ICG/PTWS XXVI

NATIONAL REPORT SUBMITTED BY:

NEW ZEALAND

PART 1: BASIC INFORMATION

1. ICG/PTWS Tsunami National Contact

Name:	David Coetzee
Title:	Manager, Capability & Operations
Organization:	Ministry of Civil Defence & Emergency Management
Postal Address:	P.O. Box 5010 Wellington 6145 New Zealand
e-mail Address:	david.coetzee@dpmc.govt.nz

2. ICG/PTWS Tsunami Warning Focal Point

Name:	David Coetzee
Title:	Manager, Capability & Operations
Responsible Organization:	Ministry of Civil Defence & Emergency Management
Postal Address:	P.O. Box 5010 Wellington 6145 New Zealand
e-mail Address:	david.coetzee@dpmc.govt.nz

3. Tsunami Advisor(s)

Name:	Dr Ken Gledhill
Title:	GeoNet Project Director; Tsunami Experts Panel Coordinator
Postal Address:	P.O. Box 30368 Lower Hutt 5040 New Zealand
e-mail Address:	k.gledhill@gns.cri.nz

4. Tsunami Standard Operating Procedures for Local Tsunami

Unlike distant source tsunami (more than 3 hours travel time) and regional source tsunami (1 to 3 hours travel time) official warning for local source tsunami is unlikely to be timely in all areas because of the close proximity of faulting, the continental plate subduction zone, and volcanoes along our coastline. The *National Tsunami Advisory and Warning Plan* (www.mcdem.govt.nz) recognises this reality with the following text:

> **SPECIAL CONSIDERATION – LOCAL SOURCE TSUNAMIS**
> **A tsunami generated in conjunction with a nearby large earthquake or undersea landslide may not provide sufficient time to implement official warning procedures.**
> **Persons in coastal areas who:**
>
> **experience strong earthquakes (hard to stand up);**
> **experience weak earthquakes lasting for a minute or more;**
> **observe strange sea behaviour such as the sea level suddenly rising and falling, or hear the sea making loud and unusual noises or roaring like a jet engine;**
>
> **should not wait for an official warning. Instead, let the natural signs be the warning. They must take immediate action to evacuate predetermined evacuation zones, or in the absence of predetermined evacuation zones, go to high ground or go inland.**

While the time constraint is recognised, the same procedures for warning apply as described below for distant source tsunami.

5. Tsunami Standard Operating Procedures for Distant Tsunami

5.1 Responsible Organisations

Ministry of Civil Defence & Emergency Management (MCDEM)
MCDEM maintains a National CDEM Warning System (NWS) for the purpose of the dissemination of national level warnings to local authorities, government departments, lifeline utilities and the public. For this purpose it maintains a 24/7 duty system. Via its duty system, MCDEM is responsible for identification and characterization of tsunamigenic events.

GNS Science (GeoNet)
GeoNet is a national geological hazards monitoring and data collection system operated by GNS Science. GeoNet is funded by the Earthquake Commission (New Zealand's government mandated disaster insurer) and Land Information New Zealand. It incorporates distributed data centres and duty officers on 20 minute 24/7 rapid response to earthquakes, volcanic events, landslides and tsunami. GeoNet is MCDEM's official advisor for characterization of tsunamigenic events.

The GeoNet Project Director also coordinates a panel of tsunami experts across research and academic institutions in New Zealand. The panel (referred to as the Tsunami Experts Panel) can be activated at any time by GeoNet to assist with interpretation and assessment of data related to a tsunami event.

5.2 Thresholds and Criteria
Initial tsunami advisories or warnings are issued by MCDEM as a default action when information received meet or exceed specific thresholds, and when an event does not meet the thresholds but based on advice received from GeoNet/Tsunami Experts Panel, is considered to hold a potential threat for New Zealand. When an event does not to hold a threat for New Zealand but information otherwise available is considered to potentially lead to public concern, a *National Advisory- No Threat* may be issued.

The thresholds for issuing default initial national tsunami advisories or warnings by MCDEM are described in the *National Tsunami Advisory and Warning Plan* and are as follows:

Region	Location	Thresholds	Template to use
0	**NZ Local (within ±500km from any NZ shore)**	**Mw≥7.5 and depth <100km**	**National Warning – Tsunami: Threat to NZ**
1	**South West Pacific (includes NZ local source)**	**Mw≥8 and depth <100km**	**National Warning – Tsunami: Threat to NZ**
		Mw>7.5-≤7.9 and depth <100km	**National Advisory – Tsunami: Potential threat to NZ**
2	**South America**	**Mw≥8.0 and depth <100km**	**National Advisory – Tsunami: Potential threat to NZ**
3	**Central America**		
4	**Cascadia**		
5	**Aleutians Rat Island**		
6	**Kurile Islands Kamchatka**		
7	**Japan**		
8	**Other (any location not inside a circle on map)**		

Table 1: Thresholds for default tsunami advisories and warnings

Subsequent national advisories or warnings are issued by MCDEM based on assessment provided by GNS Science and the Tsunami Experts Panel.

For National Warnings, further assessment about expected arrival times and threat estimation is included in notifications:

Information about expected arrival times is derived from modeling conducted by the PTWC and moderated by GNS Science. The information is expressed as the estimated time of arrival (ETA) of the first (lead) wave at a given coastal point.

Supplementing PTWC forecasts, GNS Science also applies modeling (see 10.1.1) to provide information about the maximum expected water elevation (amplitude). The amplitudes at shore and threat categories that can be assigned for 42 coastal zones are as follows:

Maximum expected amplitude at shore		Threat definition
	<0.2m	**No threat**
	0.2-1m	**Marine & Beach Threat (incl. harbours, estuaries & small boats)**
	1m-3m	**Marine and Land threat**
	3m-5m	
	5m-8m	
	>8m	

Table 2: Tsunami threat categories

Figure 1: Coastal zones for tsunami threat forecasts

5.3 Other Agencies Response
Following the issue of a national tsunami advisory or warning, local authorities are responsible for local threat assessment and for activating local public alerting mechanisms, following their own procedures, while national agencies activate response plans relevant to their areas of business. MCDEM maintains a Memorandum of Understanding with key media (radio and TV) for the public broadcasting of warnings.

5.4 Dissemination
National tsunami advisories and warnings are disseminated to all local authorities, key national agencies and the media. Information is communicated via the National CDEM Warning System, using SMS, e-mail and Twitter and FaceBook accounts. The processes applied under the National CDEM Warning System are described in *The Guide to the National CDEM Plan* (www.mcdem.govt.nz).

5.5 Termination
All national tsunami advisories or warnings (except *National Advisory- No Threat*) are followed up by continuous subsequent advisories/warnings until a formal cancellation is issued via the National CDEM Warning System.

5.6 Response to warnings during inter-sessional period
During the inter-sessional period:

National Advisory - Tsunami: No Threat to NZ notifications were issued by MCDEM for the following events:

21.07.2013	New Zealand	M 6.5
16.08.2013	New Zealand	M 6.6
02.04.2014	Chile	M 8.2
20.04.2014	PNG	M 7.5

24.06.2014	Kermadec Islands	M 6.8
17.11.2014	New Zealand	M 6.5
30.03.2015	PNG	M7.6

Table 3: *National Advisory – Tsunami: No Threat to NZ* notifications issued between June 2013 and April 2015.

National Advisory – Tsunami: Potential Threat to NZ notifications were issued by MCDEM for the following events:

13.04.2014	Solomon Islands	M 7.6
14.04.2014	Solomon Islands	M 7.4

Table 4: MCDEM *National Advisory – Tsunami: Potential Threat to NZ* notifications issued between June 2013 and April 2015.

National Warning – Tsunami: Threat to NZ notifications were issued by MCDEM for the following events:

Nil		

Table 5: MCDEM *National Warning – Tsunami: Threat to NZ* notifications issued between June 2013 and July 2015.

6. National Sea Level Networks

6.1 New Zealand Tsunami Monitoring Network

GNS Science and Land Information New Zealand (LINZ) operate a network of real-time tsunami gauges around the New Zealand coasts and on nearby offshore islands as part of GeoNet, New Zealand's geological hazards monitoring system; see http://www.geonet.org.nz). The network consists of 17 tsunami monitoring stations (Figure 2). These are owned, designed and operated by New Zealand as part of the LINZ-GNS Science partnership. An additional two Australian stations at Norfolk Island and Macquarie Island complement the network.

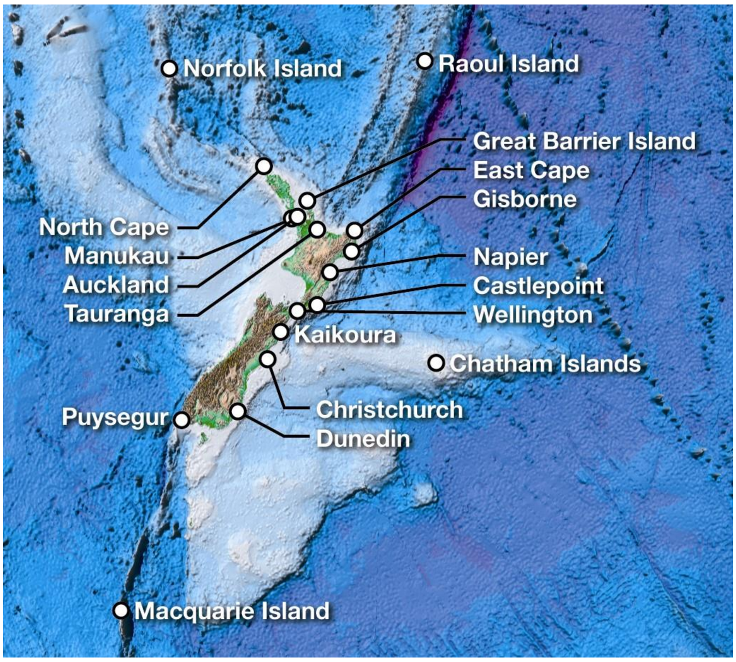

Figure 2: New Zealand Tsunami Monitoring Network. The New Zealand Tsunami Monitoring Network consists of 17 tsunami monitoring stations including two stations on Raoul Island. This network is complemented by the Australian tsunami monitoring stations on Norfolk Island and Macquarie Island.

At each New Zealand station, sea level is measured by two pressure sensors submerged in the ocean. Sea level measurements, sampled at 10 Hz, are transmitted to the GeoNet Data Management Centre in Lower Hutt. Data are available to tsunami warning centres in real-time via the GTS as well as over the Internet via Seedlink (a seismic data exchange protocol).

The National Institute of Water and Atmospheric Research (NIWA), port companies, regional and district councils operate various sea-level gauges which complement the operational near real-time monitoring undertaken by GeoNet (New Zealand's geological hazard monitoring system).

Real-time raw and de-tided time series are displayed on the GeoNet website: http://www.geonet.org.nz/tsunami/gauges and freely available for download via the GeoNet ftp site: ftp://ftp.geonet.org.nz/tsunami.

A new site is planned for Charleston on the west coast of the South Island at the same site as (and replacing) the NIWA site which has been decommissioned. Currently the site installation is awaiting good weather conditions. This site will have the same dual pressure sensor installation as the other LINZ-GNS sites (operated as a part of GeoNet).

NAME	CODE	LATITUDE	LONGITUDE	DATE_OPENED	SENSORS
Wellington	WLGT	-41.2846	174.7791	6/03/2007	2 x Druck
Napier	NAPT	-39.4757	176.9201	26/09/2007	2 x Druck
Chatham Island	CHIT	-44.0240	-176.3675	16/12/2007	2 x Druck
Gisborne	GIST	-38.6754	178.0229	10/03/2008	2 x Druck
Tauranga	TAUT	-37.6411	176.1812	21/05/2008	2 x Druck
East Cape	LOTT	-37.5504	178.1590	10/10/2008	2 x Druck
North Cape	NCPT	-34.4148	173.0487	23/12/2008	2 x Druck
Auckland	AUCT	-36.8314	174.7865	26/03/2009	2 x Druck
Boat Cove, Raoul Island	RBCT	-29.2800	-177.8944	18/05/2009	2 x Druck
Fishing Rock, Raoul Island	RFRT	-29.2511	-177.9038	18/05/2009	2 x Druck
Castlepoint	CPIT	-40.8993	176.2317	16/09/2009	2 x Druck
Dunedin	OTAT	-45.8143	170.6294	25/02/2010	2 x Druck
Kaikoura	KAIT	-42.4129	173.7028	27/05/2010	2 x Druck
Manukau	MNKT	-37.0466	174.5117	15/07/2010	2 x Druck
Great Barrier Island	GBIT	-36.1890	175.4889	26/07/2010	2 x Druck
Christchurch	SUMT	-43.5701	172.7738	11/08/2010	2 x Druck
Puysegur	PUYT	-46.0848	166.5894	28/11/2009	2 x Druck

Table 6: New Zealand Tsunami Monitoring Network: site names, codes, locations, date opened and deployed sensors. Stations are ordered according to date opened.

6.2 National Institute of Water and Atmospheric Research (NIWA)-coordinated sea-level network

NIWA continues to coordinate on-line presentation of data from an open-coast network of sea-level gauges around New Zealand, (see Figure 3 below) mostly recording at one minute intervals. Five NIWA gauge sites have been closed due to budget constraints. The Jackson Bay gauge owned by the National Tidal Centre (Bureau of Meteorology, Australia), burnt down due arson in January 2012, has since been re-instated via an agreement between Bureau of Meteorology and NIWA. The network is not real-time, but stations can be interrogated on demand or used for post-event analysis. A daily update on sea levels, tides, storm surge and tsunami from selected sites can be found at: https://www.niwa.co.nz/our-services/online-services/sea-levels

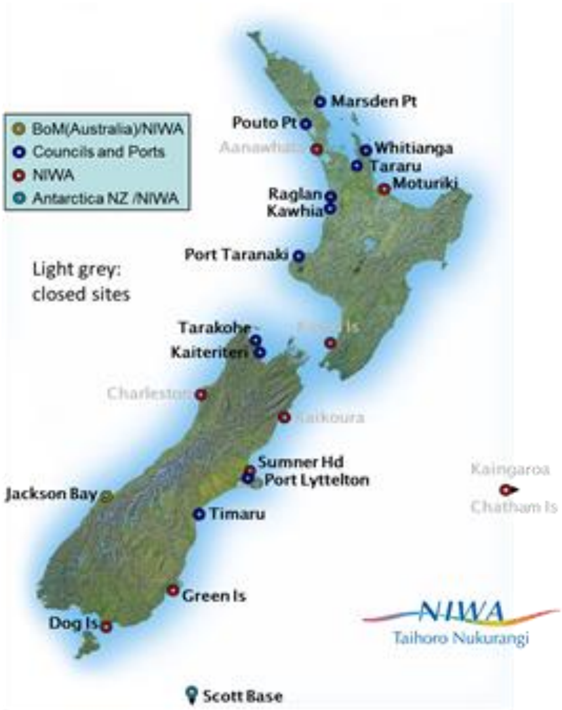

Figure 3: NIWA coordinated sea-level network (with grey labelled sites now closed).

7. Information on Tsunami occurrences

During the inter-sessional period (June 2013 – April 2015) none of the events listed in Tables 3 – 5 were recorded on the GeoNet tsunami monitoring network and the NIWA coordinated network.

8. URL's of national tsunami-related web sites

www.gns.cri.nz

www.geonet.org.nz/tsunami

www.niwa.co.nz

www.civildefence.govt.nz

PART 2: NATIONAL PROGRAMMES AND ACTIVITIES INFORMATION

9. EXECUTIVE SUMMARY

The New Zealand Tsunami Risk Management Programme continued to make progress towards tsunami mitigation in New Zealand during the inter-sessional period. The programme is led by the Ministry of Civil Defence & Emergency Management (MCDEM) and focuses on improving the quality and effectiveness of warnings, enhancing evacuation planning and standardising signage and public advice.

The work conducted under the Programme focus on four strands, and is either completed or of on-going nature:

- Knowledge: Improving our understanding of tsunami sources relevant to New Zealand and their threat potential.

- Warning Systems: Upgrading of the National CDEM Warning System and providing guidance to local authorities on public alerting systems.

- Planning: Development and maintenance of a National Tsunami Advisory and Warning Plan that formally states the warning system for tsunami. Also, providing guidance on tsunami evacuation zones and mass evacuation planning.

- Public Awareness: Setting national standards for tsunami signage and tsunami sirens, and establish consistent public education/messages.

The programme is on-going with the focus mainly on further knowledge improvement, e.g. research on sources, further development of modelling and enhancing ability to warn on local source tsunamis.

10. NARRATIVE

NEW ZEALAND CAPABILITIES IN RELATION TO TSUNAMI MITIGATION

This section is presented in two parts. Firstly, work conducted under the MCDEM sponsored Tsunami Risk Management Programme is described. Secondly work conducted individually or collectively by research agencies (in particular GNS Science and NIWA) is described as individual items.

10.1 Tsunami Risk Management Programme

The Tsunami Risk Management Programme is led by the Ministry of Civil Defence & Emergency Management (MCDEM). It was established in 2007 to focus on improving the quality and effectiveness of warnings, enhancing evacuation planning and standardising signage and public advice.

To ensure inclusiveness in decisions and subsequent acceptance of outcomes under the programme by local authorities, MCDEM established a Tsunami Working Group to consider and approve a stream of work to improve tsunami resilience in New Zealand. The Working Group represents civil defence emergency management at national and local level and is chaired by MCDEM.

The Working Group agreed that to improve tsunami resilience, the following areas need to be addressed:

- **Knowledge:** Improving our understanding of tsunami sources relevant to New Zealand and their threat potential.
- **Warning Systems:** Upgrading of the National CDEM Warning System and providing guidance to local authorities on public alerting systems.
- **Planning:** Development and maintenance of a National Tsunami Advisory and Warning Plan that formally states the warning system for tsunami. Also, providing guidance on tsunami evacuation zones and mass evacuation planning.
- **Public Awareness:** Setting national standards for tsunami signage and establish consistent public education/messages.

Work towards all the above areas is funded by MCDEM and many of its objectives have been delivered. The programme is however on-going with the more recent focus on further knowledge improvement, e.g. research on sources, further development of modelling, a review of the national tsunami risk assessment, improvement of existing guidelines and the development of a national standard for tsunami sirens.

Individual strands of work conducted under the Tsunami Risk Management Programme in the inter-sessional period are described below.

10.1.1 Review of the Tsunami Hazard Risk in New Zealand

Following the 2004 Indian Ocean tsunami, the Government requested the Ministry of Civil Defence & Emergency Management (MCDEM) to report on New Zealand's exposure to tsunami risk. MCDEM commissioned GNS Science to conduct this assessment and the report *Review of Tsunami Hazard and Risk in New Zealand* was completed in 2005. See www.mcdem.govt.nz

Advanced research and understanding of tsunami risk indicated that an update of the 2005 assessment was necessary. MCDEM commissioned GNS Science to conduct this update which was published in August 2013.

A substantially revised probabilistic hazard model has been constructed for the 2013 report. It evaluates the potential of all known seismic sources to generate tsunami, and provides a quantitative assessment of tsunami hazard at all areas of the New Zealand coast. It therefore provides a more refined estimate of the tsunami hazard for all parts of the New Zealand coastline (the 2005 report focused only on the main metropolitan centres). The updated report can be found on the MCDEM website www.mcdem.govt.nz .

10.1.3 Public Alerting

To support local authorities with the selection of the most appropriate public alerting mechanisms, MCDEM published a guideline *Public Alerting: Options Assessment* in 2009 that:

- Assess all public alerting options currently available in New Zealand
- Assess and advise on public alerting options not currently available in New Zealand
- Introduce an assessment tool that local authorities can apply to identify the most appropriate public alerting mechanisms for their specific circumstances, e.g. demographic, geographic, budget factors

The guideline was updated in 2014 to account for new technologies. It is available on the MCDEM website: www.mcdem.govt.nz

An all of government project was initiated in 2014 to establish of a mobile based national public alerting capability. An indicative business case was prepared and the project is now at the detailed business case stage. Subject to funding, implementation will start in the second half of 2015. The preferred option is a multi-channel approach that includes Cell Broadcasting and/or SMS technology as well as a Smartphone Application.

10.1.5 National Tsunami Advisory and Warning Plan

The *National Tsunami Advisory and Warning Plan* was updated by MCDEM in 2014 to reflect the new PTWC products. The Plan states the following:

- Responsibilities (agencies) with regard to tsunami warning
- Processes for tsunami notifications
- Types of tsunami notifications
- Action guidelines
- Templates
- Tsunami categories and threat

The Plan is available on the MCDEM website: www.mcdem.govt.nz

10.1.6 Guideline on Tsunami Evacuation Zones

A standard for tsunami evacuation zones in New Zealand and guidelines for defining and mapping tsunami evacuation zones was published by MCDEM in December 2008. The guideline followed extensive research (looking at experiences elsewhere in the world) and consultation within the NZ Tsunami Working Group. The *Guideline on Tsunami Evacuation Zones* is available on the MCDEM website: www.mcdem.govt.nz

The guideline is currently under review to reflect the updated *Review of Tsunami Hazard and Risk in New Zealand* and to provide for enhanced mapping methodology. This work will be completed in 2015.

10.1.9 National Tsunami Siren Standard

Although New Zealand does not advocate the use of sirens for tsunami warning, the reality is they are being used by local authorities and they have subsequently been calling for a national technical standard in this regard. Based on research and technical engineering input, a standard was developed and published in 2014.

The *National Standard for Tsunami Sirens* is available on the MCDEM website: www.mcdem.govt.nz

10.1.11 Tsunami Seminars

A series of regional tsunami seminars were held in 2013 jointly by MCDEM and GNS Science to communicate the 2013 updated version *Review of Tsunami Hazard and Risk in New Zealand* report and to consult local authorities on the development of the Sirens Standard. Each seminar covered the same topics but was held in a different region across New Zealand.

A seminar was held in Gisborne in October 2014 to start discussion on the next focus topics for the Tsunami Risk Management Programme, such as the development of guidance on land use planning from a tsunami hazard perspective, building standards and specifications for vertical evacuation structures.

10.2 Other Work Conducted by Research Agencies

10.2.1 Submarine landslide studies in Kaikoura Canyon

Research being carried out by NIWA scientists in collaboration with Environment Canterbury, The University of Canterbury and the University of Bremen (Germany) is helping provide new insights into the tsunami risk from undersea landslides in the Kaikoura Canyon. The Kaikoura Canyon is a submarine canyon just off the east coast of the South Island, and connects the continental shelf with deep ocean basins to the north. Submarine landslides are one of the main processes that create submarine canyons. Modelling by NIWA scientists in 2006 looked at the potential severity of tsunamis off the Kaikoura coast, either triggered by submarine earthquakes or as a result of a submarine landslide of sediment occurring at the head of the Kaikoura canyon.

Kaikoura is the most dynamic and active submarine canyon on the New Zealand margin, coming to within 500 metres of the shoreline and dropping to 1000 metres deep within 5 km of the shoreline. Previous modelling showed that a submarine landslide at the head of the canyon would cause a significant tsunami that would arrive in South Bay with very little warning. The maximum modelled wave height is 13 m above sea level. Given the severe consequences of this scenario, NIWA scientists were very keen to apply state of the art surveying techniques to the problem to determine if the landslide tsunami source is realistic.

New geophysical, geological and geotechnical data have been collected from the canyon head area to map the shape of the seafloor, determined the thickness of the sediment and analyse how much sediment is accumulating in the canyon head due to ocean currents and large storm activity. Currently a laboratory program is being completed by a doctoral student at the University of Canterbury to determine the strength of the potentially unstable sediments. This will be incorporated into a geomechanical model to calculate slope stability and determine the potential size and location of failures and what level of earthquake-generated ground shaking might be required to cause failure. In 2015/2016 numerical modelling of tsunami generation and propagation from these landslide sources will be modelled for the Kaikoura region.

This work is jointly funded by NIWA and Environment Canterbury. http://www.niwa.co.nz/news/niwa-survey-work-helps-assess-kaikoura-tsunami-risks

10.2.2 Review of tsunami hazards in New Zealand: Journal paper

An extensive review paper on the tsunami hazard, assessment and risk in Aotearoa–New Zealand from AD 1868 to 2012, has been compiled by Darren Ngaru King and published in Earth Science Reviews. This paper presents a systematic review of peer-reviewed journal articles, scientific reports, books and research theses covering tsunami hazard, assessment and risk in Aotearoa-New Zealand (A–NZ). 222 references were identified as directly relevant to tsunami hazard, assessment and risk in A–NZ with a further 51 references identified by scrutinising the original 222 references.

A meta-analysis of the collective scholarship shows six principal areas of scientific endeavour: (i) observation and cataloguing of modern and historical tsunami impacts caused by earthquakes and landslides, (ii)modelling and evaluation of near- and far-field generated tsunamis, (iii) detailed mapping and assessment of offshore seismic and other geological structures responsible for near-field tsunami generation, (iv) investigation and cross-referencing of Holocene palaeo-records of tsunami deposits preserved in wetlands, dunes and other coastal landforms, (v) survey and reconnaissance of modern and historical tsunami impacts, and (vi) guidance for tsunami hazard mitigation, preparedness and land-use planning. Synthesising all of these references, it is clear that A–NZ has been affected by remote, regional and locally generated tsunami during the historic, pre-written and pre-human periods. Further, scientific knowledge of tsunami risk and the forces responsible for tsunami generation has greatly improved. However, in spite of the many scientific advances detailed in this review, much more remains to be done to better understand and deal with the diverse tsunami hazard and risk facing A–NZ.

King, D.N. 2015. Tsunami hazard, assessment and risk in Aotearoa-New Zealand: A systematic review. Earth Science Reviews. 145 (2015) 25-42

10.2.3 Palaeo-tsunami Database

Funding from the Ministry of Civil Defence & Emergency Management (MCDEM) to update the New Zealand Palaeo-tsunami Database was confirmed in December 2014. The work programme aims to bring together all known information about palaeo-tsunamis across New Zealand to produce a user-friendly tool for quantifying and qualifying tsunami hazard and risk for coastal-marine planning and management. This work will build upon the recent release of the historical tsunami database by the GNS Science and comprise:

(i) a systematic review of existing records of palaeo-tsunamis that have impacted New Zealand – including quality assurance of all available data;
(ii) the configuration, design, and implementation of a database that is compatible with the development of other internationally significant databases;
(iii) peer-reviewed raw data readily available for the scientific community involved in tsunami hazard and risk research; and
(iv) an experimental web-interface capable of facilitating enhanced processing, analysis and interpretation of palaeo-tsunami information.

This collaborative project involves the National Institute of Water and Atmosphere (NIWA), University of New South Wales (UNSW), Environment Canterbury (ECAN) and Dumpark Ltd.

10.2.4 Wairau Lagoon paleo-tsunami study (NIWA and UNSW)

Māori oral traditions (pūrākau) from the north-east coast of the South Island of Aotearoa-New Zealand reference multiple experiences with extreme environmental disturbances and impacts. Previous research has shown there is significant agreement between the geographies of risk that derive from such pūrākau and contemporary scientific data about palaeo-tsunamis. It is within this context as well as the critical proximity of Wairau Lagoon to the southern Hikurangi subduction zone interface that the potential for a record of palaeo-tsunami events was recognised. Sedimentary, geochemical, micro-fossil (diatom and pollen) and geochronological analyses were recently completed to evaluate the character and approximate age of disturbance deposits found across the Wairau Lagoon. Topographical surveys were also undertaken to help place and interpret any evidence found in the geographical and geomorphological context of the wider Wairau Lagoon site. The findings from this work are currently being written up for peer-reviewed publication.

10.2.5 Tsunami Generation Propagation and Inundation Modelling at GNS Science

At GNS Science, another tsunami modelling package, COMCOT (Cornell Multi-grid Coupled Tsunami), has been developed on the basis of an earlier recreation by the wave research group at Cornell University, USA and has been continuously being improved by Dr. Xiaoming Wang in the past couple of years (Liu et al., 1998; Wang and Power, 2011). The model is capable of simulating tsunami generation by instantaneous or transient seafloor movement, transoceanic propagation and run-up and inundation in coastal areas.

With this tsunami modelling package, tsunami inundation studies have also been carried out for several coastal communities around New Zealand, including coastal communities in Bay of Plenty (e.g., Tauranga, Mt Maunganui, Papamoa, Matata, Wairake, Te Tumu, Wahakatane, Ohope and Opotiki), Gisborne (Poverty Bay, Tokomaru Bay, Tolaga Bay, Hicks Bay and Te Araroa) and Southerland (e.g., Tiwai Point, Bluff and New River Estuary), with the likely worst-case scenarios constructed from the seismic sources in Puysegur Trench, Hikurangi Trench, Tonga-Kermadec Trench, Southern New Hebrides and South America.

Liu, P. L.-F.; Woo, S.-B. and Cho, Y.-S. (1995). Computer programs for tsunami propagation and inundation. Technical report, Cornell University, USA, 1998.

Wang, X. and Power, w. (2011). COMCOT: a Tsunami Generation Propagation and Run-up Model, GNS Science Report 2011/43 127 p, in press.

10.2.6 Mitigating Tsunami Risk in Coastal Development

In the past two years, GNS has completed several studies in collaboration with Tauranga City Council on incorporating tsunami hazards into its long-term coastal development planning. Under the banner of SmartGrowth – a collaboration involving Tauranga City Council, Western Bay of Plenty District Council and Bay of Plenty Regional Council working with industry and community groups, these studies analyse the tsunami inundation potentials and resulting impact on human life in the coastal suburbs of Papamoa, Wairake, Te Tumu and Matata and provide a number of measures that can be incorporated into land use planning in order to reduce loss of life.

10.2.7 Review of Data Sources for Tsunami forecasting in New Zealand

A review report has been completed at GNS Science on existing sources of data information, including seismic data, GPS and coastal tide gauge data, in New Zealand and their readiness for tsunami forecasting (Barberopoulou et al., 2013). The report summarises the up-to-date operational status and current utilization of these types of data and analyses their availability and potential improvements for real time tsunami forecasting in New Zealand.

Barberopoulou, A.; Ristau, J.; D'Anastasio, E. and Wang, X. (2013). Sources of information for tsunami forecasting in New Zealand, GNS Science Report 2013/32. 64p.

10.2.8 Historical Tsunami Database in New Zealand

A historical tsunami database has been continuously under compilation at GNS Science in order to preserve historical information on past tsunami events in one location and in a format that will make it an important resource for future research both in New Zealand and internationally. The database is also being used to document modern events so that there is a central repository for information about tsunamis that impacted New Zealand. Such information will aid understanding of the threat that tsunamis pose to New Zealand and, combined with other data such as palaeotsunami records (tsunami deposits), can help in estimating recurrence intervals for damaging tsunamis at different parts of the coastlines in New Zealand.

As part of this project there is a requirement for checking, editing and cross-referencing of source material and database entries. Collection and entry of material on recent tsunamis is also required.

10.2.9 Landslide Tsunami Hazard Study

A joint contestable research project has been completed by GNS Science and NIWA on the topic of landslide tsunami hazard assessment. The research focused on the investigation and development of appropriate methodologies and numerical tools to evaluate tsunami hazards from submarine landslides, particularly in Cook Strait as an example.

Magnitude-frequency curves for landslide occurrence were developed from geological knowledge and empirical data on landslides collected from the Cook Strait Canyon. A method of estimating landslide occurrence through seismic data and geophysical properties was also developed.

The study developed a method to efficiently model tsunami generation by a landslide within the constraints of a canyon. This was used to model the effects (in terms of wave height at coast) of potential tsunamis generated by landslides of varying sizes throughout the Cook Strait Canyon.

The information on landslides and tsunamis was combined to produce a probabilistic tsunami hazard assessment giving wave heights at the coast for the entire Cook Strait region. Furthermore, this methodology could be used to study landslide-tsunami hazard in other regions.

10.2.10 Tsunami in New Zealand Ports and Harbours

This Natural Hazards Research Platform (NHRP) commissioned research involves two subcontract projects that have now been completed.

The first research project provided GNS and MCDEM with a set of guidelines and a decision-making flow charts for estimating the onset time, severity and duration of tsunami induced water levels, currents and surges at the studied New Zealand ports and harbours. Numerical tools will be used to model and analyse the responses of the ports and harbours to the recent far-field tsunami events. Its outcome will enhance MCDEM's ability to respond to a far-field tsunami hazard and give site-specific recommendations in real time.

The second research project focuses on the resilience of port structures to tsunami in New Zealand. The characteristics of tsunami loading on port/wharf structures will be analysed and summarised using physical and numerical structure-tsunami interaction experiments at the University of Auckland. The outcome will assist with the development of fragility models for the estimation of damage states and losses for a range of return period tsunami events and will be integrated into the national Riskscape assessment tool.

10.2.11 Local Tsunami Early Warning System Study

A recent feasibility study undertaken by GNS Science in collaboration with international partners assessed the feasibility of implementing a local tsunami early warning system focussing on "tsunami earthquakes" in New Zealand. The March 1947 tsunami earthquake off the coast north of Gisborne, New Zealand was chosen for this work. A data set was created using hybrid simulations of dynamic and static displacements similar to the March 1947 tsunami earthquake. These data were used to assess GeoNet's detection capabilities and potential required updates to the network. A suite of detection, classification and inversion algorithms were tested with the simulated data. The conclusion from this study was that an event similar to the 1947 Gisborne Tsunami Earthquake could be detectable by the network in real time. A combination of seismic and geodetically derived deformation data is required to drive a rapid detection, classification and inversion algorithm chain. For an operational Early Warning system to be implemented a large portion of the geodetic sensor network needs to be upgraded to stream data in real time.

10.2.12 Tsunami Mitigation Cost-benefit Study

A recent cost-benefit study of tsunami mitigation in New Zealand highlighted the current low investment in all aspects of tsunami preparedness compared with comparable risks. For example, tsunami mitigation receives around 1/20 of the funding compared to more frequent risks (normalised so the comparison is valid) such as vehicle accidents. The study also suggested that the operation of a fully staffed 24/7/365 warning centre is a necessity (currently New Zealand uses on-call staff). The study was commissioned by the Earthquake Commission (New Zealand's mandated disaster insurer) and carried out by the New Zealand Institute of Economic Research (NZIER).

David Coetzee
ICG/PTWS Tsunami Warning Focal Point and National Contact
Ministry of Civil Defence & Emergency Management
New Zealand

10 April 2015