The Inevitable Ripple – New South Wales Emergency Management of the Solomon Islands Tsunami April 2nd 2007

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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 agency (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, however the recent 2nd of April 2007 Solomon Islands Tsunami provided the first real life test for the Plan.

In close consultation with the SES, the Bureau of Meteorology provided real time warnings to the community during this event. The liaison between the 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. Since, European settlement New South Wales (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 these communities.

The NSW State Emergency Service (SES) is the combat (lead) agency for tsunami in NSW. It has developed a detailed tsunami emergency plan and is currently managing a program to develop a comprehensive understanding of tsunami risk. It is being

supported by the Australian Bureau of Meteorology in the development of warning systems; and the NSW Department of Environment and Climate Change 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 2nd of April, 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. Earthquakes have generated the majority of tsunami recorded on the Australian coast. 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 most destructive tsunami experienced world wide.

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. 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. 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.

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. Narrow bays, inlets and estuaries may cause funnelling effects that enhance tsunami magnitude. Offshore reefs and shallows can act to reduce tsunami magnitude but may also focus tsunami at particular locations. The combination of these factors means 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 90 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. 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 over 30 tsunami since European settlement, many of which have been too small to produce noticeable effects. The largest tsunami recorded in 1868, 1877 and 1960 were recorded as tide gauge measurements of approximately one metre (Geoscience Australia, 1996). 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.

The historical record is useful when assessing the tsunami risk, but is limited by its short length of just over 210 years. The absence of impact from large tsunami over recent history is not on it's own sufficient to preclude the possibility of impact from larger events.

Paleo-tsunami researchers have reported that larger tsunami have impacted upon the NSW coast before European settlement measuring tens of metres (Bryant and Nott, 2001; Bryant and Young 1996; Bryant, Young and Price, 1992). Other researchers, however, have questioned these conclusions (Dominey-Howes, 2007, Dominey-Howes et al., 2006, Synolakis and Fryer 2001, Felton and Crook 2003) and further research is needed to validate the paleo-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 SES began in early 2004, prior to the Asian tsunami of the 26th of December. It has been a consequence of that event that the priority for tsunami research and planning has been given greater emphasis. The plan was endorsed at the State Emergency Management Committee meeting held in December, 2005. This followed extensive investigation and consultation by the planning staff of the 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 for actual events.

The Tsunami Emergency Sub Plan is comprehensive in scope and deals with; preparedness, response and the initiation of recovery. The plan accounts for all possible tsunami magnitudes and generating mechanisms. The plan is strategic and 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, etc.

To ensure that key stakeholders are aware of the Plan, the Plan has been exercised and a series of briefing held to educate emergency managers about the arrangements contained within the Plan.

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

Tsunami Warning Systems

Advice about potential tsunami that may impact on Australia is issued by the Bureau of Meteorology, as part of the Australian Tsunami Warning System. Further information regarding the Australian Tsunami Warning System is available from the Bureau of Meteorology website.
http://www.bom.gov.au/oceanography/tsunami/atws_summary.shtml

The NSW Bureau of Meteorology Regional Forecasting Centre is responsible for the initial broadcast distribution of NSW Tsunami Warnings. The 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 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. 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.

Davidson & Rynn (1998) in their assessment of tsunami risk in Australia recognised the high risk along the NSW coast. Initial estimates made by the SES using 2001 census information suggest that 250,000 people live within 500 metres of the NSW coast and estuaries and below the 10 metre AHD contour. This estimate rises to some 330,000 people when considering people living within one kilometre of the NSW coast and estuaries and below the 10 metre AHD contour. Approximately 20% of the population potentially at-risk of tsunami is over the age of 65, which is greater than the state-wide average of 13%.

Vulnerability to tsunami is greatest between the Shoalhaven coast and the Newcastle coast, reflecting the high population density in this area. This vulnerability is expected to increase as a consequence of expanding coastal development in response to; continuing population growth, population ageing and the coastal retirement trend. Vulnerability is also seasonal and peaks during the summer months, especially during school holidays from December through to the end of January.

The work to prepare the Tsunami Emergency Sub Plan has 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 them.

It is clear that the knowledge gaps regarding tsunami risk must be addressed. To this end the State Emergency Service and the NSW Department of Environment and Climate Change 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.
- 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.

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

The 2nd of April 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 generated a tsunami, which resulted in tsunami warnings being issued for coastal areas in NSW. The first public warnings were issued at 8:20 am AEST and encouraged people 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; 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 steamed continuous coverage of the situation. At 1:30 pm AEST the warning was officially cancelled by the Bureau of Meteorology.

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, however, no significant damage or injuries were reported. Some key observations and lessons learnt from the event included:

- Having a well exercised plan was a big advantage and a worthwhile investment. The partnerships which were built between the SES and other emergency services during the planning process ensured that coordination of operations was effective;
- Not all key stakeholders were aware of the NSW Tsunami Emergency Sub Plan, reinforcing that there is an ongoing need to market emergency plans to ensure awareness of them;
- There was some confusion in advice messages regarding what was meant by deep water and shallow water. Messages will now refer to geographical descriptions, such as open ocean, harbours and estuaries, rather then depths.

- A lack of consequence information made operational decision making difficult, reinforcing the need for risk assessment work to be undertaken.
- Different warning messages issued in a neighbouring state resulted in confusion, especially when these warning messages largely rated the threat as insignificant. This resulted in some people not responding appropriately to warnings.
- 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 serous 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.
- The media and some emergency services provided advice to the public that warnings were cancelled before they actually were. To ensure that this does not occur during future events, the media and other emergency services need to be aware that Bureau of Meteorology Tsunami Warnings are the official warning products for Australia, and not disseminate cancellation advice messages until the Bureau of Meteorology issues a cancellation.

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 Plan.

The primary focus of current 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.

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