

Hikurangi and Kermadec Islands Earthquakes 5 March 2021

Post-Event Report

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1 PURPOSE

The National Emergency Management Agency (NEMA) is working to embed a culture of continuous improvement. Every emergency provides an opportunity to reflect on our performance and identify opportunities to improve our work to build safe and resilient communities in Aotearoa New Zealand. NEMA works with its partners, stakeholders and the media to achieve this.

The purpose of this report is to provide an overview of the NEMA response to the earthquakes and subsequent tsunami threats generated by a series of large earthquakes off the East Coast of New Zealand and in the Kermadec Islands on 5 March 2021. The report captures aspects of the response that may be improved and aspects that worked well. In particular, the report focuses on lessons for effective communication in future events, with the intention of providing clear and timely advice, mitigating confusion, and ultimately, preserving life safety.

The report represents NEMA's standard process following each response with debriefing, capturing lessons, and identifying any corrective actions that may be necessary. Although this process focuses on NEMA's own response performance, the end-to-end tsunami warning process involves a number of agencies. The report identifies areas where NEMA will lead work with these agencies to improve the overall process. The response of regional CDEM Groups and wider context of the CDEM framework and its structures were not in scope for the report.

2 EXECUTIVE SUMMARY

New Zealand's tsunami risk is comparable to or larger than its earthquake risk. The most significant threat comes from tsunami generated within one to two hours travel time from the nearest New Zealand coastline. No part of the New Zealand coastline is completely free from tsunami hazards.

The National Emergency Management Agency (NEMA) is New Zealand's lead agency for tsunami hazards and has statutory responsibility for issuing official warnings and advisories relating to tsunami activity. In giving effect to this role NEMA is led by its wider objective of putting the safety and wellbeing of people at the heart of the emergency management system.

On Friday 5 March 2021, three large earthquakes occurred offshore of New Zealand. The first earthquake occurred at 2.27am (a Magnitude 7.3 off East Cape) and was followed by two earthquakes in the Kermadec Islands, a Magnitude 7.4 earthquake at 6.41am and a Magnitude 8.1 earthquake at 8.28am. They all generated tsunami that overlapped and were recorded around New Zealand. This was a complex series of events that resulted in a response that was generally well-managed. This report focuses on the collective response to these three separate events.

There were many positives for NEMA during this response, including the prompt evacuation actions by the public, the performance of the National Warning System and use of Emergency Mobile Alerts (EMAs), and proactive engagement with the media throughout the response. However, areas for further improvement remain, in particular ensuring more timely advice is provided to the public and speeding up the end-to-end warning process.

A comprehensive debriefing process was undertaken after this response to ensure that lessons were captured from these events. This report provides an overview of the events and their impacts, the response at the national level, and the strategic and operational findings captured through the debrief process. It also suggests remedies for areas that can be improved.

2.1 Strategic Findings

2.1.1 The provision of advice to the public needs to be sped up

While there is a fine balance between the need for speed and accuracy in the event of tsunami warning, for local source events speed should be of the essence. Speeding up the provision of tsunami warnings is a key focus for the Government, and NEMA and GNS Science have identified some areas for improvement in relation to the tsunami warning process.

2.1.2 Further improvements to the distribution of agency responsibilities would improve the tsunami warning process

Rapid and effective tsunami warnings continue to be hampered by the current practice whereby GNS Science is responsible for monitoring and making tsunami threat assessments while NEMA is responsible for issuing tsunami warnings and advisories. The layers of this arrangement create complexity and can cause delay.

2.1.3 Collaboration between agencies was supported by existing relationships

Relationships should continue to be developed and maintained, particularly through cross-agency exercising and system learning. Continued strong engagement between the NEMA and GNS Science Duty Teams is needed to ensure swift assessment and response (warnings).

2.1.4 Public understanding of what to do when there is a local source tsunami is improving

The primary tsunami warning for a local source earthquake will always have to be the natural warning signs themselves (i.e. the shaking) due to the short travel time from the earthquake epicentre to the nearest coastline (often under 15 minutes). It is encouraging that many coastal communities did not wait for official warnings and self-evacuated upon recognising the natural warning signs following the East Cape earthquake on 5 March 2021. This is a positive sign and indicates that public education messages, in particular the “Long or Strong, Get Gone” messaging and tsunami arrangements for local source tsunami events, have been effective.

2.2 Operational Findings

2.2.1 Scientific advice from GNS Science continues to be best for New Zealand

As a New Zealand-based organisation, only GNS Science has the necessary depth and breadth of local scientific knowledge required to make informed estimates of a tsunami’s threat for New Zealand.

2.2.2 Activation in response was effective

The NEMA Duty Team was responsive and the use of Microsoft Teams was good for communication and visibility of actions. There was clear and decisive decision making, especially following the third earthquake event (based on the magnitude and location of the earthquake).

2.2.3 The widespread use of EMA messaging was generally effective but the overlap of national and local EMAs needs further consideration

This was the first response where a significant number of EMA messages were disseminated over wide geographic areas. Three EMAs were sent by NEMA to instruct people to evacuate. Eighteen EMAs were also sent by CDEM Groups to widen evacuation areas and to notify people in regions where strong and unusual currents were expected.

Although in line with pre-existing mandates, the issuing of both national (NEMA) and local (CDEM Group) EMAs led to some confusion. This needs to be addressed moving forward.

2.2.4 Public information was disseminated through a wide variety of channels and extensive ‘reach’ was achieved

The NEMA Public Information Manager and the wider communications team proactively engaged with the media throughout the response.

The media did an excellent job of clearly communicating life safety messages throughout what was a dynamic and complex sequence of events, reinforcing the vital role they play as an emergency communications channel.

Support was expressed for the role played by the GNS Science representative who contributed to the media stand-ups, alongside the Minister for Emergency Management and acting Director CDEM, to provide scientific context and advice.

2.2.5 There is continued confusion between the use of land threat versus beach and marine threat

The use of the term 'Beach and Marine Threat' continues to be perceived by both the media and the public as the same as a 'Land Threat'. Confusion between the two threat categories can result in an incorrect perception from the public that they need to evacuate.

This has been an identified issue in previous tsunami threats and changes have been made to the text used in warning and advisory templates to better explain the differences. However, further refinement of the text and public education will be required in advance of future events.

2.2.6 The events had the potential to stretch NEMA resources

Although this series of events did not result in casualties or significant land damage, the long duration nature of such a response from the early hours of the morning began to impact on NEMA staff wellbeing and resourcing.

Due to the early and repeated tsunami notifications that all NEMA staff receive, even those staff not on duty were experiencing constant interruptions to sleep prior to any rostered shift they were required for. The impacts of this would have become more pronounced with a longer duration event.

2.3 Although tsunami warning processes have improved, more work is needed to address recurring issues

A number of areas have been recommended for improvement following previous tsunami responses and have been acted on. However, a number of areas do not have quick fixes and require continued focus to lift the effectiveness of New Zealand's tsunami monitoring and warning systems.

NEMA has established an Exercises, Evaluation and Lessons Management Team to improve cross-agency continuous improvement processes following emergency responses and simulation exercises. The planned introduction of a national lessons management system will bolster continuous improvements efforts and support the increased effectiveness of the tsunami warning system.

3 INTRODUCTION

3.1 New Zealand's tsunami risk

New Zealand's tsunami risk is comparable to or larger than its earthquake risk. Large tsunamis have occurred in New Zealand within written history but have resulted in few deaths and relatively modest damage. However, Maori tradition records several large tsunami killing many people within the last 1000 years. Archaeological evidence indicates that several coastal settlements around New Zealand were abandoned for higher ground in the mid-1400s and there is also geological evidence of tsunami with up to 60m run-ups affecting the New Zealand coast within the last 6000 years.

New Zealand's location astride a plate boundary means that it experiences many large earthquakes. Some cause large tsunami. New Zealand's coasts are also exposed to tsunami from submarine and coastal landslides, and from island and submarine volcanoes. In addition, tsunami generated by large earthquakes at distant locations, such as North and South America, or the Aleutians in the North Pacific Ocean, could also be damaging in New Zealand.

Tsunami with run-up heights of a metre or more have occurred about once every 10 years on average somewhere around New Zealand, a similar frequency to Hawaii and Indonesia, but about one third of that in Japan. Smaller tsunami occur more frequently and are often only detectable on sea-level recorders.

With intensification of coastal development over the last few decades, a large tsunami today is likely to be very damaging. One of the most significant threats comes from tsunami generated within one-two hours travel time from the nearest New Zealand coastline.

New Zealand can expect tsunami in the future. Some coasts are more at risk than others because of their proximity to areas of high local seismic activity, or exposure to tsunami from more distant sources. No part of the New Zealand coastline is completely free from tsunami hazard.¹

Over the last five years, New Zealand has experienced a number of regional or local tsunami events and our ability to respond to these threats has developed over this period although there are further lessons to learn. Some of the previous events experienced were:

- East Cape earthquake and tsunami: 2 September 2016
- Kaikoura earthquake and tsunami: 14 November 2016
- Kermadec Islands earthquake and tsunami 16 June 2019.

3.1.1 The tsunami warning process

NEMA is New Zealand's official agency for providing tsunami advisories and warnings. GNS Science, via the National Geohazards Monitoring Centre, is responsible for monitoring and reviewing earthquake and tsunami related data to determine what it means for New Zealand. Only advisories and warnings issued by NEMA represent the official threat status for New Zealand, as the information used is confirmed by GNS Science.

Assessing tsunami activity and providing accurate, timely warnings depends on the location (distance) of the earthquake. A distant source tsunami gives GNS Science time to gather confirmed data and assess the tsunami's characteristics. The more distant the tsunami's origin, the more time available to assess it, and the more accurate that assessment will be. Unfortunately, the inverse is also true. If the tsunami's origin is close to New Zealand (a so-called

¹ For more on New Zealand's tsunami hazard, see Power, W. L. (compiler). 2013. Review of Tsunami Hazard in New Zealand (2013 Update), *GNS Science Consultancy Report 2013/131*.

local-source event), a tsunami could arrive within minutes and communities must act immediately. GNS Science may not have enough time to assess the threat, and NEMA may not have enough time to issue an official warning before the first waves arrive.

The warning process is different for local-source earthquakes as compared with tsunami generated from further away (regional and distant-source tsunami). Local-source tsunami include those originating in the Kermadec Island area, which have been identified as requiring similar treatment to a local-source event, given tsunami waves may have a travel time of approximately one hour to the nearest New Zealand coastline depending on the earthquake epicentre. This report focuses on local-source and Kermadec Island-source earthquakes and associated processes.

New Zealand's first tsunami monitoring information originates from the United States' National Oceanic and Atmospheric Administration (NOAA), which is responsible for the Pacific Tsunami Warning Center (PTWC) in Hawai'i which focusses on Pacific Ocean countries tsunami threats. PTWC is able to locate and characterise earthquakes anywhere in the Pacific basin and provide a tsunami threat estimation and ongoing updates until the threat has passed, in some cases over 24 hours later for trans-Pacific waves.

New Zealand has augmented this internationally sourced capability with the National Geohazards Monitoring Centre (NGMC)², a 24/7 service operated by GNS Science with funding from the Ministry of Business, Innovation and Employment (MBIE). When regional and distant earthquakes occur, the NGMC receives a tsunami threat message from the PTWC which it then uses to determine whether the threat meets NEMA's thresholds for advisories and warnings. For local earthquakes, the NGMC determines the earthquake characteristics from New Zealand's own geophysical networks.

When NEMA receives notification of an earthquake, either via Geonet or the Pacific Tsunami Warning Centre (PTWC) in Hawaii, the NEMA Duty Team reviews the earthquake parameters against pre-agreed thresholds and consults with GNS Science. If the earthquake is within the thresholds, NEMA will rapidly send out an *Earthquake being assessed* message via the National Warning System. When an earthquake is close to, but does not meet the thresholds, NEMA acts upon advice from GNS Science. These thresholds are outlined in the *Tsunami Advisory and Warning Plan [SP 01/20]* (available at www.civildefence.govt.nz). The NEMA Duty Team uses standard operating procedures to guide them in the process of whether or not to issue an advisory or warning.

National Warning System messages are sent to central government agencies, regional CDEM Groups, local authorities, emergency services, lifeline utilities and media. The information is also published on NEMA's website and social media channels (Facebook and Twitter).

The NEMA Duty Team is comprised of eight staff covering the roles of Duty Manager, Duty Officer, Warning Systems Specialist, Public Information Manager, Webmaster, a Duty Support Officer and two Regional Emergency Management Advisors (to support CDEM Groups in the North Island and the South Island). NEMA Duty responsibilities are performed by staff in addition to their business as usual roles. Unlike the GNS Science National Geohazard Monitoring Centre (NGMC), which is a dedicated and centralised 24/7 'awake' capability, NEMA's Duty Team is not 'awake' 24/7, working instead on an around the clock on-call basis.

² <https://www.gns.cri.nz/Home/Services/National-Geohazards-Monitoring-Centre>

3.1.2 Continuous improvement

Extensive work has gone into developing tsunami standard operating procedures over the years, and after every real event or exercise, they are modified as required to reflect any lessons identified. Investment in new tools to lift New Zealand's assessment capability has supported improved outcomes.

Since Exercise Tangaroa in 2016 (a national exercise based on a tsunami generated in the Kermadec Islands) and subsequent real local-source events, significant improvements have been made in the provision of tsunami warnings and advice to the public. These have included:

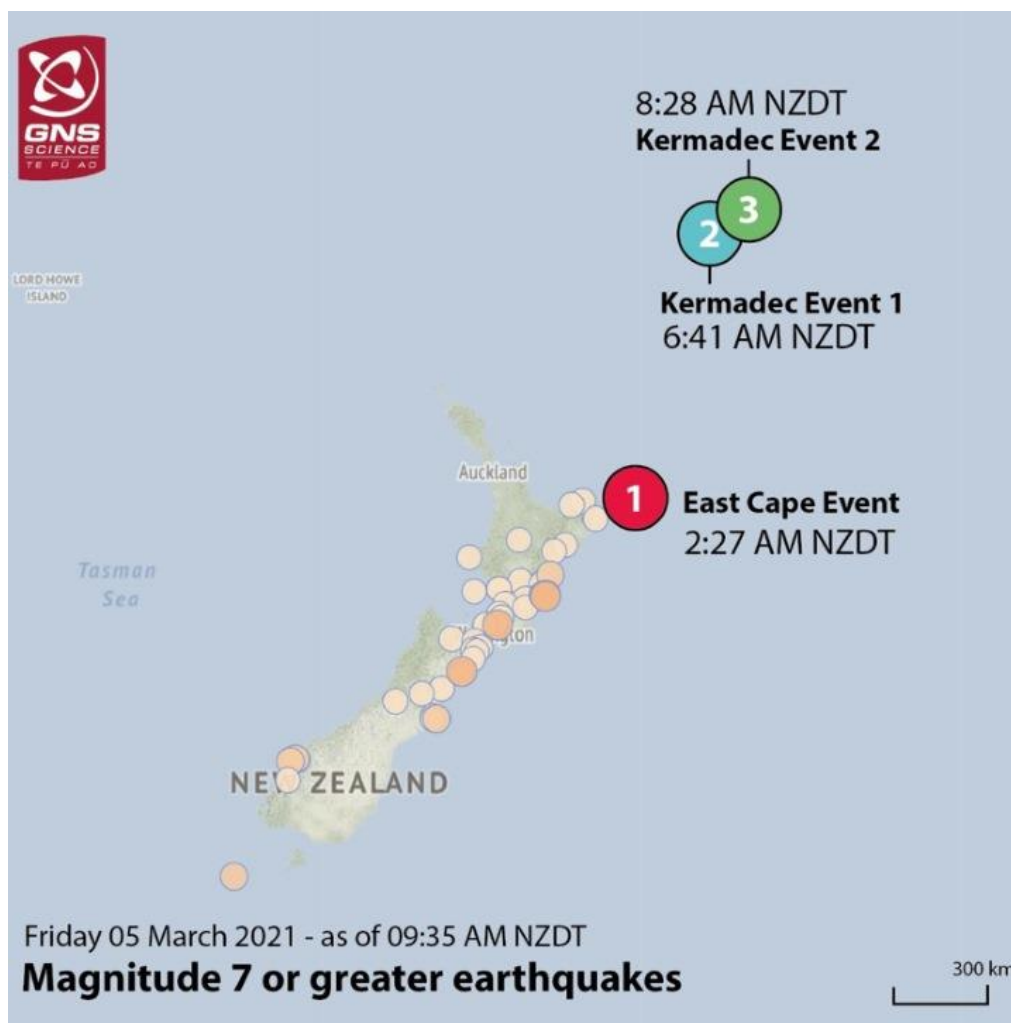
- The introduction of the Emergency Mobile Alerting (EMA) system, a cell-based broadcasting system for providing warning messages direct to the public in at-risk areas.
- An upgrade of the National Warning System that provides warning and advisories to partner agencies, the media and the public through improved processes.
- Ongoing public education, including the introduction of the “*Long or Strong, Get Gone*” campaign to encourage the public to follow natural warning signs and self-evacuate following a large earthquake felt on the coast.
- The establishment of GNS Science's National Geohazard Monitoring Centre, a 24/7 awake monitoring capability.
- Investment in Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys. NEMA receives threat advice from GNS Science; they are in turn advised by the Tsunami Experts Panel (TEP), which uses data from DART buoys to confirm tsunami detection, supplement models and refine threat maps.
- Improved collaboration and engagement between the NEMA and GNS Science Duty Teams, including a weekly duty drill where various scenarios are exercised.
- Strengthening how we work with broadcast media to ensure a common understanding of our arrangements and enable effective use of their channels during events.

4 OVERVIEW OF THE RESPONSE

4.1 Event Overview

On Friday 5 March 2021, three large earthquakes occurred offshore of New Zealand. The first earthquake occurred at 2.27am (a Magnitude 7.3) off East Cape which was widely felt across the country. This was followed by a Magnitude 7.4 earthquake at 6.41am and a Magnitude 8.1 earthquake at 8.28am in the Kermadec Islands to the north east of the North Island. All three earthquakes caused tsunami that reached New Zealand shores.

This was a complex series of events. This report focuses on the collective response to these three separate events.



Other earthquakes are noted using a felt scale

- | | | | |
|-----------|----------|----------|------------|
| ■ Extreme | ■ Severe | ■ Strong | ■ Moderate |
| ■ Light | ■ Weak | | |

4.1.1 East Cape Event, Magnitude 7.3, 2.27 AM, 5 March 2021

The East Cape (Hikurangi) earthquake occurred at 2.27am on 5 March 2021 and required scientific assessment to determine whether there was a tsunami threat to New Zealand. A National Advisory: Earthquake Being Assessed message was issued at 2.42am, four minutes after the NEMA Duty Team was notified of the earthquake.

After scientific assessment by GNS Science, a *National Tsunami Warning: Threat to Land and Marine Areas* was issued at 3.28am, 48 minutes after the *National Advisory: Earthquake Being Assessed* message was issued. An Emergency Mobile Alert advising at-risk communities (see Figure 3) to evacuate immediately was issued at 3.36am, one hour and 9 minutes after the earthquake occurred.

Further National Warning and Advisory messages were issued over the next two hours (as per arrangements set out in the [National Advisory and Warning Plan](#)), until GNS Science advice determined the threat to land had passed and evacuees were advised they could return home. A *National Advisory: Tsunami Activity – Cancelled* message was issued at 6.01am. No significant damage due to earthquake shaking was reported following this event.

4.1.2 Kermadec Event 1, Magnitude 7.4, 6.41 AM, 5 March 2021

After receiving notification of this earthquake by PTWC at 6.51am and following scientific advice, the NEMA Duty Team issued a *National Advisory: Tsunami Activity* message 38 minutes later at 7.29am, advising of the likelihood of strong and unusual currents and unpredictable surges at the shore. Further National Advisory messages followed over the next hour at 7.47am and 8.30am continuing to advise people to stay away from beaches and out of the water due to strong and unusual currents and surges.

4.1.3 Kermadec Event 2, Magnitude 8.1, 8.28 AM, 5 March 2021

A *National Warning: Tsunami Threat* message was issued at 8.45am, 17 minutes after the NEMA Duty Team was notified of this earthquake by PTWC. This warning was based on previously determined scientific thresholds for earthquakes of magnitude 7.9+ at a depth of <150km in this region. The warning was accompanied by an Emergency Mobile Alert message issued at 8.46am advising at-risk communities (see Figure 5) to evacuate immediately.

Following further scientific assessment by GNS Science, a *National Warning: Tsunami Threat to Land and Marine Areas* message was issued at 9.11am which contained more refined information relating to the threat areas. Further updates were provided at 9.49am, 10.44am, 11.40am, 12.41pm, until the tsunami threat was downgraded and a *National Advisory: Tsunami Activity* message was issued at 1.17pm warning of strong and unusual currents, and unpredictable surges at the shore. At this point people that evacuated were advised they could return, while they were still advised to stay out of the water due to on-going strong currents. A further update was provided at 2.48pm. Following further advice from GNS Science that the tsunami threat had passed, a *National Advisory: Tsunami Activity – Cancelled* message was issued at 3.45pm, signalling the end of the response to this event.

This was the first response where a significant number of EMA messages were disseminated over wide geographic areas. Three EMAs were sent by NEMA to instruct people to evacuate.

Throughout the day, Northland, Auckland, Waikato, Bay of Plenty, Tairāwhiti and Canterbury CDEM Groups also used the Emergency Mobile Alert system to advise residents in at-risk communities to evacuate, to stay away from the coast and beaches and when it was safe to return home.

Although in line with pre-existing mandates, the issuing of both national (NEMA) and local (CDEM Group) EMAs led to some confusion. This needs to be addressed moving forward.

The NCC stood down at 4.00pm with ongoing monitoring through usual duty processes.

4.1.4 Tsunami waves generated

All three earthquakes on 5 March 2021 produced tsunami waves that overlapped and were recorded all around New Zealand.

Tsunami waves were recorded by the DART buoy network, with actual wave arrivals observed after about 20 minutes and processed data being available to the Tsunami Experts Panel (TEP) an hour after the earthquake.

This is important for two reasons:

- Initial tsunami forecasts were based on seismic magnitudes and only grossly described the tsunamigenic potential of the earthquakes.
- DART instruments provided 'clean' open-ocean tsunami signals associated with each earthquake that were used to calibrate tsunami models. Direct measurements of the tsunami from the DART buoy network allowed GNS Science to better estimate the size, location and timing of tsunami arrivals at the New Zealand coastline, which in turn supported the issuing of warnings and advisories by NEMA, including faster notification of when it was safe to return following evacuation.

GNS Science instruments recorded the tsunami from the M7.3 East Cape earthquake reaching a maximum amplitude of about 30-35 cm at Lottin Point (East Cape) and about 10-20 cm at Great Barrier Island. This was closely followed by tsunamis generated by the M7.4 and M8.1 Kermadec Island earthquakes. These waves overlapped to produce a tsunami between 35 and 40 cm in amplitude at the Great Barrier Island tsunami gauge and recorded at many other gauges around New Zealand. The unusual wave activity lasted several days.

4.2 Summary of Actions Taken by NEMA Staff

Earthquake and tsunami timeline of events - 5 March 2021

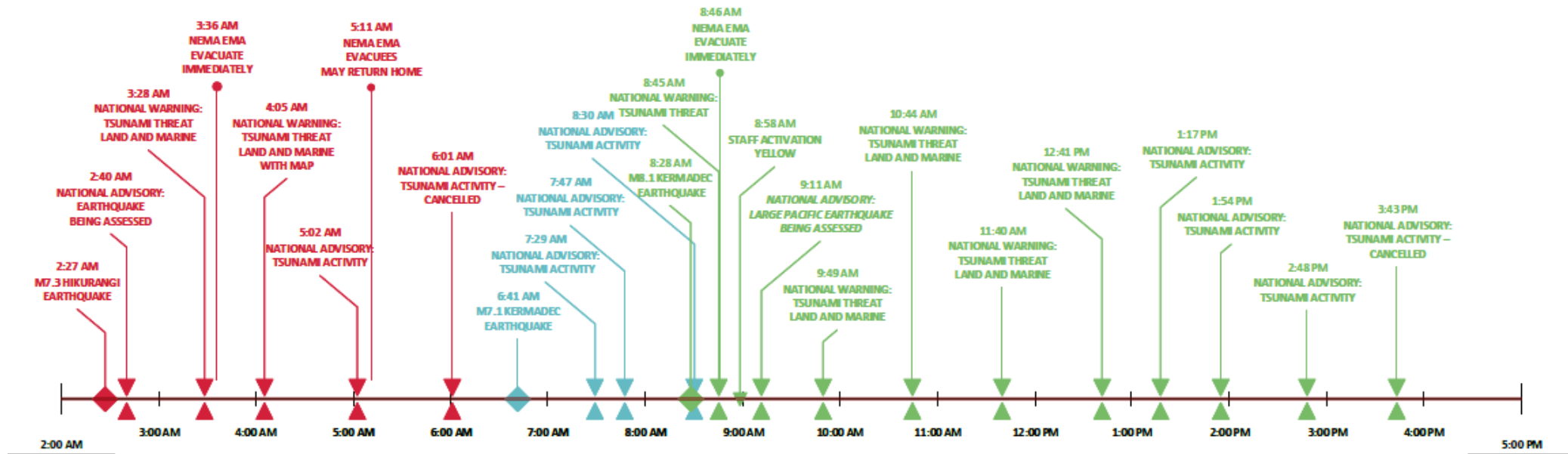


Figure 2: Earthquake and tsunami timeline of events – 5 March 2021

4.2.1 NEMA Response actions on 5 March 2021

The NEMA Duty Team initially responded to the first earthquake remotely as the first and second earthquakes occurred outside of normal business hours on Friday 5 March 2021. The NEMA National Coordination Centre (NCC), located in the basement of the Beehive in Wellington, was activated within an hour following the first earthquake.

The initial earthquake event on Friday 5 March 2021 met the threshold for NEMA to immediately issue a *National Advisory: Earthquake Being Assessed* message while it waited for GNS Science to provide further information. This message provides rapid assurance to the public that NEMA is actively assessing the situation while the formal advisory or warning is being confirmed. Updates to Twitter, Facebook and the NEMA website occurred automatically (pushed to social media by the National Warning System).

NEMA issued the initial 'Earthquake Being Assessed' message at 2.42am. At 2.55am, GNS Science provided information to indicate that a land threat on the East Coast was possible. However, before NEMA could issue a tsunami warning based on this advice, GNS Science provided new advice at 3.06am that there was no land threat.

The difference between a land threat and a beach and marine threat is quite significant, especially during the middle of the night. NEMA standard operating procedures for a land threat require the sending of an Emergency Mobile Alert (EMA) to the public (to alert them to evacuate immediately), whereas a beach and marine threat would not require the issuing of an EMA.

Based on the advice from GNS Science, the NEMA Duty Team elected to use a different template to communicate the advice. However, as the Duty Team was preparing the national advisory message, GNS Science advised a return to a land threat. The NEMA Duty team had to develop a new templated message based on warning for a land threat, along with an Emergency Mobile Alert message to at-risk areas to evacuate immediately. Once again, updates to Twitter and Facebook occurred automatically (pushed to social media by the National Warning System). The changing science advice delayed the issuing of the warning.

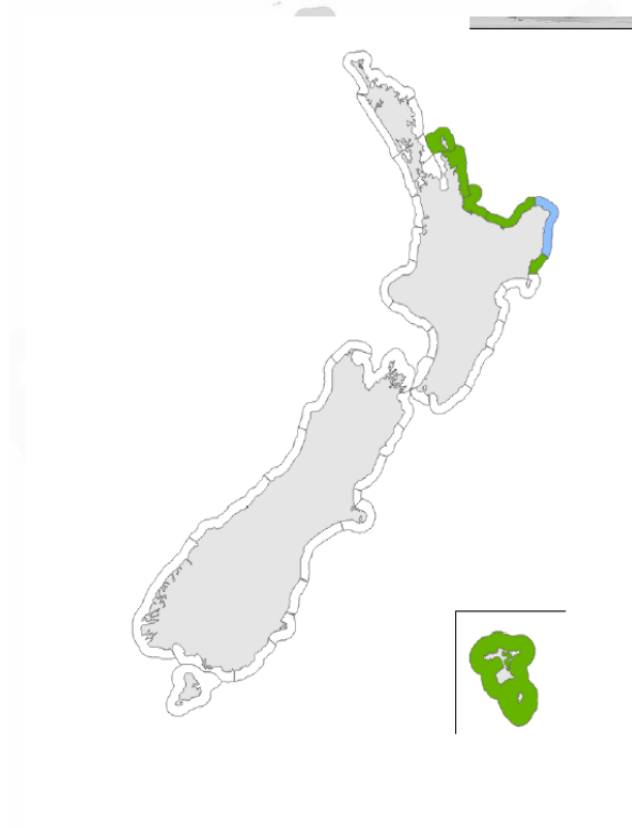
GNS Science has a suite of pre-prepared maps for a range of scenarios that allow for a swift estimate of expected threats to the New Zealand coastline. However, each event is unique, and a bespoke map is created with the relevant earthquake parameters to better define the threat and these take time to produce.

The second national warning system message issued at 3.30am included a bespoke map indicating which coastal zones were under threat (see Figure 3 below).

Figure 3: Tsunami Forecast Map issued for the Hikurangi earthquake (Event 1) at 0330 AM on 5 March 2021.

Tsunami Forecast Map

Earthquake details: M7.2 Hikurangi Subduction Zone
 Time of earthquake: NZDT 2.58am 05/03/2021
 Map issued at: 03.30 NZT DD/MM/2020



NOTE:

1. The stated threat levels may apply to any one of the series of waves generated by the event and not necessarily to the first wave. The first wave is not always the largest or highest and waves are likely to continue for many hours.
2. The threat levels suggest the largest wave at any coastal point inside the zone. Wave heights will vary within a zone.
3. The amplitudes do not include the tidal state (sea level) at the time the wave reaches the shore.
4. The estimate is for the maximum expected wave amplitude at shore. Run-up can be up to twice as high on steep slopes onshore near the coast i.e. a wave measuring 5m at shore can run-up as high as 10m on-land near the shore.
5. The expected wave amplitudes (crest to sea level) at the shore are likely to be different to measurements given in PTWC bulletins. PTWC measurements are taken at sea level gauges in the open ocean or at coastal points off-shore from New Zealand. NEMA information represents the official threat estimates.

| Maximum expected amplitude at shore | Threat definition |
|-------------------------------------|---|
| <0.3m | No threat |
| 0.3–1m | Beach & Marine Threat (including harbours, estuaries and small boats) |
| 1–3m | Land & Marine Threat |
| 3–5m | |
| 5–8m | |
| >8m | |

Following further assessment by GNS Science, the threat from this event was downgraded at 5.02am and a *National Advisory: Tsunami activity – expect strong and unusual currents and unpredictable surges at the shore* message was issued, allowing those who had evacuated to return to their homes.

At 6.01am, the National Advisory message was cancelled, based on GNS Science's modelling and ocean observations on tide gauges and the New Zealand DART Buoys that the threat of strong and unusual currents had passed for all parts of New Zealand including the Chatham Islands. The NEMA Duty Team returned to monitoring, while the NEMA NCC was still activated.

At 6.51am, The NEMA Duty Team received notification from the Pacific Tsunami Warning Centre (PTWC) in Hawaii of a magnitude 7.5 (later downgraded to a magnitude 7.4) earthquake in the Kermadec Islands. Based on the location, this event did not meet the thresholds for immediately issuing a warning message and was therefore discussed with GNS Science. A *National Advisory: Tsunami Activity* message was subsequently issued at 7.29am, including the bespoke notation that this message was referring to a separate earthquake to the Hikurangi earthquake earlier in the morning to avoid confusion. A subsequent advisory message (issued at 7.45am) included a bespoke forecast map indicating which coastal zones were under a beach and marine threat (see Figure 4 below).

Figure 4: Tsunami Forecast Map issued for the Kermadec earthquake (Event 2) at 0745 AM on 5 March 2021.

Tsunami Forecast Map

Earthquake details: M7.4 Kermadec Earthquake
 Time of earthquake: 06:41 NZDT 05/03/2021
 Map issued at: 07:45 NZDT 05/03/2021



NOTE:

1. The stated threat levels may apply to any one of the series of waves generated by the event and not necessarily to the first wave. The first wave is not always the largest or highest and waves are likely to continue for many hours.
2. The threat levels suggest the largest wave at any coastal point inside the zone. Wave heights will vary within a zone.
3. The amplitudes do not include the tidal state (sea level) at the time the wave reaches the shore.
4. The estimate is for the maximum expected wave amplitude at shore. Run-up can be up to twice as high on steep slopes onshore near the coast i.e. a wave measuring 5m at shore can run-up as high as 10m on-land near the shore.
5. The expected wave amplitudes (crest to sea level) at the shore are likely to be different to measurements given in PTWC bulletins. PTWC measurements are taken at sea level gauges in the open ocean or at coastal points off-shore from New Zealand. NEMA information represents the official threat estimates.

| Maximum expected amplitude at shore | Threat definition |
|-------------------------------------|---|
| <0.3m | No threat |
| 0.3–1m | Beach & Marine Threat (including harbours, estuaries and small boats) |
| 1–3m | Land & Marine Threat |
| 3–5m | |
| 5–8m | |
| >8m | |

While continuing to respond to this event, the NEMA Duty Team received notification of a second significant earthquake in the Kermadec Islands occurring at 8.28 am. As a magnitude 8 earthquake (later upgraded to magnitude 8.1), this earthquake met the threshold for issuing a *National Warning: Tsunami Threat to Land and Marine areas* and this was subsequently issued at 8.45 am, 17 minutes after the earthquake occurred (at 8.28am) and five minutes after the NEMA Duty Team was notified of this earthquake by the PTWC. This warning was based on previously determined scientific thresholds for earthquakes of magnitude 7.9 or above at a depth of <150km in this region. This message included a pre-developed map indicating the coastal areas required to immediately evacuate (see Figure 5). Following this message, an Emergency Mobile Alert was issued at 8.46 am to at-risk communities (black areas on the map) instructing them to evacuate immediately.

Following further scientific assessment by GNS Science, a *National Warning: Tsunami Threat to Land and Marine Areas* message was issued at 9.11am which contained more refined information relating to the threat areas. A subsequent National Warning message issued at 0949 included a bespoke forecast map, providing more detail on the coastal areas at risk and the expected tsunami amplitudes at shore (see Figure 6).

Further updates were provided at 10.44am, 11.40am, 12.41pm, until the tsunami threat was downgraded and a *National Advisory: Tsunami Activity* message was issued at 1.17pm warning of strong and unusual currents and unpredictable surges at the shore. At this point people that evacuated were advised they could return, while they were still advised to stay out of the water due to on-going strong currents. A further update was provided at 2.48pm.

Following advice from GNS Science that the tsunami threat had passed, a *National Advisory: Tsunami Activity – Cancelled* message was issued at 3.45pm, signalling the Beach and Marine

threat had passed for all areas. This meant that all people who had evacuated could now return home. At this point, EMA messages advising of evacuation were cancelled.

Figure 4: Initial Advice Land Threat Map issued for the Kermadec Island earthquake (2) at 0845 am on 5 March 2021.

Initial Advice Land Threat Map

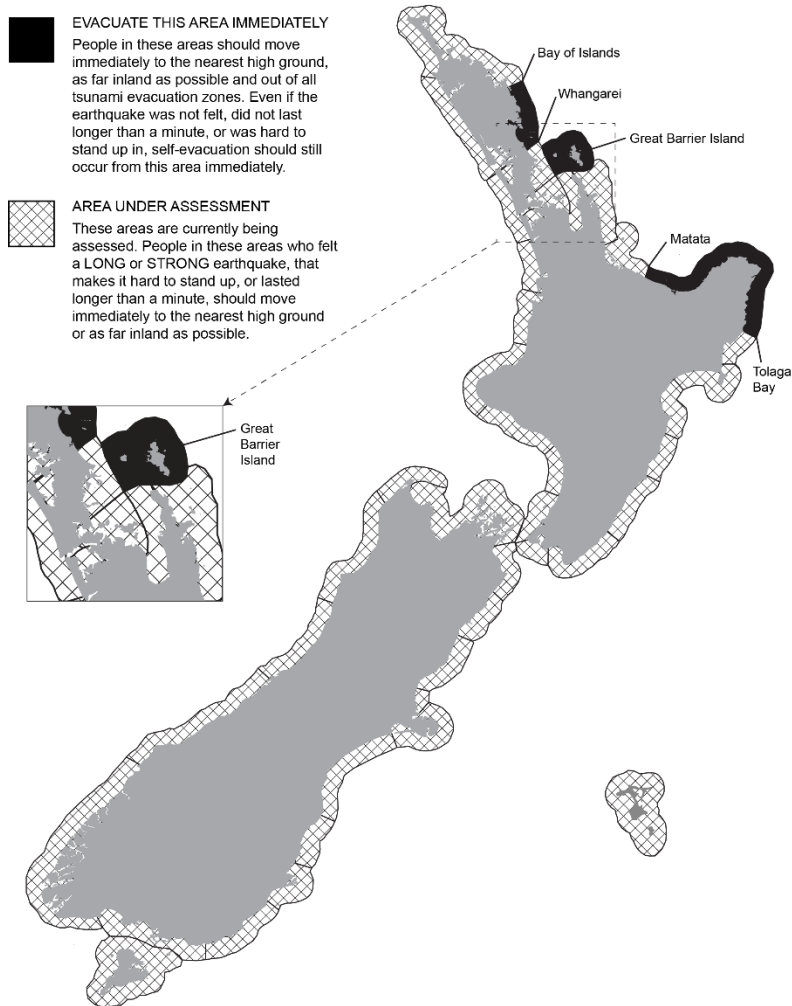


Figure 5: Tsunami Forecast Map issued for the Kermadec Island earthquake (2) at 0935 AM on 5 March 2021

Tsunami Forecast Map

Earthquake details: M8.1 Kermadec Earthquake #2
 Time of earthquake: 08:28 NZDT 05/03/2021
 Map issued at: 09:35 NZDT 05/03/2021



NOTE:

1. The stated threat levels may apply to any one of the series of waves generated by the event and not necessarily to the first wave. The first wave is not always the largest or highest and waves are likely to continue for many hours.
2. The threat levels suggest the largest wave at any coastal point inside the zone. Wave heights will vary within a zone.
3. The amplitudes do not include the tidal state (sea level) at the time the wave reaches the shore.
4. The estimate is for the maximum expected wave amplitude at shore. Run-up can be up to twice as high on steep slopes onshore near the coast i.e. a wave measuring 5m at shore can run-up as high as 10m on-land near the shore.
5. The expected wave amplitudes (crest to sea level) at the shore are likely to be different to measurements given in PTWC bulletins. PTWC measurements are taken at sea level gauges in the open ocean or at coastal points off-shore from New Zealand. NEMA information represents the official threat estimates.

| Maximum expected amplitude at shore | Threat definition |
|-------------------------------------|--|
| <0.3m | No threat |
| 0.3–1m | Land & Marine Threat (including harbours, estuaries and small boats) |
| 1–3m | |
| 3–5m | |
| 5–8m | |
| >8m | |

It should be noted that three major earthquakes in one day is unique and, as a result, this generated a large volume of messages via the National Warning System. As the events ‘overlapped’ it was important to be very clear about which messages related to which event.

It was fortunate that these events did not lead to major land inundation, however, strong and unusual currents and surges were recorded/observed.

Throughout the response, media were kept informed by the Public Information Management team through proactive calls and reactive responses. Radio and television interviews were proactively arranged. A media stand-up was held at 11.30am in the Beehive Theaterette, with the Minister for Emergency Management, the Acting Director Civil Defence Emergency Management, and a GNS Science representative.

4.3 Use of locally owned tsunami warning sirens

The decision to use sirens and their ongoing maintenance is the responsibility of CDEM Groups and local authorities. If CDEM Groups and local authorities do choose to install tsunami sirens they need to comply with the *Tsunami Warning Sirens Technical Standard [TS03/14]*.

Sirens were not widely used to provide warnings following the earthquakes on 5 March 2021. Northland CDEM Group was the only Group which used sirens as part of their warning system, with some 202 sirens activated on both the east coast of Northland and the northern part of the West Coast of Northland. No issues were identified during this activation by the Northland CDEM Group.

A siren replacement programme has already commenced in Northland (prior to the events of 5 March 2021) using new technology and conforming to the *Tsunami Warning Sirens Technical Standard [TS03/14]*. This is a significant step forward and the capability of the new sirens will allow a reduction in the number of sirens across Northland. Northland's geography and patchy mobile coverage means the Northland CDEM Group considers that the siren system continues to be an important part of tsunami response in Northland.

It is important to recognise that sirens are only one component within a wider warning system, and, as with any tools, have their advantages and disadvantages.

NEMA's position on the use of fixed sirens for tsunami warning is provided in the *Tsunami Warning Sirens Technical Standard [TS03/14]*. In short, NEMA does not regard sirens as effective or reliable alerting mechanisms in local source tsunami events. Local source tsunami, where the earthquake has occurred close to New Zealand's coastline can arrive within minutes at areas closest to the shore and there may not be time to issue an official warning before the first wave arrival, nor even activate the sirens. The sirens themselves may also be damaged by the earthquake itself. Sirens are known to cause complacency, which subverts the most reliable warning system for local source tsunami - the natural warning itself.

5 STRATEGIC FINDINGS

5.1 The provision of advice to the public needs to be sped up further

Since 2016, there have been significant improvements in the provision of tsunami warnings and advice to the public, including the implementation of the Emergency Mobile Alert system, and improvements to the National Warning System. However, there will always be areas for improvement in the effort to keep people safe.

There is a fine line between the need for speed (automation) and bespoke crafting of National Warning System messages, public information messages and social media posts. The end-to-end process for issuing a tsunami warning is complex and takes time (often under considerable time pressure) and decisions are made with the information available at the time (but noting that the situation is often evolving and will change rapidly).

There was a high level of uncertainty in the advice being provided by GNS Science following the first (East Cape) earthquake on 5 March 2021 due to the complexity of the earthquake event, and advice fluctuated between a land threat and a beach and marine threat. NEMA waited for the 'best' advice before issuing a warning and this resulted in the first warning being issued 48 minutes after the initial *Earthquake Being Assessed* message. NEMA acknowledges that a warning to the public should be issued more quickly.

It should be noted that it is seldom possible to issue any official warning for a local source event, given the short travel time (often less than 15 minutes to the nearest coastline). It is therefore imperative that the public heed natural warning signs and our public education campaigns underscore the importance of *Long or Strong, Get Gone*. In these circumstances, official warnings will still be issued to provide swift confirmation to communities of any assessed threat and to provide a warning to communities further away from the earthquake source.

In contrast, the warning message for the third earthquake (Kermadec 2) at 8.45 am, was issued much faster within 17 minutes of the earthquake occurring. This can be attributed to the fact that pre-computed maps have already been embedded in the national warning system templates for Kermadec source events and NEMA staff were already awake and in the National Coordination Centre responding to the previous Hikurangi and Kermadec earthquakes.

Although the response for this event was satisfactory, NEMA assesses the timeframe can still be improved.

There is a fine balance between the need for speed and accuracy in the event of tsunami warning. However, for local-source events, speed should be of the essence. Speeding up the provision of tsunami warnings is a key focus for NEMA and GNS Science. Both agencies have identified some areas for improvement in relation to the tsunami warning process which are described below.

Recommendations

- NEMA to continue to work with GNS Science on speeding up tsunami warnings.
- Work with GNS Science to enhance NEMA's ability to issue public advice while science assessments are still underway.

What we are already doing

- In the meantime, NEMA has developed an interim solution to improve the tsunami warning process for local-source events, which involves the application of a series of pre-established maps to guide the initial response to earthquakes from M7.0 and higher in the

Hikurangi Trough area. In this situation, NEMA will issue an EMA reinforcing the *Long or Strong Get Gone* message to areas that are likely to be under land threat, even in the absence of GNS Science advice. This process took effect from Friday 19 March 2021, and only applies for earthquakes in the Hikurangi Trough area.

5.2 Review agencies' responsibilities for tsunami warning

This issue has been raised following previous tsunami responses and continues to be a factor in the effective and timely provision of tsunami warnings and advice to the public.

Rapid and effective warnings are hampered by the current practice where GNS Science is the agency with responsibility for making tsunami threat assessments, while NEMA is the agency responsible for issuing tsunami warnings in New Zealand. In most other countries, tsunami warning is undertaken by the agency that is also responsible for monitoring and assessment (similar to the MetService being responsible for both assessing weather threats and issuing warnings). The current arrangement for tsunami adds layers of complexity and causes delay.

Effective warnings are also impeded by the fact that, unlike the GNS National Geohazard Monitoring Centre, which is a dedicated, centralised 24/7 'awake' capability, NEMA's Duty Team is not dedicated, centralised, and 'awake' 24/7.

The 2018 Technical Advisory Group Report *Better Responses to Natural Disasters and Other Emergencies* recognised that if NEMA did not have an awake duty team, delays with communication of warnings and establishing a response would be inevitable.³ In its response to the Report, the Government recognised the need for an integrated 24/7 operation for the monitoring, alerting and warning of emergencies, and recommended it be considered as part of the development of a business case for a new National Emergency Management Facility.⁴

In the 2019 Cabinet paper agreeing to the establishment of NEMA, the Government committed to some of the money appropriated for NEMA in Budget 2019 being used to address issues with the current approach in which NEMA (then MCDEM) staff are on call and woken up if needed.⁵

NEMA has a programme of work underway to review Duty arrangements, which sits alongside the ongoing work with GNS Science to improve the end-to-end system for tsunami monitoring and warning.

Recommendations

- Continue to explore options to speed up tsunami warnings, including transferring the responsibility for tsunami warning to GNS Science, and/or a dedicated 24/7 (awake) monitoring, alerting and warning capability for NEMA.

What we are already doing

- Continue engagement already underway between the NEMA and GNS Science duty teams to ensure swift two-way communication during events and identifying areas within the end-to-end process that could be sped up.

³ <https://dpmc.govt.nz/sites/default/files/2018-01/ministerial-review-better-responses-natural-disaster-other-emergencies.pdf>

⁴ <https://dpmc.govt.nz/sites/default/files/2018-08/natural-disasters-emergencies-government-response-tag-report.pdf>

⁵ <https://dpmc.govt.nz/sites/default/files/2019-09/nema-4158513.pdf>

5.3 Collaboration between agencies was enhanced by pre-existing relationships

New Zealand has a relatively small but interconnected CDEM sector (made up of NEMA plus 16 regional CDEM Groups employed by local councils). Recent exercises and emergency events since 2016 such as Exercise Tangaroa (national tsunami exercise) and the Kaikoura earthquake and tsunami, have consolidated the existing history of collaboration between CDEM and other emergency management professionals. Overall, the relationships between agencies that have been developed and tested in recent exercises and events have been a major contributor to the success of responses to recent emergency events. The relationships that now exist in the sector should be cultivated further as agencies continue to develop their preparedness for events and look towards future simulation exercises.

Recommendation

- Continue to mature existing relationships, particularly through cross-agency simulation exercising, system learning and continuous improvement initiatives.

What we are already doing

- Under the aegis of the Emergency Services Leadership Board, agencies are planning a table-top exercise to evaluate the multi-agency response to the March 5 earthquake and tsunami events.

5.4 Public understanding of regional and local source tsunami is improving

NEMA and GNS Science are constrained in their ability to issue timely and effective tsunami warnings because of the limited response time available following local and regional source events. Furthermore, threat assessment is not an exact science - the series of earthquakes on 5 March 2021 proved to be complex for scientists. Similar challenges were experienced after the East Cape earthquake and tsunami of 2 September 2016 and the Kaikoura earthquake and tsunami of 14 November 2016, which were both complex and unusual events.

The primary tsunami warning for a local source earthquake will always have to be the natural warning signs themselves (i.e. the shaking) and understanding of this by the public is improving. Official warnings are unlikely to be issued rapidly enough to warn communities nearest to the tsunami source and it is encouraging that many coastal communities did not wait for official warnings and self-evacuated upon recognising the natural warning signs following the East Cape earthquake on 5 March 2021. This is a positive sign and indicates that public education messages, in particular the “*Long or Strong, Get Gone*” messaging and local tsunami arrangements about local source tsunami events, have been effective. We note that a \$340,000 continuation of the *Long or Strong, Get Gone* campaign had already been planned for April-May 2021. A burst of television advertising was subsequently brought forward to the week beginning 9 March 2021 to build awareness while events of 5 March were fresh in the public’s mind.

Recommendations

- Continue the “*Long or Strong, Get Gone*” public education campaign.
- Broaden the reach of the annual “*Shake Out*” campaign in partnership with emergency services agencies.

6 KEY OPERATIONAL FINDINGS

This section summarises the key operational findings from the events of 5 March 2021.

6.1 Leadership of coordinated interagency response

6.1.1 Scientific advice from GNS Science continues to be best for New Zealand

GNS Science is the only agency with the necessary depth and breadth of local scientific knowledge required to make informed estimates of a tsunami's effect on New Zealand. Information that comes from international agencies, such as the Pacific Tsunami Warning Centre (PTWC) in Hawaii, is always examined as part of the assessment process – but data from international agencies should never be considered as definitive for New Zealand.

Recommendation

- Continue to ensure all CDEM Groups, media and central and local government agencies are aware that NEMA represents the official source of information for tsunami warnings in New Zealand and that Pacific Tsunami Warning Centre (PTWC) messages do not represent the official warning status for New Zealand.

6.1.2 Activation in response was effective

Feedback indicates that the NEMA Duty Team was responsive and the use of Microsoft Teams was good for communication and visibility of actions. The support the CDEM Groups received from the NEMA Senior Regional Emergency Management Advisors was of value and appreciated. The Duty Team were confident in their roles and supported each other. There was clear and decisive decision making, especially following the third earthquake event.

The National Warning System performed well and the use of additional contextual information indicating that messages related to new and different earthquakes was well-received.

GNS Science provided scientific information that was fit for purpose to enable warnings to be disseminated and communication was clear. There was value in having GNS Science representatives in the National Coordination Centre (NCC) and contributing to the media stand-ups to provide scientific context and advice.

Recommendations

- NEMA to continue to work with GNS Science, CDEM Groups and partner agencies to ensure roles and responsibilities are understood.
- GNS Science and NEMA to continue to undertake regular drills and simulated exercises to identify areas for improvement to communication channels and standard operating procedures.

6.1.3 The widespread use of EMA messaging was generally effective

Over the course of the three events on 5 March 2021, 21 Emergency Mobile Alerts (EMAs) were issued by NEMA and CDEM Groups (see Appendix B). This was the first real event where there were a significant number of EMA messages disseminated over wide geographic areas since the system was introduced in 2017. EMAs were issued to instruct people to evacuate as well as advise when it was safe to return home. EMAs were also sent in regions where strong and unusual currents were expected.

The map below shows the areas where EMAs were issued over the course of all events on 5 March 2021. A detailed list of the EMAs sent is attached at Appendix B.

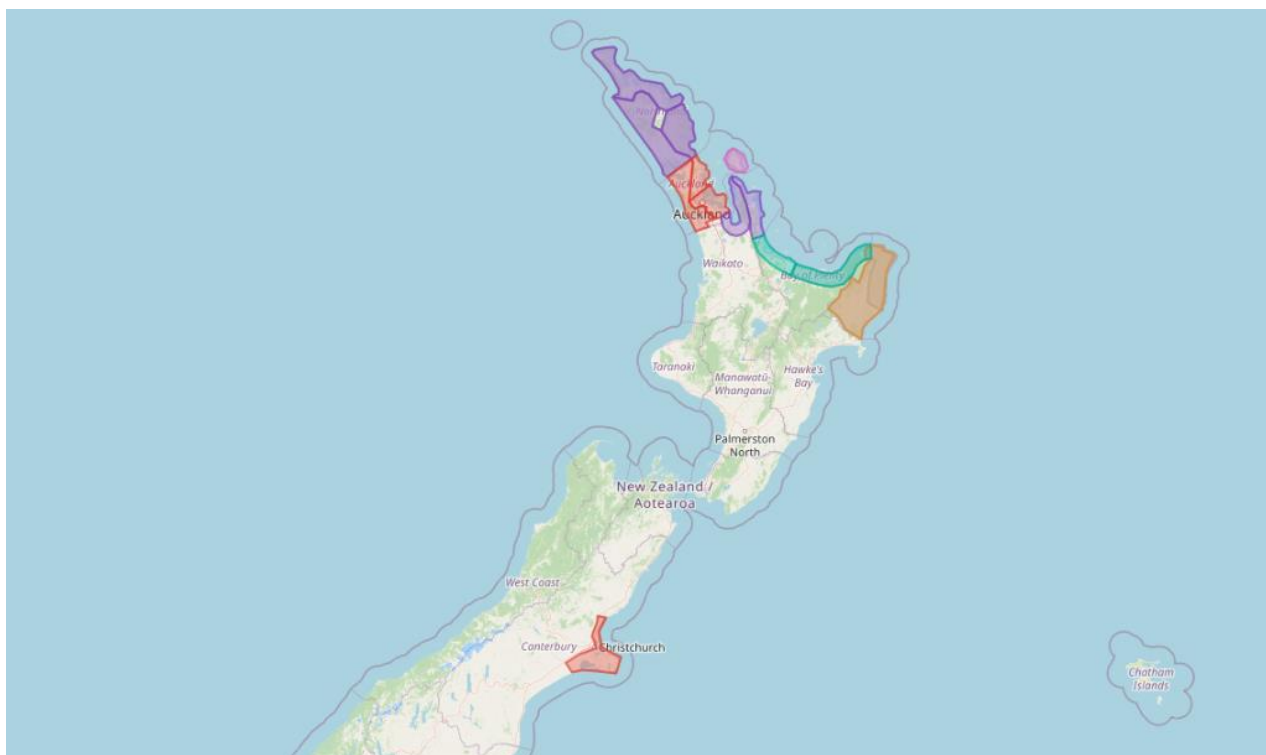


Figure 6: Map showing areas where EMAs were issued on 5 March 2021.

Success rates were between 95.2% and 100% for each provider (Spark, Vodafone, 2 degrees) – this means the number of cell sites within the defined area that successfully broadcast the message. Based on a 2019 Colmar Brunton Survey – which found that 70% of handsets receive EMAs - NEMA estimates that approximately 1.5 million people received an alert on 5 March 2021.

There was some confusion by the public about which agency (NEMA or a regional CDEM Group) was responsible for issuing some of the EMA messages and this detail wasn't always clear within the messages issued by CDEM Groups. There were also some concerns expressed by members of the public who thought they should have received a message but didn't. Generally, this was due to them being located in an area that was not under land threat and where a message had therefore not been broadcast. In other instances, members of the public complained that they received the EMA messages too late. This was because some CDEM Groups issued EMA messages for areas that were only under a beach and marine threat, sometime after the initial evacuation messages that were issued by NEMA.

Recommendations

- NEMA to continue to work with CDEM Groups on tsunami warning procedures to ensure consistent response at local levels.
- NEMA to review process for CDEM Groups issuing EMAs to develop thresholds for use and to standardise language and format.
- NEMA to review the impact of national and local EMAs being issued to understand whether clarity is improved or diminished for local communities.
- NEMA to continue to develop public education material on the purpose of the EMA system and when and how messages are received.

6.2 Public information management

6.2.1 Public information was disseminated through a wide variety of channels and extensive 'reach' was achieved

Throughout the response to the earthquakes and tsunami on 5 March 2021, a variety of platforms were utilised to disseminate accurate information to the public, including media briefings, social media (Facebook and Twitter), and web-based activity.

The Public Information Manager and the wider NEMA communications team proactively engaged with the media throughout the response.

The media did an excellent job of clearly communicating life safety messages throughout what was a dynamic and complex sequence of events, reinforcing the vital role they play as an emergency communications channel. This event brought to fruition the benefits of the ongoing partnership between NEMA and key broadcast partners for the issuing of life safety information during emergencies.

There was recognised value in having a GNS Science representative contributing to the media stand-ups to provide scientific context and advice, and to support the preparation of the Minister for Emergency Management and acting Director CDEM.

Recommendations

- NEMA to continue to work with media outlets before, during and after events to further strengthen relationships.
- NEMA to continue to invite GNS Science representation in media stand-ups during events to provide scientific context and advice and to support the preparation of spokespeople.

6.2.2 There is continued confusion between the use of land threat versus beach and marine threat

We have received feedback from CDEM Groups that there remains some confusion with the media and public over the use of the term 'Beach and Marine Threat' (i.e. when people need to stay out of the water and away from the shoreline and when boats/ships could be affected by unusual currents/swells) and that this continues to be perceived as the same as a 'Land Threat' (i.e. when people need to evacuate inland or to higher ground). This has been an identified issue in previous tsunami threats and changes have been made to the text in warning and advisory templates to better explain the differences. Confusion between the two can result in an incorrect perception from the public that they need to evacuate.

Following previous events, National Warning System templates have been amended to more clearly indicate that for areas not under a land threat, no evacuations are necessary but to warn that strong currents may be present so people should avoid beach and marine activity. However, further refinement of the template text and public education will be required in advance of future events.

Recommendation

- Further review the tsunami warning and advisory templates and associated maps to continue to improve clarity on the actions the public are expected to take.

6.2.3 The events had the potential to stretch NEMA resources

Although this series of events did not result in casualties or significant land damage, the long duration nature of such a response from the early hours of the morning began to impact on NEMA staff wellbeing and resourcing.

Due to the early and repeated tsunami notifications that all NEMA staff receive, even those staff not on duty were experiencing constant interruptions to sleep prior to any rostered shift they were required for. The impacts of this would have become more pronounced with a longer duration event.

There were also impacts on the rostered Duty Team, who were leading the response to the tsunami events, but also monitoring for other event notifications, and operating on little sleep. This would be alleviated if NEMA has a dedicated 24/7 'awake' capability, allowing dedicated rostered staff to focus on monitoring for any additional events while a simultaneous event response was led by other NEMA 'response' staff.

In addition, although not evident in this response due to the absence of casualties or damage caused by the tsunami impacts, there was the potential for a resourcing capacity issue to develop given NEMA's dual responsibility as both the national warning agency for tsunami, and its responsibility for the coordination of emergency response.

NEMA has two distinct roles in relation to tsunami – to issue warnings and to lead and coordinate the response if that becomes necessary. The analysis of threat information and subsequent issue of timely and accurate warnings (potentially over a period of 24 hours or more) is labour intensive and diverts resources from NEMA's response coordination role. NEMA is stretched in its current resourcing model if it is required to perform both roles simultaneously.

Considering the life-safety context of the tsunami warning responsibility, the accuracy and timeliness of threat information has to take priority while the warning is in effect; however, resourcing this comes at the cost of sufficient simultaneous attention to the response coordination role (which in other responses would be NEMA's primary or only focus).

Recommendations

- Continue to review and improve the NEMA duty system.
- Continue scoping the NEMA 24/7 (awake) monitoring, alerting and warning capability, with a view to implementation as soon as practicable.
- Continue to increase capability and capacity through emergency management system workforce planning, including the provision of surge staffing from across the National Security System and through increased collaboration with emergency services agencies under the umbrella of the Emergency Services Leadership Board.

What we are already doing

- Work is already underway to improve coordination and collaboration between NEMA and emergency services agencies, which will bolster NEMA's capability to fulfil its coordination role in parallel with its warning role.

7 CONCLUDING OBSERVATIONS

Overall, the response to the earthquake and tsunami threat on 5 March 2021 was efficient and effective. There were many positives for NEMA including the prompt evacuation actions by the public, the performance of the National Warning System and the use of Emergency Mobile Alerts, and the proactive engagement with the media throughout the response.

This was a complex series of events, and a number of improvements introduced over the last five years to speed up and improve the delivery of tsunami warning messages showed their value during this response. These include the use of Emergency Mobile Alerting by both NEMA and the regional CDEM Groups, improvements to the National Warning System, the development of the 24/7 capability of the National Geohazards Monitoring Centre (NGMC) at GNS Science, and the focus on the development of the relationship between the NEMA and GNS Science Duty Teams.

The positive evacuation actions taken by the public showed the value and take up of the “Long or Strong, Get Gone” messaging and the importance of ongoing tsunami public education engagement. There was also demonstrated value in the proactive engagement NEMA has undertaken with the media to help improve tsunami warning understanding, and to bolster media arrangements during an emergency.

Following the comprehensive debriefing process, the following key findings have been identified that will benefit from a continued improvement focus:

- I. The provision of advice to the public needs to be sped up
- II. Further improvements to the distribution of agency responsibilities would improve the tsunami warning process
- III. Collaboration between agencies was supported by existing relationships
- IV. Public understanding of what to do when there is a local source tsunami is improving
- V. Scientific advice from GNS Science continues to be best for New Zealand
- VI. Activation in response was effective
- VII. The widespread use of Emergency Mobile Alert messaging was generally effective
- VIII. Public information was disseminated through a wide variety of channels and extensive ‘reach’ was achieved
- IX. There is continued confusion between the use of land threat versus beach and marine threat
- X. The events had the potential to stretch NEMA resources.

A number of areas have been recommended for improvement following previous tsunami responses and have been acted on. However, some areas do not have quick fixes and require continued focus to lift the effectiveness of New Zealand’s tsunami monitoring and warning systems. NEMA’s planned introduction of a national lessons management system will bolster our continuous improvements efforts.

APPENDIX A NATIONAL WARNING SYSTEM MESSAGES

A.1 East Cape Event, 2.27 AM, 5 March 2021

| Time issued on 5 March | Message |
|------------------------|---|
| 0240 AM | National Advisory: Earthquake Being Assessed |
| 0328 AM | National Warning: Tsunami Threat Land and Marine |
| 0405 AM | National Warning: Tsunami Threat Land and Marine with Map |
| 0502 AM | National Advisory: Tsunami Activity |
| 0601 AM | National Advisory: Tsunami Advisory for New Zealand Cancelled |

A.2 Kermadec Event 1, 6.41 AM, 5 March 2021

| Time issued on 5 March | Message |
|------------------------|-------------------------------------|
| 0729 AM | National Advisory: Tsunami Activity |
| 0747 AM | National Advisory: Tsunami Activity |
| 0830 AM | National Advisory: Tsunami Activity |

A.3 Kermadec Event 2, 8.28 AM, 5 March 2021

| Time issued on 5 March | Message |
|------------------------|---|
| 0845 AM | National Warning: Tsunami Threat |
| 0949 AM | National Warning: Tsunami Threat to Land and Marine |
| 1044 AM | National Warning: Tsunami Threat to Land and Marine |
| 1140 AM | National Warning: Tsunami Threat to Land and Marine |
| 1241 PM | National Warning: Tsunami Threat to Land and Marine |
| 1317 PM | National Advisory: Tsunami Activity |
| 1354 PM | National Advisory: Tsunami Activity |
| 1448 PM | National Advisory: Tsunami Activity |
| 1543 PM | National Advisory: Tsunami Advisory for New Zealand Cancelled |

APPENDIX B EMERGENCY MOBILE ALERT MESSAGES

B.1 East Cape Event, 2.27 AM, 5 March 2021

| Time issued on 5 March | Message | Issued By |
|------------------------|-----------------------------------|-----------------|
| 0336 AM | TSUNAMI – Evacuate Immediately | NEMA |
| 0511 AM | UPDATE – Evacuees may return home | NEMA |
| 0519 AM | TSUNAMI – Return Home | Tairāwhiti CDEM |

B.2 Kermadec Event 1, 6.41 AM, 5 March 2021

No EMA messages issued for this event.

B.3 Kermadec Event 2, 8.28 AM, 5 March 2021

| Time issued on 5 March | Message | Issued By |
|------------------------|--|--------------------|
| 0846 AM | TSUNAMI – Evacuate Immediately | NEMA |
| 0858 AM | TSUNAMI – Evacuate Immediately (Great Barrier Island Only) | Auckland EM |
| 0905 AM | TSUNAMI – Evacuate Immediately | Tairāwhiti CDEM |
| 0922 AM | TSUNAMI – Evacuate Immediately | Northland CDEM |
| 0948 AM | TSUNAMI – Evacuation Continues | Tairāwhiti CDEM |
| 1010 AM | TSUNAMI – Evacuation Continues | Northland CDEM |
| 1011 AM | TSUNAMI – Evacuate Immediately and Strong Unusual Currents | Bay of Plenty CDEM |
| 1058 AM | TSUNAMI – Strong and Unusual Currents | Waikato CDEM |
| 1135 AM | TSUNAMI – Strong and Unusual Currents (Metropolitan Only) | Auckland EM |
| 1142 AM | TSUNAMI – Strong and Unusual Currents | Tairāwhiti CDEM |

| | | |
|---------|--|--------------------|
| 1152 AM | TSUNAMI – Strong and Unusual Currents | Northland CDEM |
| 1200 PM | TSUNAMI – Strong and Unusual Currents | Canterbury CDEM |
| 1334 PM | TSUNAMI – Change in Evacuation (Great Barrier Island Only) | Auckland EM |
| 1334 PM | TSUNAMI – Return Home | Northland CDEM |
| 1411 PM | TSUNAMI – Strong and Unusual Currents Advisory Lifted | Canterbury CDEM |
| 1456 PM | TSUNAMI - Cancelled | Bay of Plenty CDEM |
| 1512 PM | TSUNAMI – Return Home | Auckland EM |
| 1549 PM | TSUNAMI – Strong and Unusual Current Advisory Lifted | Auckland EM |