Method

The Wellington tsunami inundation zone comprises coastal areas around Kapiti, Porirua, Wellington City, and the Hutt Valley regions, where there is a total of 46 primary and secondary schools within the inundation zone. Researchers were interested to know whether the ShakeOut earthquake exercise had acted as a prompt to undertake tsunami planning and preparedness activities. How prepared were these schools for tsunami events in terms of, for example, knowledge of and practice for evacuating to higher ground, and procedures for family reunification?

A questionnaire surveying earthquake and tsunami preparedness was developed by the Joint Centre for Disaster Research, Massey University and GNS Science, and peer-reviewed by the WREMO. The questionnaire was divided into two main parts. Part 1 focused on school engagement in tsunami activities in the 2015 ShakeOut campaign, including questions concerning recognition of the tsunami zone, evacuation practice, classroom teaching, resources for teachers, and planning at home. Part 2 focused on general tsunami preparedness activities, including response plans, stakeholder involvement, drill practices, family reunification plans, classroom teaching and resources, and challenges to preparation. The nine tsunami-related preparedness activities were developed through a review of school preparedness literature and in consultation with emergency management practitioners working with schools. Ethics approval was granted by the Massey University Human Ethics Committee in November 2015.

Six weeks after the ShakeOut exercise, the authors visited 42 of the 46 schools in the Wellington tsunami inundation zone to hand out questionnaires. A reply-paid envelope was provided for ease of return. Distributing the surveys in person provided an opportunity to increase hazard awareness dialogue, to thank the school in advance for their participation at a busy time of the year, and to discuss any concerns in completing the survey the school may have raised. Schools were asked to return their questionnaire by the end of the school year, which was three weeks after distribution of the questionnaires. Seventeen schools consented to participate in the study (see Table 1), and questionnaires were completed by either the principal or a senior staff member. The study was conducted at the end of the school year, a time when schools are typically engaged in many end-of-year activities. It is likely that time and effort considerations at such a busy time of year impacted on the number of participating schools.



Tsunami steps at Seatoun School, Wellington (seen in the background) were funded by a community fund-raising event (shown in the photo) on 13 March 2016 and from local council. Image: David Johnston

Although comprising a sample of only 17 schools, the present exploratory study serves as a starting point for understanding some aspects of school preparedness for tsunami, and informs some future research requirements.

Table 1: Participating schools by type.

School Type	n
Full primary (Y 1-8)	10
Contributing primary (Y 1-6)	5
Composite (Y 1-13)	1
Secondary (Y 9-13)	1

Results

Results of the survey include general tsunami preparedness actions undertaken by schools and also tsunami activities associated with the 2015 ShakeOut drill. Fifteen of the seventeen schools were primary schools (and one school was a composite of Years 1-13), so results are almost exclusively relevant to primary school students (i.e. Years 1-8).

Knowledge of own environment

Sixteen schools (94 per cent) reported being aware their school was located in the tsunami inundation zone.

Tsunami-related preparedness activities

All schools reported undertaking some of the nine tsunami preparedness activities (see Table 2), with 11 schools reporting they had undertaken all nine preparedness activities. Sixteen of the 17 schools had developed a tsunami response plan. The school without a tsunami response plan did not know the school was in a tsunami inundation zone. Sixteen schools had also developed communication plans from the evacuation site, had get-away kits, had developed family reunification procedures from the evacuation site, and had informed families of the reunification procedures. Less common was the development of a map showing the school's evacuation route, and least common was evaluation of the school's tsunami preparedness activities.

Tsunami evacuation drills

Five schools (29 per cent) conducted a tsunami evacuation as part of their ShakeOut drill. The main obstacles identified enroute to higher ground were congestion during evacuation due to multiple schools using the same routes, and potential obstacles on the evacuation route (e.g. power lines down and students having to cross roads). Four schools (24 per cent) reported having never conducted a tsunami drill.

Evaluation of tsunami evacuation drills

All 17 schools evaluated their performance in the ShakeOut drill. While 15 schools (88 per cent) included students in the evaluation of ShakeOut, only four of the schools (24 per cent) regularly involved students in the evaluation of their tsunami drills. Parents and caregivers were involved in evaluating tsunami preparedness activities in less than 20 per cent of schools. More than half (59 per cent) of school Boards of Trustees (BoTs) (i.e. individual school governance bodies) were involved in the ongoing evaluation of tsunami preparedness activities in their school. The WREMO and emergency services were involved in evaluations in only two schools. Although the questionnaire asked who had been involved in evaluations, the questionnaire did not gather data on the nature of the evaluations.

Classroom teaching about tsunami

During the ShakeOut exercise, 16 schools (94 per cent) reported teaching and learning about earthquakes. Although it could be expected that tsunami would be discussed in relation to earthquakes, less than half of the schools (41 per cent) reported doing this.

Of all aspects of tsunami teaching, the most widely taught was the importance of getting to higher ground, reported by ten schools (59 per cent). About one quarter of schools (24 per cent) provided staff with information for preparing for a tsunami at home. However, just under half of schools (47 per cent) taught students how to prepare at home for a tsunami.

Table 2: Tsunami-related preparedness activities undertaken by schools.

Tsunami-related preparedness activities	per cent	n
Created an earthquake response plan	100	17
Developed procedures for how staff and students with special needs or disabilities will get to tsunami evacuation point	100	17
Created a tsunami response plan	94	16
Developed procedures for communicating from the tsunami evacuation point (e.g., with families, emergency services, WREMO)	94	16
Prepared 'get-away' kit to take during an evacuation (e.g., first aid kit, contact lists for students, important documents, portable radio, student's medicines)	94	16
Developed procedures for family reunification at the tsunami evacuation point	94	16
Informed parents/caregivers about the family reunification procedures	94	16
Developed a map showing school evacuation routes to tsunami evacuation point	82	14
Evaluated tsunami preparedness activities	71	12

Classroom resources for tsunami education

Regardless of whether schools were teaching about earthquakes or tsunami, the ShakeOut website was the most widely used resource for preparedness education (12 schools, 71 per cent). 'What's the Plan, Stan?' (WTPS), the educational resource provided to all primary and intermediate schools by the Ministry of Civil Defence and Emergency Management, was next, being used by about half of schools (53 per cent), though it is not known how extensively the resource was used. Another resource compiled by emergency management practitioners, the 'It's Easy' Planning Guide from the WREMO, was used by about a quarter of schools (24 per cent).

Stakeholder involvement in tsunami-related planning and drills

Schools reported involving a range of stakeholders in their tsunami preparedness. Stakeholders most commonly involved in developing tsunami response plans were school staff (15 schools: 88 per cent), BoTs (12: 71 per cent), and emergency management personnel (seven: 41 per cent). Only six schools (35 per cent) included parents/caregivers and students. Three schools (18 per cent) involved emergency services, and only one school consulted local *iwi* (i.e. indigenous Māori residents

descended from a common ancestor and associated with a distinct territory) when developing response plans.

Drills were predominantly conducted with staff and students (75 per cent), and to a lesser degree with parents and caregivers present (35 per cent). External stakeholders (e.g. emergency management personnel and emergency services) were generally not involved as regular observers, helpers or participants.

Family reunification drills

Only seven schools (41 per cent) conducted annual family reunification drills from the tsunami evacuation point, with one additional school reporting having practised reunification drills with families 'every few years'. Neither the secondary school nor the composite school in the study, both located in the Wellington CBD (Thorndon), reported having ever having conducted a family reunification drill from their tsunami evacuation point.

Barriers or challenges to tsunami preparedness activities

The greatest barrier to schools' tsunami-related preparedness activities (see Table 3) was limited time in the curriculum to provide students with education about tsunami (59 per cent). In addition, relatively common challenges faced by schools in their tsunami preparedness efforts were the availability of teacher-time for preparing tsunami education programs (29 per cent) and a lack of resources to help students and staff prepare at home (29 per cent).

Table 3: Barriers or challenges to tsunami preparedness activities in schools.

Barriers and Challenges	per cent	n
Limited curriculum time available to teach students about tsunami	59	10
Limited time available to prepare the school for a tsunami	29	5
Limited resources about how to prepare for tsunami at home	29	5
Limited resources for teaching students about tsunami	29	5
Limited knowledge on how to prepare the school for a tsunami	12	2
Limited resources on how to prepare the school for a tsunami	12	2
Limited staff knowledge to teach students about tsunami	12	2

Discussion

Knowledge of own environment

The majority of schools were able to recognise that their location placed them at risk from tsunami and had undertaken preparedness activities in response to that risk. However, the present study suggests the likelihood that many New Zealanders, including staff and students of at-risk schools, are unaware of how to recognise potential tsunami inundation zones, and are not prepared to respond appropriately in a tsunami event. While the present study comprised only 17 schools in the Wellington region, these findings are supported by Johnson and colleagues (2014a) and Tipler and colleagues (2016) who also found that education programs had not succeeded in fully preparing schools for a tsunami event. Findings of the present study have implications for wider NZ. Tsunami impacts pose a greater life-safety threat to the schools located in the Wellington tsunami inundation zone represented in the present study than the widely acknowledged earthquake risk, and yet some schools are less prepared for a tsunami than for a significant earthquake.

Tsunami-related preparedness activities

All schools in the present study undertook a range of tsunami preparedness activities. However it is unclear how extensive schools' preparation and planning efforts were. Previous research conducted in schools in NZ (Johnson *et al.* 2014b, Tipler *et al.* 2015) and internationally (e.g. Graham *et al.* 2006, Johnson *et al.* 2014b, Kano *et al.* 2007) has found that while most schools undertake basic emergency preparedness activities (plans and drills), the learning outcomes for the students and staff, and the depth of emergency preparedness activities remains unclear. For example, an impact evaluation would be needed to understand if students and staff understood the causes of tsunami and knew how to protect themselves whether at school or other less familiar locations.

New Zealand students need this type of education regardless of where they live and go to school. In the present study, there was little emergency planning that involved parents and caregivers. These findings suggest a potential weakness in the national requirement to have a school plan for which there are no guidelines on stakeholder involvement and on how the plan should be formulated or evaluated.

Tsunami evacuation drills

Three-quarters of schools in the tsunami zone practised a tsunami drill at least once a year. One school found that high numbers of students (700+) and the distance to an evacuation zone posed a barrier to their tsunami evacuation efforts. For such large schools, comprehensive plans are required that are tailored to the needs of the particular school and its environs to

ensure plans and drills are well developed, workable, and practised.

Practising a tsunami drill is also an important educational opportunity for students and staff to understand why they would be asked to move to high ground in an emergency event. There may be little time in an emergency event for explanation and execution. An evaluation of a similar ShakeOut tsunami drill in two coastal schools in Washington State, USA found that about a quarter of middle and high school students in both schools were unaware they were practising a response for a tsunami (Johnson *et al.* 2014a). Schools should be concerned that without practice and education, their students and staff may be ignorant of the life-saving measures necessary for both individual and group safety.

Evaluation of tsunami evacuation drills

Evaluation of emergency drills provides opportunities to assess participant performance and also a chance to review the schools existing emergency plans and procedures. The Tipler and co-authors (2016) examination of school participation in the 2012 ShakeOut exercise identified 18 lessons learned by schools including the importance of establishing building evacuation criteria; considering potential hazards along evacuation routes. And using drills as opportunities for promoting and improving school preparedness. Behavioural activities often reveal practical aspects of learning that classroom teaching and learning can sometimes miss. For example, the value of drills was demonstrated for some schools that identified the safety route they needed to make special preparations for in future (e.g. teaching students how to behave around live power lines that may have collapsed onto a road they had to cross to higher ground). While the majority of schools (88 per cent) involved students in the evaluation of the ShakeOut earthquake drill, numbers were much lower (23 per cent) for the school's tsunami drills conducted at other times. Planning and evaluating drills can be valuable learning exercises for students if opportunities are provided for them to take part in these activities. Frequent moderate earthquakes in the region and, to date, no tsunami in the living memories of students and staff, could account for the difference between attention given to the evaluation of earthquake drills, compared with tsunami drills.

Evaluation is critical to ongoing improvement in preparedness. Evaluation of emergency drills provides opportunities to assess participant's performance and also a chance to review the schools' existing emergency plans and procedures.

Classroom teaching about tsunami

Less than half of schools (41 per cent) reported teaching students about tsunami as part of the ShakeOut exercise, which is in line with findings from the Coomer and co-authors (2008) survey of 84 Wellington schools (43 per cent). Such teaching is critical to NZ students,

and it is important that all students have access to tsunami education and response actions (e.g. rapid evacuation to higher ground) wherever they live, and in particular where schools are situated in tsunami zones. In NZ, annual fire drills are the only safety drills required by law. Otherwise schools design their own curriculum based on the National School Curriculum (Ministry of Education 2016). The principal function of the National School Curriculum is to 'set the direction for student learning and to provide guidance for schools as they design and review their curriculum' (Ministry of Education 2016). That is, students are engaged in self-care programs at school and learn how to keep themselves safe. But the nature of these programs is determined by the school and there is no specific curriculum requirement for learning and practising tsunami safety. Through public education and research dissemination, emergency management practitioners and researchers can recommend that schools include hazards education programs. Schools can be invited to take part in hazards drills and education programs provided from outside the school. Effective pedagogy would support the integration of hazards education with other areas of the curriculum to motivate and consolidate learning. However, schools have the ultimate decision and control of their curricula.

Encouraging students to prepare at home for earthquakes and tsunami was reported by just under half of schools (47 per cent). A previous survey of preparedness in 355 NZ schools (Tipler *et al.* 2015) found much higher rates of students and staff being encouraged to prepare for emergencies at home (72 per cent). It is possible that schools in the present study expected students would transfer their learning from school to other environments. However, studies reveal that:

1. students do not always understand the rationale for being taught particular safety behaviours
2. student learning is not necessarily applied in new situations or environments (e.g. Johnson *et al.* 2014a, Tipler *et al.* 2016).

It is important that students understand the rationale for tsunami safety and other safety behaviours they are taught so they can make sense of their learning and develop safety initiatives in other areas of their lives. It is likely that if follow-up tsunami activities from school were taken home to share with others, these activities could reinforce learning and be motivating for the whole family, potentially increasing protection for the wider community from a tsunami at any time.

Classroom resources for tsunami education

Linking classroom resources to the national ShakeOut exercise provided relevant and easily-accessible material for schools. This is an important point, as time for teachers to prepare, and curriculum space for earthquake and tsunami education are both important factors in how much time and effort teachers can give to tsunami education at school. The wide media coverage of ShakeOut assisted schools to focus their efforts in being part of a national exercise, and promoted the use

of up-to-date and readily-available resources to support the exercise itself and associated teaching. Teachers understand that students generally enjoy activities where they are finding out something for themselves, and there is a vast electronic source of material, including some instructional games, that students could now be encouraged to use.

Research on NZ schools' use of WTPS found that a school-wide curriculum topic on disasters, driven by school leadership, was one of the strongest facilitating factors of disaster education in schools (Johnson *et al.* 2014b).

Stakeholder involvement in tsunami-related planning and drills

School staff were the highest group involved in planning tsunami preparedness activities, followed by BoTs, and emergency management personnel. Parents and students were not widely consulted, and only one school consulted local *iwi* when developing response plans. Planning could be more inclusive, and give greater attention to detail if perspectives of all stakeholders were considered. The Canterbury, NZ, earthquakes of 2010-2012 have taught us lessons about the value of local *iwi* playing a significant role. For example, Phibbs and colleagues (2016) assert that disaster risk management should be inclusive of ethnic differences so that policy and planning at all levels integrates the cultural strengths of minority groups. It could be expected that the response in the tsunami zone of the present study could be strengthened if local *iwi* were included in participation.

Involving parents in planning, participating, and evaluation would be likely to encourage greater interest and support for students, as well as increasing resilience in the wider community. Likewise, it is important that BoTs are involved in evaluating tsunami preparedness activities, as BoTs have an invested interest and legal responsibility in keeping students safe at their schools. It is also important that school staff consult emergency management experts as well, to maximise hazards-understanding and safety protocols in schools.

Family reunification drills

In the present study, a minority of schools had ever conducted annual family reunification drills from their tsunami evacuation point. In a real-life emergency, the first priority for parents and caregivers would be to get to the school and be with their children. When parents and caregivers are not aware of the schools tsunami evacuation plans there is an increased likelihood they may put themselves at risk by going to the school rather than to the evacuation site (Johnson *et al.* 2014a). Another study conducted in the USA (American Academy of Pediatrics 2008) stated that when parents are unclear about the school's family reunification procedures they can aggravate the crisis and negatively influence the school's ability to respond. Family reunification drills and protocols are imperative, and it is critical that all schools in all parts of the country have

well-established procedures for children to be reunited with their parents and caregivers.

Barriers or challenges to tsunami preparedness activities

Schools have tight curricula, and teachers have demanding schedules. However, the schools involved in the present study were all located within a tsunami zone, and it is important that BoTs and teachers prioritise tsunami preparedness within their curriculum and teaching-preparation time. Teaching resources are available, and there is vast material available through reputable internet sources, as well as through materials such as WTPS provided by the Ministry of Civil Defence and Emergency Management and the WREMO.

Conclusion

Results from the present study reveal that participating schools in the Wellington tsunami inundation zone have undertaken at least some tsunami preparedness activities, and some schools reported planning and practising drills. However, not all at-risk schools are fully prepared for a tsunami in terms of evacuating to higher ground and family reunification. Preparation is critical, given that tsunami is one of the greatest life-safety risks for students attending school within the Wellington tsunami inundation zones.

While the ShakeOut drill provided a pivotal point around which some schools undertook tsunami-related activities, the safety of students could be increased in future if the ShakeOut drill were linked to tsunami planning and preparedness activities, taking additional account of companion research in earthquake and tsunami safety (Johnson *et al.* 2014a).

Limitations and future research

The present study was a pilot study, and although the aims did not include an evaluation of preparedness drills, it is recognised as a limitation of the study. To date, little work has been done to evaluate the effectiveness of drills, and this lack of evaluation is supported by Johnson and colleagues (2014a) in their Washington study of student learning earthquake response capacities. Johnson and colleagues' 2014 quantitative data revealed learning improvements overall for the sample of 495 students who completed questionnaires before and after practising earthquake drills. However, at an individual level, the study revealed that many students did not understand what to do to keep safe in unfamiliar environments, and did not understand the rationale for some of the safety behaviours they had been taught. Future research is necessary to develop and trial comprehensive evaluation tools for a pilot study investigating tsunami preparedness in schools. As a first step, future research could explore tsunami drill behaviour and learning in a small sample of schools, and

work with these schools to develop a practical and valid tsunami preparedness evaluation tool.

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Dr Victoria Johnson is an independent consultant based in San Francisco, CA. She is co-Chair of International Association of Emergency Managers' Caucus on Children and Disasters. Her research focuses on disaster education for children.

Dr Julia Becker is a disaster researcher at GNS Science, New Zealand, and specialises in understanding what makes communities resilient, disaster preparedness, land-use planning, emergency management, and warnings. She has worked on issues related to a variety of natural hazards including earthquakes, tsunami, flooding, adverse weather and volcanoes.

Professor Kevin Ronan is Foundation Professor in Psychology and Chair in Clinical Psychology, School of Health, Human and Social Sciences at CQUniversity Australia. He is also Chair of the Disaster Reference Group of the Australian Psychological Society. Kevin as a clinical psychologist who specialises in hazards and disasters, problems of youth and families (e.g., effects of disasters including trauma; conduct disorder; anxiety disorders; child maltreatment), schizophrenia, and program outcome evaluation.