Emergency management of tsunami in New South Wales and the response to the Solomon Islands tsunami April 2nd 2007

Gissing, Webb and Hanslow provide an insight into the emergency management of tsunami in NSW including the current activities being undertaken to prepare for tsunami and provide an overview of the NSW response to the April 2007 Solomon Islands tsunami.

Abstract

New South Wales has a well developed tsunami emergency plan, which details the arrangements for the preparation for, response to and the initiation of recovery coordination arrangements following the impact of a tsunami. The NSW State Emergency Service (SES) is the combat (lead) agency for the emergency management of tsunami in NSW and responsible for planning for and controlling tsunami response operations when they occur. The arrangements within the State Tsunami Emergency Sub Plan have been exercised, but the April 2nd 2007 Solomon Islands Tsunami provided the first real life test for the Plan.

In close consultation with the NSW SES, the Bureau of Meteorology provided real time warnings to the community during this event. The liaison between the NSW SES and the Bureau on the day highlighted the benefits of detailed pre-event planning and scenario-based exercises. Both agencies were aware of the capabilities of the system and the messages to be provided.

This paper will provide an insight into the emergency management of tsunami in NSW including the current activities being undertaken to prepare for tsunami and provide an overview of the NSW response to the 2nd of April Solomon Islands tsunami.

Introduction

Globally, many tsunami events in history have caused significant death and destruction. In recent times being demonstrated by the Indian Ocean tsunami of 2004. New South Wales (NSW) is exposed to numerous potential sources of tsunami within the Pacific Ocean. The most frequent source of tsunami within this region is from subduction zones located at continental plate boundaries. Source zones of significance to NSW include the New Hebridies Trench offshore of Vanuatu, the Tonga-Kermadec Trench north of New Zealand, the Puysegur Trench south of New Zealand and the Peru and Chile trenches west of South America. Landslides on the steep continental shelf edge around the south east of Australia are also a potential source of tsunami (Burbidge and Cummins, 2007). One hundred and seventy landslide scars have been identified along the coast of NSW (Jenkins & Keene, 1992).

Since European settlement NSW has been impacted by numerous small tsunami with reports of some damage to property and infrastructure. No detailed tsunami risk studies have been conducted along the NSW coast, hence little is known about the magnitude of the risk posed by tsunami to NSW coastal communities.

The NSW State Emergency Service (SES) is a 10,000 strong volunteer emergency service responsible for performing the role as the combat (lead) agency for floods, storms and tsunami in NSW. The NSW SES's combat agency role for tsunami has been recognised since 2004. Prior to this, command and control arrangements for the emergency management of tsunami were unclear. The State Flood Plan (a sub-plan to the State DISPLAN (Disaster Plan)) acknowledged the NSW SES as the combat agency. However, some local DISPLANs recognised emergency operation controllers as the control authority. The NSW SES was considered best placed to undertake the role of combat agency based upon its experience with and role in flood

emergency management and because in broad terms, tsunami is a type of flood - hence a logical extension of the NSW SES's flood role. The NSW SES was also recognised as having the appropriate capabilities to develop tsunami emergency plans and warning systems, and had developed much experience relating to the warning and evacuation of communities.

The NSW SES has developed a detailed tsunami emergency plan and is currently managing a program to develop a comprehensive understanding of tsunami risk. It is being assisted by developments in the Australian Tsunami Warning System and the formation of the Joint Australian Tsunami Warning Centre between the Bureau of Meteorology and Geoscience Australia; Emergency Management Australia in undertaking tsunami capacity development programs and the design of community education material; and the NSW Department of Environment and Climate Change, with assistance from Geoscience Australia in the management of tsunami risk studies.

This paper discusses tsunami in the NSW context and outlines advances in emergency management of tsunami and the experiences and lessons learnt from the April 2nd, 2007 tsunami event.

Characteristics of tsunami

A tsunami is a series of ocean waves generated by a sudden displacement of large volumes of water. In the process of the sea level returning to equilibrium, waves are generated which propagate outwards from the source region. They may be caused by the vertical movement of the sea floor as a result of large earthquakes; submarine or coastal volcanic eruptions; meteor impacts; or coastal landslides either land based or submarine (Burbidge and Cummins, 2007). Earthquakes have generated the majority of tsunami recorded on the Australian coast (Allport and Blong, 1995). However, not all earthquakes generate tsunami. To generate a tsunami, the fault where the earthquake occurs must be underneath or near the ocean, and cause vertical movement of the sea floor over a large area. Shallow focus earthquakes along subduction zones (where one tectonic plate is pushed under another) are responsible for the majority of tsunami experienced world wide (Blong et al, 2000).

Tsunami travel outward in all directions from their point of generation (but not necessarily with equal energy in every direction) and can strike coastal areas great distances from their source. Tsunami speed is dependent on water depth. In deep water and open ocean, tsunami can reach speeds of 800 kilometres per hour (Blong et al, 2000). Heights of tsunami in deep water are only small and can go unnoticed. As a tsunami enters shallow water its speed decreases rapidly. This causes the wave length of the tsunami to decrease and the height of the wave to increase (UNESCO IOC ITIC, 2005).

It is important to note that despite these changes a tsunami's energy flux, which is dependent upon both its wave height and speed remains nearly constant. Energy begins to be lost once a tsunami begins to rush onshore. Some energy is reflected offshore, while shoreward propagating energy is lost through friction and turbulence (Bureau of Meteorology, 2008)

The height of the run-up at the coast associated with a tsunami is dependent on the tidal level at the time of arrival, the incoming wave characteristics (height, period etc) as well as the configuration of the coastline and shape of the ocean floor (Bryant, 1991). Narrow bays, inlets and estuaries may cause funnelling effects that enhance tsunami magnitude (Blong et al, 2000). These factors mean that the flooding produced by a tsunami can vary greatly from place to place over a short distance.

A tsunami is not a single wave, but a series of waves. The time that elapses between the passage of successive wave crests at a given point is usually from 5 to 60 minutes, although higher frequency oscillations may also be present. Oscillations of destructive proportions may continue for several hours, and several days may pass before the sea returns completely to its normal state (IOC, 2005). The first wave in the series may not be the largest. The approach of a tsunami may be preceded by abnormal ocean behaviour. Depending on whether the first part of the tsunami to reach the shore is a crest or a trough, it may appear as a rapidly rising or falling tide.

Within harbours and estuaries even relatively small tsunami can cause strong currents which may have adverse consequences for both recreational and commercial boating as well as other marine based risk groups.

History of tsunami in NSW

The NSW coast has experienced some 40 tsunami since European settlement, many of which have been too small to produce noticeable effects. Many of these are outlined in Allport and Blong (1995).

The largest tsunami in 1868, 1877 and 1960 were recorded as tide gauge measurements of approximately one metre. There has been no recorded loss of life or major damage recorded as a consequence of tsunami, although, some minor damage to boats and coastal infrastructure is known to have occurred as a result of the 1960 Chilean and 1868 and 1877 Peruvian tsunami (Allport and Blong, 1995)

The historical record is useful when assessing the tsunami risk, but is limited by its short length of 220 years. The absence of impact from large tsunami over recent history is not on its own sufficient to preclude the possibility of impact from larger events.

Palaeo-tsunami research along the coast of NSW by some coastal geologists implies the coast may have been impacted by very large tsunami achieving flood heights in excess of tens of metres several times during the last 10,000 years (Bryant and Nott, 2001; Bryant and Young 1996; Bryant, Young and Price, 1992). Other researchers, however, have questioned the evidence for these proposed palaeo-megatsunami (Dominey-Howes, 2007, Dominey-Howes et al., 2006, Synolakis and Fryer 2001, Felton and Crook 2003) and further research is needed to validate the palaeo-tsunami record and its interpretation (eg Dominey-Howes, 2007).

Emergency planning for tsunami – NSW Tsunami Emergency Sub Plan

The development of the NSW Tsunami Emergency Sub Plan by the NSW SES began in early 2004, prior to the Indian Ocean tsunami of the 26th of December. It is because of that event that the priority for tsunami research and planning has been given greater emphasis in Australia (and elsewhere). The plan was endorsed at the NSW State Emergency Management Committee meeting held in December, 2005. This followed extensive investigation and consultation by the planning staff of the NSW SES with all agencies listed in the plan. In particular, it was essential that the authors of the plan had a full and detailed understanding of the nature of tsunami and of the current capabilities and limitations of tsunami detection and warning systems.

It was in the process of undertaking the required research that it became apparent that there are significant gaps in the knowledge base for tsunami world-wide and especially in the Australian context. There are differences of opinion within the scientific community about the evidence for past tsunami events and the likelihood and magnitude of tsunami in the future. The most difficult challenge for those involved in the response planning is that there is little or no information available by way of real time tsunami prediction of consequences for actual events.

The Tsunami Emergency Sub Plan is comprehensive in scope and deals with preparedness, response and the initiation of recovery. The plan deals with all possible tsunami magnitudes and generating mechanisms. The plan is strategic in nature and establishes the framework and principles for the emergency management of tsunami in NSW. Responsibilities for agencies likely to be involved in tsunami management are listed within the plan. As with all NSW emergency management plans, the plan works from an assumption that agency responsibilities should focus on those activities for which they are naturally best suited by virtue of their usual business orientation. Put simply this means: fire & HAZMAT managed by fire & HAZMAT specialists, rescue managed by rescue specialists, health managed by health specialists, warning and evacuation managed by warning and evacuation specialists, and so forth.

To ensure that key stakeholders are aware of the Plan, the Plan has been exercised and a series of briefings held to educate emergency managers about the arrangements contained within the Plan. Briefings were sponsored by Emergency Management Australia and held at eight different locations along the NSW coast during 2007. Topics presented at the briefings included the science of tsunami, tsunami warning systems, the NSW Tsunami Emergency Sub Plan, tsunami risk assessment and future planning initiatives. These briefings were attended by over 800 emergency managers illustrating the current interest in the emergency management of tsunami.

The plan is publicly available from the emergency NSW and NSW SES websites at www.emergency.nsw.gov.au and www.ses.nsw.gov.au.

Concept of operations

The concept of operations for the Plan recognises that any tsunami response operation will require a coordinated multi agency effort under the overall control of the NSW SES. The Plan separates tsunami response operations into three phases consisting of pre-impact (warning), impact and post impact.

The pre-impact phase is defined as the period before the impact of tsunami and consists of precautionary tasks focused upon the protection of life and property such as warning and evacuation; operational readiness; provision of accommodation and welfare for displaced people; protection and pre-deployment of resources; and the restriction of access to areas likely to be impacted. The ability to undertake these tasks is dependent upon the warning time available.

The impact phase is characterised by the impact of a series of separate waves over several hours. It will be difficult to undertake many activities directly within at-risk areas due to the dangers posed by the impact of further waves. Hence activities within this phase will be focused on warning, reconnaissance, welfare for evacuees and preparation for response activities during the post impact phase.

The post-impact phase begins upon advice that the destructive potential of a tsunami has ceased and that it is safe for emergency services to enter affected areas (if any). The scale of post impact phase activities will be dependent on the size of the event that has occurred. Some activities conducted during this phase may include reconnaissance, search and rescue, treatment of sick and injured, welfare provision, disaster victim identification, response to fire and hazmat incidents and provision of advice to the community.

The work to prepare the Tsunami Emergency Sub Plan identified that both marine and land based elements are vulnerable to tsunami. It is likely that all significant tsunami (i.e. those that are noticeable) will affect marine based risk groups who may be vulnerable to the effects of unusual currents as well as varying water levels, whilst larger tsunami are likely to cause damage to land based elements. It is therefore important to distinguish between these two classes of tsunami within the concept of operations, and to determine what actions will be necessary in each scenario during each of the defined phases of tsunami response operations.

Tsunami warning systems

Advice about potential tsunami that may affect Australia is issued by the Bureau of Meteorology, as part of the Australian Tsunami Warning System. The Bureau has formed the Joint Australian Tsunami Warning Centre with Geoscience Australia. This centre produces information regarding the level of potential tsunami threat and this forms the basis of public Tsunami Warnings issued by the Bureau's Regional Offices. Further information regarding the Australian Tsunami Warning System is available from the Bureau of Meteorology website www.bom.gov.au/tsunami

The Bureau of Meteorology is responsible for the initial broadcast distribution of NSW Tsunami Warnings. The NSW SES is responsible for directing the dissemination of tsunami warnings via narrowcast means at regional and local levels.

Warnings will be disseminated by broadcast media; doorknocking; fixed and mobile public address systems; marine radio; variable message signs and the internet. The NSW SES has undertaken further research into other possible warning dissemination methods and is currently considering the implementation of further methodologies.

Available effective warning time will vary depending upon the distance of our coastline from the point of tsunami generation. In the event of a tsunami being generated directly offshore of our coast, little to no warning will be available at the point of first impact apart from possible environmental warning signals such as the recession of the ocean prior to tsunami impact. The best warning strategy for local tsunami is public education to ensure that the community is aware of environmental cues and what actions to take when they are observed.

Tsunami risk assessment

The hazard magnitude for tsunami threatening NSW is difficult to assess because of a lack of suitable research. A consequence of the lack of research is that, no detailed tsunami hazard assessments have been conducted to assess what areas may be exposed to the greatest hazard (Opper and Gissing, 2005). The general nature of the information available from the short history of tsunami occurrence and lack of detailed modelling also makes it difficult to estimate magnitude-frequency relationships for tsunami.

It is clear that the knowledge gaps regarding tsunami risk must be addressed. To this end the NSW SES and the NSW Department of Environment and Climate Change with support from Geoscience Australia have entered into a partnership to manage a tsunami risk assessment scoping study for the NSW coastline. Funding for the study was successfully obtained through the Natural Disaster Mitigation Program.

The study will compose the following components:

- Identification of tsunami sources, including an assessment of their relative tsunamigenicity;
- Summary of NSW tsunami history, including paleotsunami studies;
- Estimation of travel times for each credible tsunami source;
- Estimation of wave heights along the entire NSW coast to 50m depth for regional and distant tsunami sources;
- Broad based assessment of coastal vulnerability;
- Assessment of the influence of typical coastal configurations on tsunami magnitude;
- Assessment and collation of available topographic and bathymetric data to facilitate future modelling of tsunami inundation; and
- Assessment of inundation and risk modelling requirements.

The outcomes of the study will provide a general assessment of tsunami risk and provide information for the prioritisation of communities for future detailed tsunami inundation modelling as well as some of the inputs required to perform this modelling.

The provision of more detailed risk assessment information will allow for more detailed emergency planning and community specific education programs to be conducted.

The April 2nd 2007 Solomon Islands tsunami event

At 6:40 am AEST on Monday the 2nd of April 2007, a magnitude 8.1 earthquake located 10 kilometres below the seafloor in the Solomon Islands occurred. As a consequence of the earthquake a tsunami was generated. In the areas closest to the point of tsunami generation severe damage was experienced by the waves reported to have been several metres high. Some 52 reported

deaths occurred in the Solomon Islands, with some 5,500 people displaced (Fritz and Kalligeris, 2008; OCHA, 2007)

Tsunami Bulletins were issued by the Pacific Tsunami Warning Centre, which warned of potential impacts on the Australian coast. As a consequence tsunami warnings were issued by the Bureau of Meteorology for the East Coast, including NSW.

The first public warnings were issued at 8:20 am AEST and indicated that the NSW coast could be affected by 10:15 AEST. The public were encouraged to take the following safety actions:

- People at the beach should leave the beach, and any areas exposed to surf and move to higher ground;
- People in boats in shallow water should immediately return to land, secure vessels and move to higher ground;
- Boats and ships at sea should move to deep water and not return to harbour until advised that it is safe to do so;
- If you see the sea go out like a very low tide then immediately go to high ground; and
- People should keep listening to the local media for updated information and advice and follow instructions and advice from emergency services.

As a consequence of warnings beaches were closed and swimmers were evacuated; some Sydney ferry services were suspended; some vessels moved offshore from ports and a small number of schools were evacuated. Throughout the morning of the 2nd, most media agencies streamed continuous coverage of the situation. At 1:30 pm AEST the warning for NSW was officially cancelled by the Bureau of Meteorology.

NSW SES State and coastal Region Operation Centres were opened as well as many local coastal Unit Headquarters to monitor the situation and to pass information to supporting agencies and the public.

As outlined in the Plan, NSW SES operations were supported by various other agencies including Local Government, Surf Life Saving NSW, NSW Police Force, Port Corporations, NSW Maritime, Royal Volunteer Coastal Patrol, Australian Volunteer Coast Guard and VRA Sea Rescue.

Actions undertaken by emergency services included enhancing operational readiness, disseminating warnings to people in or on water, closure of beaches in consultation with local government councils, monitoring and reconnaissance and management of the media.

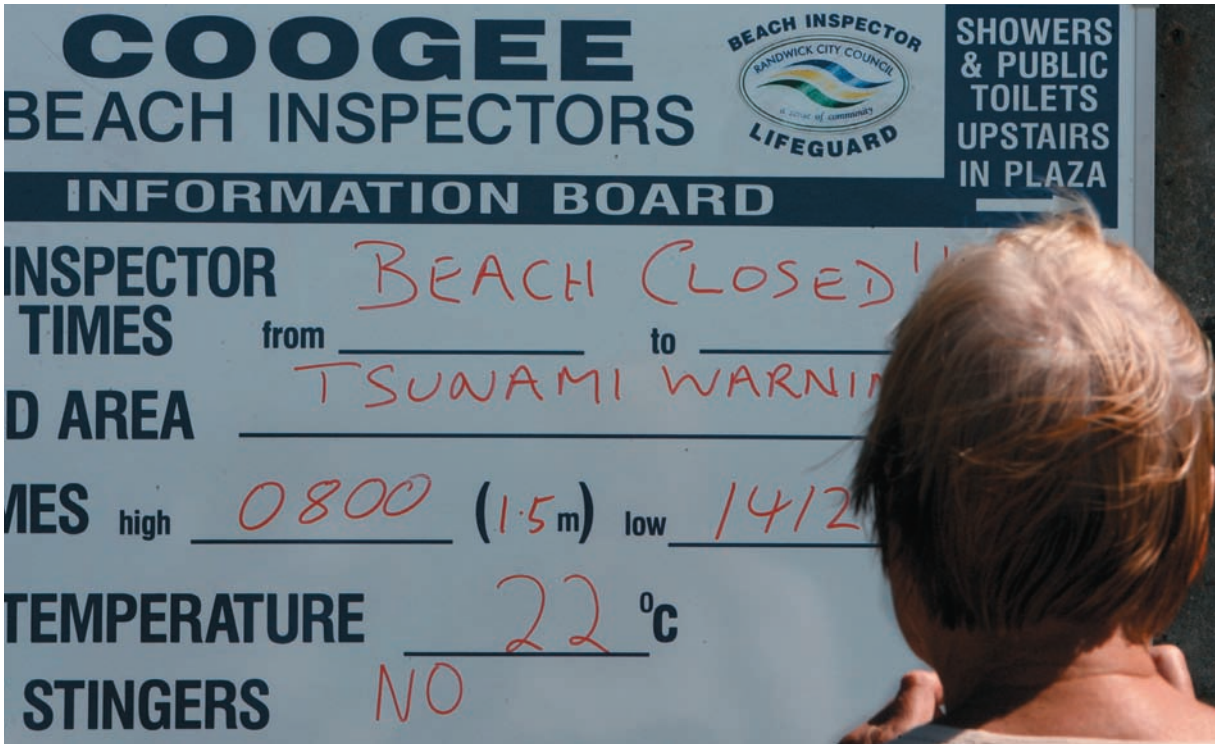
A small tsunami was measured along the NSW coast as small changes in tides over short periods of time. Some strong currents were observed at Coffs Harbour. Tidal anomalies measured at Tweed Heads matched well with the predicted NSW arrival time of 10:15 AEST. Fortunately, no significant damage or injuries were reported. Table 1 below details peak tsunami wave heights collected at 15 minute intervals at locations along the NSW coast and offshore islands.

Table 1 Peak tsunami wave heights

Location	Maximum Wave Height (Crest to Trough) (Metres)
Norfolk Island	0.4
Lord Howe Island	0.18
Tweed Heads	0.14
Brunswick	0.16
Ballina	0.11
Yamba	0.08
Coffs Harbour	0.18
Tomaree	0.13
Sydney	0.14
Creswell	0.07
Bermagui	0.12
Eden	0.4

Some key observations and lessons learnt from the event included:

- It was clear at subsequent debriefs that having a well exercised plan was a big advantage and a worthwhile investment. The partnerships which were built between the NSW SES and other emergency services during the planning process ensured that coordination of operations was effective;
- Not all key stakeholders at the local level were aware of the NSW Tsunami Emergency Sub Plan, reinforcing the fact that there is an ongoing need to market emergency plans to ensure awareness of them;
- Post event debriefs and reviews regarding warning effectiveness managed by the SES indicated that the large majority of residents became aware of the tsunami warnings through the media. Since, the event occurred during morning hours when people were travelling to or attending work; it was relatively easy to reach people through this communication method. If the event had occurred outside of waking hours other warning methods would have been required to supplement the media. However, due to the much lower number of people who would have been within the potential area of concern during this event, the warning task would have been much smaller in scale.



© Fairfax photos

Many beaches were closed as a consequence of the tsunami warning on April 2nd, 2007.

- There was some confusion in advice messages regarding what was meant by deep and shallow water. Messages will now refer to geographical descriptions, such as open ocean, harbours and estuaries, rather than depths.
- A lack of consequence information made operational decision making difficult, reinforcing the need for detailed risk assessment work to be undertaken.
- Modern communication means that information is very quickly exchanged across State borders. The need for consistent messages across State borders is vital to ensure that warnings do not create confusion and are appropriately responded to.
- Though the event showed that warning advice messages needed refinement. The process of developing these messages with the Bureau prior to the event and the procedures for warning consultation between the Bureau and the NSW SES enhanced the ability of both agencies to provide consistent information to the public during the event.
- It is the experience of the NSW SES and evident through post event reviews that the majority of the community does not recognise tsunami as a hazard to the NSW coast and hence believed that the event would not have any serious consequences. This experience illustrates the need for community education programs to be delivered which raise awareness regarding the tsunami hazard and appropriate actions to undertake in response to tsunami warnings. Similar observations and conclusions have been made by Bird and Dominey-Howes (2006; 2008)
- It is vital that the media and other emergency services are aware of the structure of the total tsunami warning system and that Bureau of Meteorology Tsunami Warnings are the official warning products for Australia, and all broadcast information should be consistent with the information contained within them. An education campaign has been undertaken by the NSW SES in conjunction with Emergency Management Australia, Geoscience Australia, NSW Department of Environment and Climate Change and the Bureau of Meteorology to enhance the knowledge of the total tsunami warning system amongst the media and emergency services.

Conclusion

The 2nd of April tsunami event provided the first real test of the NSW Tsunami Emergency Sub Plan. Lessons learnt will be incorporated through an ongoing review of the State Tsunami Emergency Sub-Plan.

The primary focus of current NSW tsunami management initiatives is to maximise the capacity of emergency services to combat tsunami, in particular to enhance the ability to warn and evacuate people at-risk. Without detailed risk assessment information these tasks will be much more difficult to undertake, as was illustrated by the 2nd of April tsunami event.

Future initiatives will focus upon community education; more detailed emergency planning and advanced warning systems. Community education programs will be aimed at developing understanding of the tsunami risk posed to communities and empowering people to take appropriate action in response to a tsunami. These enhancements also fundamentally depend on the tsunami risk assessment process.

References

Allport, J.K. and Blong, R.J., 1995, *The Australian Tsunami Database* (Four Volumes). Natural Hazards Research Centre, Macquarie University, Australia.

Bird, D. and Dominey-Howes, D., 2006, Tsunami risk mitigation and the issue of public awareness. *Australian Journal of Emergency Management*, v. 21 n. 4, 29-35.

Bird, D. and Dominey-Howes, D., 2008, Testing the use of a 'questionnaire survey instrument' to investigate public perceptions of tsunami hazard and risk in Sydney, Australia. *Natural Hazards* 45, 99-122.

Blong, R.J., Sinai, D., and Packham, C., 2000, *Natural Perils in Australia and New Zealand*. Swiss Re Australia Limited, Australia.

Bryant, E., 1991, *Natural Hazards*. Cambridge University Press, United Kingdom.

Bryant, E., Young, R. and Price, D., 1992, Evidence of tsunami sedimentation on the south eastern coast of Australia. *Journal Geology* 100, 753-765.

Bryant, E. and Price, D., 1996, Bedrock-sculpturing by tsunami, South Coast New South Wales, Australia. *Journal Geology* 104, 565-582.

Bryant, E. and Nott, J., 2001, Geological Indicators of Large Tsunami in Australia. *Natural Hazards* 21, 231-249.

Burbidge, D. and Cummins, P., 2007, *A Preliminary Tsunami Hazard Map for Australia*, Geoscience Australia, Canberra

Bureau of Meteorology (2008) *Tsunami Information*. Bureau of Meteorology. Available at: http://www.bom.gov.au/tsunami

Dominey-Howes, D., 2007, Geological and historical records of tsunami in Australia. *Marine Geology* 239(2007), 99-123.

Dominey-Howes, D., Humphreys, G. and Hesse, P., 2006, Tsunami and palaeotsunami depositional signatures and their potential value in understanding the Late-Holocene tsunami record. *The Holocene* 16 (8), 1095–1107.

Felton, E. A. and Crook, K.A.W., 2003, Evaluating the impacts of huge waves on rocky shorelines: an essay review of the book 'Tsunami – The Underrated Hazard' *Marine Geology* 3304, 1-12.

Intergovernmental Oceanographic Commission (IOC), 2005, Communications Plan for the Tsunami Warning System in the Pacific. Intergovernmental Oceanographic Commission. Available at: http://ioc3.unesco.org/indotsunami/mauritius05/TWSP_Communications_Plan_2005_rev2.pdf

Jenkins, C. and Keene, J., 1992, Submarine slope failures of the southeast Australian continental slope: a thinly sedimented margin. Deep Sea Research v. 39 n. 2, 121-136.

Opper, S. and Gissing, A., 2005, *Anticipating Waves of Destruction – Preparing the New South Wales Tsunami Emergency Management State Plan*. State Emergency Service. Available at: http://www.ses.nsw.gov.au/infopages/2276.html

UNESCO IOC International Tsunami Information Centre, 2005, *Tsunami The Great Waves*. UNESCO IOC International Tsunami Information Centre, Honolulu, Hawaii, USA.

United Nations Office for the Coordination of Humanitarian Affairs (OCHA), 2007, *South Paciifc Tsunami – OCHA Situation Report No. 3*. Available at: www.reliefweb.int

Synolakis, C.E. and G.J., Fryer, 2001, Book Review: *Tsunami: the underrated hazard* by Edward Bryant, *Eos, Trans. Am. Geophys. Union*, 82, 588

About the authors

Andrew Gissing is the Manager of Planning for the NSW State Emergency Service. He has been a member of the service for 5 years and is responsible for the coordination of all emergency planning for the service's combat agency roles.

Andrew was an author of the NSW State Tsunami Emergency Sub Plan and has been the project manager for many of the services tsunami related activities.

Andrew is an Honorary Associate of Macquarie University and Risk Frontiers – Natural Hazards Research Centre

Rob Webb is the head of forecasting operations at the Bureau of Meteorology in NSW.

Rob has spent almost 15 years working for the Bureau, mainly in the NSW Region. He initially specialised in severe thunderstorms and bushfire meteorology before moving to Melbourne in 2003 to work on a project aimed at upgrading the Bureau's radar services.

In 2005, Rob returned to NSW and now heads the Weather Services side of the Bureau's operations there including all land and marine forecasts and warnings covering anything from District forecasts to Severe Thunderstorm Warnings to Tsunami Warnings.

Dave Hanslow is a Senior Geomorphologist with the Coastal Unit of the NSW Department of Environment and Climate Change. He has many years experience with coastal hazard management and is currently project manager for the NSW Tsunami Risk Scoping Project.