Tsunami risk mitigation and the issue of public awareness

Bird and Dominey-Howes present research findings into public awareness of Tsunami risk and consider how the results validate the preparedness strategy of Emergency Management Australia

Abstract

Selected results from a pilot investigation into public awareness of tsunami risk in the Sydney region are presented. This is fundamentally necessary for developing appropriate risk mitigation and preparedness strategies. The questionnaire survey of members of the public and coastal council officer's indicates that little has been learned since the December 2004 Indian Ocean tsunami disaster. The findings show that the strategy of Emergency Management Australia for developing awareness and building capacity are both timely and appropriate.

Introduction and aim

In 2005, the Australian Federal Treasurer announced a comprehensive end-to-end Australian Tsunami Warning System (ATWS) would be developed and implemented by Geoscience Australia (GA), the Bureau of Meteorology (BoM) and Emergency Management Australia (EMA) (Geoscience Australia, 2005). GA and the BoM would co-ordinate the detection of tsunamigenic events, monitor tsunami as they approached Australia and undertake forecast assessments of probable tsunami impacts. These agencies would evaluate what type (if any) of information and/or warning messages should be issued. When required, the BoM would issue initial warning messages to State or Territory emergency service organisations and the media through the Bureau's regional offices. Messages would also be passed to EMA's National Emergency Management Coordination Centre (NEMCC) (Sullivan, 2006). Where required, the BoM Regional Offices would issue detailed warning messages to the SES and the public.

Emergency Management Australia (EMA) is working with State and Territory emergency management officers to effect tsunami preparedness through programmes of awareness raising and community capacity building including training, exercises and planning (Sullivan, 2006). EMA aims to engage the community by assisting them to learn to recognise the signs of approaching tsunami, thus increasing their inherent level of awareness and also tailor and focus awareness raising and capacity building in specific sectors and with particular community groups (Sullivan, 2006).

Bondi Beach, Australia vulnerable to the effect of Tsunami inundation?

Meaningful public response to evacuation orders is partly dependent on:

- the clarity and accuracy of those orders;
- the time available prior to tsunami arrival;
- the efficiency of the co-ordinating emergency services etc, and significantly,
- on the public's understanding and perception of [tsunami] hazard and risk (Hurnen and McClure, 1997; Johnston and Benton, 1998; Dominey-Howes and Minos-Minopoulos, 2004; Johnston *et al.*, 2005).

Therefore, having a clear understanding of the public's perception of tsunami is a vital element in developing risk assessment and risk management procedures (Hurnen and McClure, 1997; Johnston and Benton, 1998; Gough and Hooper, 2003). The aim of this study was to use a questionnaire survey to gain an insight into the public's awareness levels of a tsunami hazard in Sydney – research that has never been done in Australia. It is hoped that the findings will be useful to EMA, State Emergency Services and others in developing risk mitigation strategies and may be used to determine whether the preparedness strategy of EMA as detailed by Sullivan (2006) is appropriate.

In order to provide context for this research, the authors briefly review the risk Sydney is exposed to in terms of those regions where tsunami may originate, noting frequency-return periods. The research method is outlined and followed by a presentation of selected results and a discussion of their significance in regard to tsunami risk mitigation and the EMA preparedness strategy.

Is Sydney at risk from tsunami flooding and if so, from where?

Approximately 330,000 people in New South Wales live within 1km of the ocean or a coastal river and at an elevation of no more than +10 metres above sea level (Molino Stewart, 2005). These people, their homes, businesses and all infrastructure are vulnerable to the effects of tsunami inundation. Research has been published that suggests the New South Wales coast (including Sydney) has been repeatedly impacted by tsunami (Bryant *et al.*, 1992a and b; Bryant, 2001; Bryant and Young, 1996; Bryant and Nott, 2001). The sources of these (mostly prehistoric) tsunami are unknown, however, work by Gusiakov (2005) is useful in defining regions that may generate tsunami damaging to Australia. Gusiakov examined the total number of earthquakes above a given threshold within the Pacific from 1901 to 2000. He compared these events with those that generated a tsunami. This allowed him to calculate a Tsunami Efficiency ratio (TE %) for each tsunamigenic region. The tsunamigenic regions are shown in Figure 1.

The TE ratios are shown in Table 1.

South America is the region most efficient at generating tsunami (followed by Indonesia and the Philippines). New Zealand/Tonga region, and the Kuril/Kamchatka region are least efficient at generating tsunami. However, these data do not adequately reflect the *total tsunami risk* because they do not include other tsunamigenic types/events such as volcano tsunami (Dominey-Howes and Keating, 2005). Table 2 presents return periods of tsunami for selected regions around the Pacific.

From Figure 1 and Tables 1 and 2, it is apparent that Sydney is at risk from tsunami generated in many of these regions – particularly those across the Pacific. Indeed, the 1960 Chile tsunami and the 1964 Alaska tsunami both affected the NSW coast including Sydney.

Figure 1: Boundaries of the main tsunamigenic regions of the Pacific (shown in black). The epicentres of tsunamigenic earthquakes that occurred in the Pacific between 1981 and 1997 are shown. The size of the circle indicates the magnitude of the earthquake and colour variation denotes intensity of the tsunami. The regions are: Alaska – Aleutians (A-A), Central America (CAM), South America (SAM), New Zealand-Tonga (NZT), New Guinea-Solomon Islands (NGS), Indonesia (IND), Philippines (PHI), Japan (JAP), Kuril-Kamchatka (K-K) and Hawai'i (HAW) (after Gusiakov, 2005).

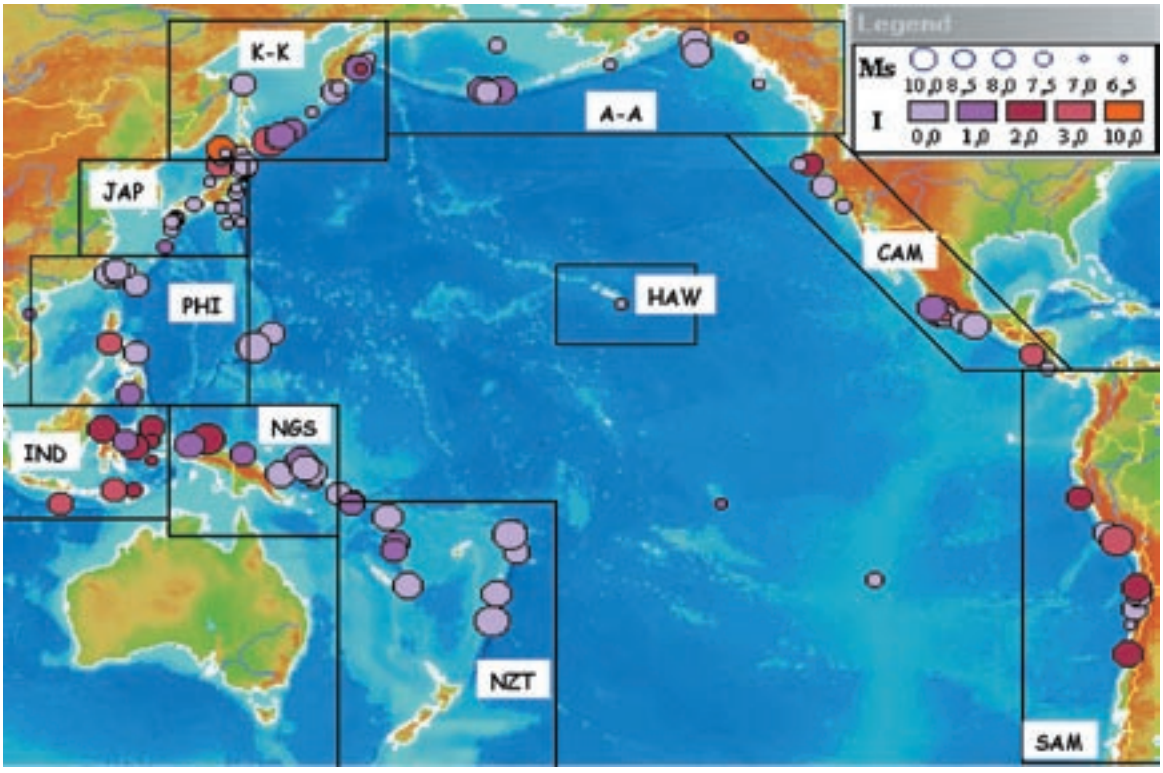

Table 1. Total number of earthquakes (EQ) and tsunami (TS) in each region, and the tsunami generating efficiency (TE %) of these earthquakes (after Gusiakov, 2005).

Region	Earthquake (EQ)	Tsunami (TS)	Tsunami Efficiency (TE)%
South America	122	102	84
Indonesia	86	68	79
Philippines	73	55	75
New Guinea – Solomon Islands	130	86	64
Central America	112	62	55
Japan	255	123	48
Alaska – Aleutians	108	49	46
Kuril – Kamchatka	150	68	45
New Zealand-Tonga	162	62	38
Hawaii*	3	13	433

* Hawaii has experienced many locally generated tsunamis but only three far-field tsunami of earthquake origin, which skews the data: the TE is 100% which says little about the efficiency of earthquake generating tsunami in the Hawaii region.

Table 2. Tsunami frequency/recurrence intervals for selected geographic regions based upon the published literature.

Region	Tsunami frequency	Reference
Kamchatka	1 large event per 1,000 years or 1 event every 30 years	Pinegina *et al.*, (2003)
Chile	1 large event every 200 years	Salgado *et al.*, (2003)
Cairns, Australia	1 event every 600 years	Nott (1997)
Japan	1 major event every 500 years	Nanayama *et al.*, (2003)
Hawaii	1 event every 30 years	Dudley and Lee (1998)
Cascadia, NW USA	6 major events in 3000 years	Hutchinson and McMillan (1997)

Note: For Kamchatka, Chile, Australia and Japan, the frequency is calculated from the records of near-field (local) tsunami only. For Hawaii, the frequency is calculated from the records of both near-field and far-field tsunami.

Method

Questionnaire surveys are a useful method for determining perceptions and knowledge of hazards (Dibben and Chester, 1999; Rohrmann, 1999; Dominey-Howes and Minos-Minopoulos, 2004; Johnston *et al.*, 2005; Spittal *et al.*, 2005). A face-to-face structured questionnaire with a range of closed and open-ended questions was used to investigate perceptions. To avoid restricting or guiding responses to closed questions with an ordinal selection, the option '*other, please specify*' was offered where applicable.

Seventeen Sydney residents (57 per cent of the participant group) were recruited together with 13 professional officers (43 per cent of the participant group) working for member councils of the Sydney Coastal Councils Group (SCCG). All participants were recruited and interviewed during October 2005. Members of the public were recruited by direct approach and all participants were permanent residents of Sydney, aged 18 years or older. Equal numbers of males and females were targeted. The only other constraint to the recruitment of participants was that they needed to be fluent in English (not necessarily people whose first language is English) in order to effectively complete the survey.

The SCCG comprises 15 councils adjacent to Sydney marine and estuarine environments and associated waterways and represents over 1.2 million Sydneysiders. The 13 council participants hold positions such as Environmental Educator, Coastal Manager, Coastal Projects Officer, Environmental Planner, Environmental Scientist, Manager of Engineering and Regulatory Services, Risk and Insurance Manager and Sustainability Consultant. The perceptions of this 'captive group' were sought for several reasons:

1. they should have a high level of awareness;
2. they are a litmus test – if they get it wrong, this bodes poorly for the wider public; and
3. to identify if they had a consensus view about warning and emergency response.

Table 3. Quick look summary of key findings from this research.

Question	Response YES	NO
% of participants who had heard of a tsunami prior to the December 2004 tsunami disaster.	83%	17%
% of participants who correctly identified earthquakes as a tsunamigenic mechanism.	100%	0%
% of participants who correctly identified subaqueous volcanic eruptions as a tsunamigenic mechanism.	87%	13%
% of participants who correctly identified subaqueous sediment slides as a tsunamigenic mechanism.	67%	33%
% of participants who correctly identified meteorite / asteroid strikes as a tsunamigenic mechanism.	60%	40%
% of participants who correctly identified subaerial volcanic eruptions as a tsunamigenic mechanism.	50%	50%
% of participants who correctly identified subaerial sediment slides as a tsunamigenic mechanism.	40%	60%
% of participants who think that Sydney is at risk from tsunami inundation.	83%	13% Don't know = 4%
The region that participants think poses the greatest risk of generating a tsunami capable of affecting Sydney	New Zealand – Tonga (90% of participants)	
% of participants who thought they knew when the last Sydney tsunami was.	20%	
% of participants who correctly identified the date of the last Sydney tsunami.	17% (of the 20%)	

All participants were asked the same questions however, two additional questions were asked of the council officers.

Results

Analyses of all the data from the survey is beyond the scope of this paper. However, selected results are provided that ought to be of interest to organisations responsible for developing tsunami risk mitigation strategies and for assisting EMA to determine the appropriateness of its preparedness strategy.

Table 3 provides a 'quick-look reference' to the key findings of this research.

In addition to the results presented in Table 3, 62 per cent of the council officers and 35 per cent of the public indicated that 'death and injury of people' were likely to be the greatest impact of a tsunami in Sydney. They gave reasons such as, *'based on the Indian Ocean tsunami there was a mass loss of life which was very disturbing'; 'can't replace people'; 'human life is more important than anything else and the coastal area is densely populated so more people could be killed'; 'loss of life is a stronger measure of danger than bricks and mortar';*
'can't put a price on human life' and, 'I doubt if the government could respond fast enough to evacuate the many people that live in low lying areas along the coast and harbour zone'.

Participants were asked to indicate whether or not they believed a tsunami warning system exists for Sydney.

Response	Result
Yes	8% of the council officers and 29% of the public
No	44% of the council officers and 18% of the public
Not Sure	38% of the council officers and 53% of the public

If participants answered 'no' they were asked, 'do you believe Sydney needs a tsunami warning system?'

Response	Result
Yes	76% of council officers and 83% of the public
No	25% of the council officers and 8% of the public
Not Sure	8% of both groups

When council officers were asked whom they think is responsible for issuing tsunami warnings they replied *'the Bureau of Meteorology'*; *'State Government'*; *'Federal Government'*; *'the SES'*; *'EMA'*; and, *'don't know!'*

When council officers were asked who they think is responsible for evacuation procedures if a tsunami was imminent they replied, *'local government'*; *'the police, fire and ambulance services'*; *'the SES'*; *'SMEC'*; and, *'all of the above!'*

Discussion, recommendations and summary

The sample size is small but it is considered that the data generated are significant for two reasons. These are:

1. this is the first time in Australia that public perception of tsunami has been investigated and reported; and
2. the *'pattern'* of findings is similar to other studies of public perception of hazards (Dominey-Howes and Minos-Minopoulos, 2004; Johnston *et al.*, 2005). This increases confidence in the findings and helps shed light on the development of risk mitigation strategies.

The percentage of participants (83 per cent) that stated they had heard of tsunami prior to the Indian Ocean event of December 2004 is considered high. People may have forgotten they had not heard of tsunami prior to this event because the media coverage following the disaster may have entered their subconscious resulting in a perception of previous knowledge. Evidence to support this comes from the fact that, in spite of the widespread media reporting and subsequent scientific discussion in the public domain, participants consistently incorrectly defined what a tsunami is. Participants commonly used the generic media term *'tidal wave'*. While the term *tsunami* has been given considerable public attention the scientific facts do not seem to have registered in the participants' collective minds. This lack of understanding of the basic science is further illustrated by the mixed and poor understanding of tsunamigenic mechanisms. The high recognition of earthquakes as a tsunamigenic mechanism is not thought to be significant as the tsunami was widely quoted as being the result of the world's second most powerful earthquake. Furthermore, all possible tsunamigenic mechanisms for the participants were listed and they were asked if they thought these processes might generate tsunami. Perhaps if participants were asked, *'what mechanisms generate tsunami?'*, they would have scored much lower.

When provided with a map that *included* tsunamigenic zones of the Pacific, the vast majority (90 per cent) of participants incorrectly identified New Zealand/Tonga as the most likely region to generate a damaging tsunami in Sydney. Only one participant correctly identified when the last tsunami affected Sydney. This is significant as the public clearly has a low 'perceived risk' of tsunami. It is believed that this is merely a reflection of the public's belief that proximity to source controls tsunami magnitude and intensity.

It is clear that the Australian public has not learnt the lesson that tsunami may be transoceanic and that Australia is at risk from far-field (distant) tsunami that may be generated in the South American region. This is a significant issue to overcome since the public may be less likely to respond to an evacuation notice given for a tsunami generated off the South American coast than they might a tsunami generated in New Zealand/Tonga.

The high percentage (62 per cent) of the council officers (compared with 35 per cent of the public) who indicated that 'death and injury of people' were likely to be the greatest impact of a tsunami in Sydney may reflect their respective professional responsibilities (or liability). Similar findings were made by Dominey-Howes and Minos-Minopoulos (2004). This suggests that future risk mitigation strategies might need to include some focus on the potential effects of tsunami on human life. Such a focus will help to increase the effectiveness of the risk mitigation message since the public may be more receptive to such a message.

Tsunamis occur in many geographic regions all over the world.

Tsunamis can have devastating effects on communities.

Knowledge of the tsunami warning system operating for the Pacific (and Sydney region) was very limited. Astonishingly, only 8 per cent of the council officers knew about the tsunami warning system whereas, 29 per cent of the public did. Surprisingly, some participants believed that Sydney does not need such a system even though most participants believed Sydney is at risk.

Responses from the council officers in terms of who they believe is responsible for issuing tsunami warnings provides startling evidence for a lack of awareness. Fifty-four percent believed that State *and* Federal governments are responsible for issuing a tsunami warning. Thirty-one per cent thought that the BoM issue warnings and a few participants believed EMA and the SES are responsible. This confusion and lack of awareness is rather alarming. There was a better understanding of the responsible agency involved in evacuation procedures with 46 per cent of council officers indicating the SES. The responses provided by the council officers were interesting in that they have (against the assumptions) a low level of awareness and a high degree of confusion about official warnings and procedures.

Public awareness of hazard can be improved through communication activities through television, radio and internet campaigns; via the distribution of information leaflets, brochures, posters and videos; and information sessions at public information meetings. Such activities are important since Schütz and Wiedemann (2000) found that providing risk information to the public resulted in an increase of public trust in risk mitigation and planning competence. This may be particularly important in the Sydney context given the view that some members of the public do not believe that the 'authorities' could successfully evacuate coastal communities in time. Public levels of ignorance and complacency can increase in relation to long intervals between hazardous events. Schütz and Wiedemann (2000) suggest that risk information should be provided to a community within a timeframe of less than once every three years to ensure risk knowledge does not decrease. However, a study conducted by Johnston *et al.*, (2005) on tsunami preparedness in coastal Washington revealed that despite distributing tsunami information through several media, erecting tsunami warning and evacuation signs, and providing maps and public displays illustrating tsunami inundation zones, levels of preparedness were still rather low. Therefore, the challenges for achieving successful community tsunami risk mitigation are numerous and complex.

In light of the results of this study and the preceding discussion, it seems that:

- further research should be conducted with a much larger sample group and a wider range of questions;
- interviews should be conducted with members from the SES, police, fire and ambulance services in order to investigate their level of tsunami awareness since they will be on the front line of dealing with an emergency;
- follow-up surveys could be undertaken at yearly intervals in order to determine how tsunami perception changes with time;
- local community tsunami vulnerability assessments should be conducted to properly identify and quantify risk;
- flood zones need to be identified and clearly signed within at risk communities;
- safe areas and evacuation shelters need to be identified and evacuation routes determined and signed;

- EMA, the SES and local councils need to develop and implement a program of public awareness building aimed at reaching multiple stakeholders (children, residents of coastal areas, visitors and tourists, boating and marine related personnel and operations);
- the public education message should include some focus on death and injury in order to communicate the seriousness of tsunami (without being alarmist);
- practice emergencies and evacuations should be staged on a regular basis; and
- it may be necessary to enshrine yearly evacuation drills in a national 'Tsunami Action Day' with fun activities to engage the public and raise awareness.

The discussion paper by Sullivan (2006) identifies a series of activities and actions that EMA in its official role within the development and implementation of the Australian Tsunami Warning System is involved with. Most of these actions tackle the issues identified in this study. Our study thus shows that the strategic plans of the EMA in terms of addressing public awareness and community capacity building are both timely, and appropriate.

Summary

Since it is not possible to prevent tsunami from occurring, effective tsunami risk mitigation will depend (to some degree) on public participation in emergency response. The public perception was investigated of tsunami in Sydney – something which has never been done in Australia. It was demonstrated that, in spite of the tragic Indian Ocean tsunami disaster of 2004, the Australian public has a limited and often confused understanding of tsunami. Careful tsunami disaster planning will need to incorporate strategies to raise public awareness of this major hazard type. The strategy of Emergency Management Australia is considered to be appropriate and timely.

References

Bryant, E.A. 2001. Tsunami – The Underrated Hazard. Cambridge University Press, United Kingdom.

Bryant, E.A., Young, R.W. and Price, D.M. 1992a. Evidence of Tsunami Sedimentation on the Southeastern Coast of Australia. *The Journal of Geology*. 100. 753–765.

Bryant, E.A., Young, R.W., Price, D.M. and Short, S.A. 1992b. Evidence for Pleistocene and Holocene raised marine deposits, Sandon Point, New South Wales. *Australian Journal of Earth Sciences*. 39. 481 – 493.

Bryant, E.A. and Young, R.W. 1996. Bedrock-Sculpturing by Tsunami, South Coast New South Wales, Australia. *Journal of Geology*. 104. 565–582.

Bryant, E.A. and Nott, J. 2001. Geological Indicators of Large Tsunami in Australia. *Natural Hazards*. 24. 231–249.

Dibben, C. and Chester, D.K. 1999. Human vulnerability in volcanic environments: the case of Furnas, São Miguel, Azores. *Journal of Volcanology and Geothermal Research*. 92. 133–150.

Dominey-Howes, D. and Minos-Minopoulos, D. 2004. Perceptions of hazard and risk on Santorini. *Journal of Volcanology and Geothermal Research*, 137, 285–310.

Dominey-Howes, D. and Keating. B. (2005). Tsunami risk in the Asia-Pacific region. In: *Catastrophe Insurance – Challenges for Insurers in the Asia-Pacific Region*. 2005. Edited by Neil R. Britton. Proceedings of a Conference sponsored by Aon Re Australia Limited. pp45–61.

Geoscience Australia. 2005. Geoscience Australia's role in the Australian Tsunami Warning System. http://www.ga.gov.au/ausgeonews/ausgeonews200506/atws.jsp Accessed: 13/11/05

Gough, J. and Hooper, G. 2003. Communicating about risk issues. http://www.europe.canterbury.ac.nz/conferences/tech2004/tpp/Gough%20and%20Hooper_paper.pdf Accessed: 06/10/05

Gusiakov, V.K. (2005). Tsunami generation potential of different tsunamigenic regions in the Pacific. *Marine Geology*, 215, 3–9.

Hurnen, F. and McClure, J. 1997. The Effect of Increased Earthquake Knowledge on Perceived Preventability of Earthquake Damage. *The Australasian Journal of Disaster and Trauma Studies*. ISSN: 1174-4707. Volume: 1997-3.

Johnston, D. and Benton, K. 1998. Volcanic hazard perception in Inglewood, New Zealand. *The Australasian Journal of Disaster and Trauma Studies*. ISSN: 1174-4707. Volume: 1998–2.

Johnston, D., Paton, D., Crawford, G.L., Ronan, K., Houghton, B. and Bürgelt, P. 2005. Measuring Tsunami Preparedness in Coastal Washington, United States. *Natural Hazards*. 35. 173–184.

Molino Stewart. 2005. Is Australia ready for its next 40 m high tsunami? *Floodplain Manager*. Molino Stewart. Vol. 1 No. 2. 1–7.

Rohrmann, B. 1999. Community-Based Fire Preparedness Programmes: An Empirical Evaluation. *The Australasian Journal of Disaster and Trauma Studies*. ISSN: 1174–4707. Volume: 1999-1.

Schütz, H. and Wiedemann, P.M. 2000. Hazardous Incident Information for the Public: Is it Useful? *The Australasian Journal of Disaster and Trauma Studies*. ISSN: 1174–4707. Volume: 2000–2.

Spittal, M.J., McClure, J., Siegert, R.J. and Walkey, F.H. 2005. Optimistic bias in relation to preparedness for earthquakes. *The Australasian Journal of Disaster and Trauma Studies*. ISSN: 1174–4707. Volume: 2005–1.

Sullivan, M. 2006. The Australian Tsunami Warning System – An Emergency Management Perspective. Unpublished Paper, Emergency Management Australia. 6pp.

About the Authors

Deanne Bird is a postgraduate research student in the Department of Physical Geography, Macquarie University, Sydney. She is investigating the significance of public awareness as a component of emergency management planning and disaster management in Australia and Iceland.

Dr Dale Dominey-Howes is a senior lecture in Natural Hazards and Physical Geography at Macquarie University and an Associate Research Fellow in the Risk Frontiers – Natural Hazards Research Centre.

Email: ddominey@els.mq.edu.au