

# Citizen science as a catalyst for community resilience building: A two-phase tsunami case study

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## Abstract

*The role of citizen science in natural hazard risk awareness, assessment, mitigation, and preparedness is being recognised as an important element of disaster risk reduction. Citizen science has potential as a collaborative resilience building activity that can help build the capacity of, and relationships between, individuals, communities, and institutions to prepare and respond to disaster. Specifically, citizen science can increase resilience by building the collective- and self-efficacy of individuals, organisations, and communities as well as other factors such as enhancing planning, coping mechanisms, social capital, community participation, leadership, empowerment, trust, and a sense of community. We present a case study of a two-phased citizen science initiative related to tsunami preparedness and response, undertaken between 2015 and 2016 in Orewa, Auckland, Aotearoa New Zealand. The activities of the first phase acted as a catalyst for the second phase and thus contributed directly to resilience building. Phase One was a citizen-initiated, co-developed survey on tsunami preparedness and intended response. The results from the survey, showing that participants had a low understanding*

*of appropriate response to a potential tsunami threat, were used by community leaders to develop a community preparedness and awareness-building exercise: Phase Two. Phase Two was a joint citizen and agency-facilitated tsunami evacuation exercise "Ahead of the Wave", with science-led data collection on evacuation numbers and timing. This initiative was aimed at improving the response capacity of a coastal community at risk of tsunami and was initiated by the community itself with support from other agencies. We present an overview of the methodological approaches taken to understand community resilience to tsunami risk in Orewa. Further, we highlight the importance that researchers working in the citizen science space must recognise the time required to invest in co-production and the importance of understanding the different motivations of organisations and individuals.*

**Keywords:** *tsunami, citizen science, community resilience, disasters, evacuation, warnings*

Citizen science is a rapidly growing area of practice and research in natural hazards and disaster risk management. Individuals and organisations recognise that citizen science has potential for collaborative resilience building and the co-production of hazard and risk knowledge and mitigation initiatives. As outlined in Aotearoa New Zealand's "A Nation of Curious Minds" government strategic plan on science and technology engagement (MBIE, 2014), such programmes seek to enhance scientific understanding and knowledge and develop community interest in science through citizen science initiatives. Developing citizen science partnership programmes to work with communities to identify and mitigate environmental risk is also highlighted in this plan as a key objective. The wide range of stakeholders and complexities in disaster risk management and citizen science can make effective collaboration challenging, particularly for resilience building and disaster risk management. Relevance, transparency, trust, partner equity, and politics are all identified as challenges for effective collaboration (e.g., Doyle, Becker, Neely, Johnston, & Pepperell, 2015). In Aotearoa New Zealand, emergency management requires collaboration, which is reflected in its Civil Defence and Emergency Management (CDEM) Act

2002 and the related National Strategy (MCDEM, 2008). Likewise, as articulated in the “Nation of Curious Minds”, Aotearoa New Zealand’s national science direction also explicitly calls for research to involve partnerships and collaboration (MBIE, 2014).

A wide range of research has identified related factors that help build community resilience and the capacity of individuals, communities, and institutions to respond to disasters (e.g., Lindell & Prater, 2002; Paton & Johnston, 2006; Solberg, Rossetto, & Joffe, 2010; Whitney, Lindell, & Nguyen, 2004), including in particular the importance of collective and self-efficacy (Becker, Paton & McBride, 2013; Lindell & Whitney, 2000; Paton & Johnston, 2006; Paton et al., 2010) which is the belief that a community or individual, respectively, can do something to prepare for, or respond to, an event. Other (interdependent) factors that influence resilience-building actions include outcome expectancy, action coping, planning, responsibility, social capital, community participation, leadership, individual and community empowerment, trust, sense of community, and place attachment (see also Aldrich & Meyer, 2014; Becker, Johnston, & Paton, 2015; Becker, Paton, Johnston, & Ronan, 2014; Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008; Paton et al., 2010).

Resilience-building methods help to increase these resiliency factors in communities. For example, research shows that participating in activities focussed on solving hazard-related problems helps to develop self-efficacy and positive outcome expectancy and motivates people to undertake practical actions to prepare for events (Paton & Johnston, 2006). Various types of participatory activities could be undertaken, and such activities might be organised and facilitated by external agencies (e.g., by national or local government agencies or Non-Government Organisations) or by citizens themselves. Specific examples of such activities include door-knocking to discuss hazard and preparedness messages, hazard mapping exercises, training for emergencies, community response planning, drills and exercises, evaluation initiatives (Becker, Paton, Johnston, Ronan, & McClure, 2017; Finnis, 2007), and community-based scientific data collection, which is often framed as citizen science.

Citizen science is a broad term that encompasses a variety of different types of projects where the public work with academic researchers to undertake scientific research. It has been popular during recent years in the

biological sciences field but has spread to many different scientific areas, including natural hazard research. The motivations, design, and outputs of the projects vary widely. Some projects are highly participatory, where citizens are involved in the project design, data collection, and analysis. Others are designed and coordinated solely by the scientist, and citizens only contribute limited amounts of data. Both ends of this spectrum, and all projects in between, can be effective for creating new scientific outputs (Bonney, Ballard, et al., 2009; Bonney, Cooper, et al., 2009; Haklay, 2013; Shirk et al., 2012).

Citizen science approaches have been applied by hazard and disaster researchers so that there is now a wide range of hazard-focussed citizen science projects, including on tornadoes, volcanoes, earthquakes, and flooding. Examples include the United States’ National Weather Service SKYWARN program that collects reports of localised severe weather via citizen “storm spotters” ([www.skywarn.org/](http://www.skywarn.org/)), the “Felt Reports” of Aotearoa New Zealand’s GeoNet (GNS Science’s hazard monitoring initiative) where citizen scientists submit rapid reports of the level of shaking they have felt after an earthquake ([www.geonet.org.nz/data/types/felt](http://www.geonet.org.nz/data/types/felt)), and the British Geological Survey’s “iGeology” which enables “citizen geologists” to submit photographs of areas of specific geologic interest, or indicate areas where geologic mapping needs to be revised or revisited ([www.bgs.ac.uk/igeology/](http://www.bgs.ac.uk/igeology/)).

However, there exists a wide range of challenges in the space of community collaboration and knowledge transfer (e.g., Doyle et al., 2015; Orchiston et al., 2016), including: a) understanding and navigating the range of citizen science approaches available; b) the willingness of scientists and citizens to participate; c) the appropriateness of adapting citizen science initiatives across a range of different communities; d) trust, particularly for information sharing; e) available time and resources; f) transparency and accountability in the process; g) identifying what citizen science is and what it is not; and h) the need to consider the role of ethics in citizen science activities.

Citizen science is being recognised as an important tool that can be used in disaster risk management to facilitate collaboration and act as a catalyst for future resilience-building activities. It has the potential to: a) enhance citizens’ “place” in disaster risk management discussions, b) enable traditional values and cultures

to be considered, c) provide opportunities for citizens to ask questions and come to greater understanding, and d) provide an environment for intergenerational conversations and a sharing of collective wisdom (Orchiston et al., 2016). Further, citizen science can increase engagement resulting in more effective and meaningful policy development, develop trust, improve the public's understanding of science, and improve risk awareness and acceptance which are necessary to carry out preparedness activities (see also Doyle et al., 2015).

There are many aspects of project design and implementation that influence the citizen science process. These include the cost of the project and who funds it (Bonney, Cooper, et al., 2009; Bonney, Phillips, Ballard, & Enck, 2016; Silvertown, 2009; Tweddle, Robinson, Pocock, & Roy, 2012), the technology used within the project design (Bonney et al., 2014; Bowser & Shanley, 2013; Haklay, 2014; Peters, 2016; Silvertown, 2009), and the resources and tools made available to the participants (Bonney et al., 2016; Bonney et al., 2014; Bowser & Shanley, 2013; Peters, 2016; Silvertown, 2009). The timeframe of the project and its development also influence this process (Bowser & Shanley, 2013; Peters, 2016), as well as the ethics process (Bowser & Shanley, 2013; Eitzel et al., 2017; Orchiston et al., 2016; Riesch & Potter, 2014) and the training provided (Becker-Klein, Peterman, & Stylinski, 2016; Bowser & Shanley, 2013; Hennon et al., 2015; Straub, 2016).

Other issues to consider include how much the participants trust in the process (Lewandowski & Oberhauser, 2016; Kelman, Lewis, Gaillard, & Mercer, 2011; Soleri, Long, Ramirez-Andreotta, Eitemiller & Pandya, 2016), the quality of the data collected (Bowser & Shanley, 2013; Bonney et al., 2014; Riesch & Potter, 2014; Soleri et al., 2016), the terminology used (Eitzel et al., 2017; Johnson, 1992; Lewandowski, Caldwell, Elmquist, & Oberhauser, 2017; Riesch & Potter, 2014; Straub, 2016), maintaining the partnerships formed during the project (Bonney et al., 2016; Kearney, Wood & Zuber-Skerritt, 2013; Soleri et al., 2016), and the initial purpose or motivations behind the project design (Bonney et al., 2016; Raddick et al., 2013; Straub, 2016; Tweddle et al., 2012).

In this paper, we outline a methodological case study approach developed during a two-phased citizen science initiative focussed on tsunami preparedness and response in Orewa, Auckland, Aotearoa New Zealand. In doing so, we describe the process of developing the initiative, rather than evaluating the outcomes of

the activities, to highlight issues of relevance for future hazard-related citizen science project design and implementation. The case study took place between 2015 and 2016, and involved Phase One, a citizen-initiated co-developed survey on tsunami preparedness and intended response actions by local residents, and from this Phase Two, a joint citizen and agency-facilitated tsunami evacuation exercise "Ahead of the Wave", with science-led data collection on evacuation numbers and timing. This initiative was aimed at improving the response capacity of a coastal community at risk of tsunami and was initiated by the community itself with support from other agencies as part of a community preparedness and awareness-building exercise.

### **Case Study Context**

Orewa is a partially low-lying community with many people residing less than one kilometre from the beach and within three metres above sea level. It is at risk from local, regional, and distant source tsunami and storm surge, as well as the occurrence of king tides. Tsunami inundation modelling has identified Orewa as being the most exposed community to tsunami in the Auckland region, with a potential 6,521 people exposed as of 2015 (Horspool, Cousins, & Power, 2015; Woods & Lewis, 2017). Local and regional tsunami in particular pose the greatest risk. As illustrated in Figure 1, this modelling gives residents under an hour to undertake an evacuation response for a local source tsunami event. Effective individual and community response to natural warnings in this timeframe will be vital for life safety. Thus, to improve the tsunami response capacity of Orewa residents, they need to be actively involved in understanding their risk and identifying practicable risk management solutions and preparedness initiatives. Additionally, it is important for residents to practice evacuation procedures.

To improve citizens' awareness of their risk and evacuation zones and routes, Auckland Civil Defence Emergency Management have developed a series of tsunami evacuation maps for all of Auckland's coastline. These maps identify three different evacuation zones depending on the modelled inundation and source of the tsunami<sup>1</sup> as well as public messaging that encourages people to be aware of natural, official, and unofficial warnings<sup>2</sup>. Citizen science activities also present opportunities for a "whole of community" approach to

1 <https://aucklandcouncil.maps.arcgis.com/apps/MapSeries/index.html?appid=81aa3de13b114be9b529018ee3c649c8>

2 [www.aucklandemergencymanagement.org.nz/hazards/tsunami](http://www.aucklandemergencymanagement.org.nz/hazards/tsunami)

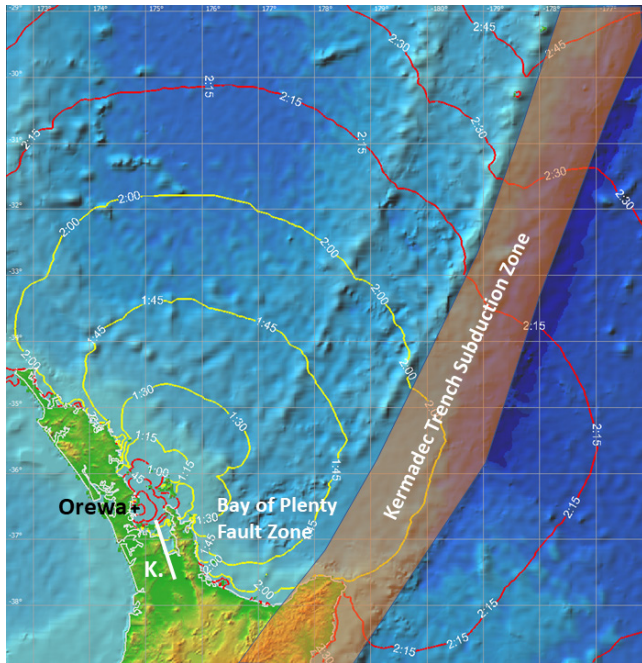


Figure 1. Tsunami travel time ( $t$ ) contours for Orewa in 15-minute increments, calculated with WinITDB (Windows Integrated Tsunami Database; see <http://tsun.sccc.ru/WinITDB.htm>). The different coloured lines are associated with  $t < 1$  hour,  $t = 1$ -2 hours, and  $t > 2$  hours. Also shown on the figure are approximate locations of the Kermadec Trench Subduction Zone, the Bay of Plenty Fault Zone, and the Kerepehi Fault (labelled as K). Travel times to the west coast of North Island are not shown. Image courtesy of William Power, GNS Science, Aotearoa New Zealand, produced August 2019. We also thank David Burbidge for contributing to its production.

preparing and addressing Orewa's tsunami risk, as they increase collaboration, participation, and knowledge transfer between community members, decision makers, government agencies, scientists, and higher education institutions.

Active community participation is particularly important for schools and their families and communities (Johnston et al., 2016). For example, research by Nakahara and Ichikawa (2013) after the 2011 Tohoku earthquake and tsunami in Japan identified that school preparedness levels directly influenced child mortality rates. As discussed by Johnson, Johnston, Ronan, and Peace (2014), if parents and caregivers are unaware of a school's tsunami evacuation plans, including plans to evacuate to tsunami safe zones, there is an increased likelihood that they may put themselves at risk by going to the school to collect children during an event, thus slowing their own evacuation process (see also Johnston et al., 2016). It is thus vitally important that such communities plan, prepare, exercise, and review best practice for tsunami by incorporating schools,

school children, and the wider community as part of the processes. Such plans and procedures are also required by schools under Aotearoa New Zealand's health and safety legislation (Health and Safety Act 2015). A school's Board of Trustees is legally required to ensure the school they govern has an emergency management plan, which is self-reported to the Education Review Office every three years. Accordingly, since 2015, a number of Orewa community and council-led initiatives have been developed to address this issue of tsunami preparedness in schools and their connected communities. This has included the use of citizen science methods to address critical science questions such as whether people know what to do in tsunami, how long the school children will take to evacuate to safe zones, and what challenges might arise. These methods have also helped to involve the community in the development of their understanding of these issues as part of a public education initiative.

We outline the methodology for the case study approach presented here then we discuss the results from these case studies which are relevant to the *process* of the citizen science initiative and the outcomes it created. In our discussion and conclusions we consider the impact of such an initiative on the development of effective collaborative partnerships and the community's overall resilience. We highlight aspects of this initiative that could be successfully applied to future citizen science projects, in terms of connecting and engaging with at-risk communities, and conclude that one of the main benefits of citizen science in disaster risk management is the potential to catalyse subsequent resilience building activities across individuals, agencies, communities, and regions.

## Method

The method for this paper is a case study approach, which develops an analysis of a "set of related events with the specific aim of describing and explaining the phenomenon" (Berg, 2007, p. 283). The definition of what constitutes a case varies and can consider a single case, a number of cases, an individual, an organisation, a group, or an event (such as an aspect of organisational change; Burton, 2000). Such case studies investigate contemporary phenomena within their real-life context (Verschuren, 2003; Yin, 1989) and provide a pragmatic and flexible research approach that provides understanding of processes, behaviours, practices, and

relationships across a diverse range of issues in context (Harrison, Birks, Franklin, & Mills, 2017).

The two-phased citizen science initiative reported here collected qualitative researcher observations of the development and occurrence of tsunami citizen science activities through the case study of Orewa. As part of our observational process, we looked closely at the type of data collected, including the quantitative results from the Phase One surveys and the Phase Two structured tsunami evacuation exercise. Short follow up conversations occurred with people involved in the activities to confirm details about their impressions of how the events unfolded and the timeline of events, to gather their perceptions of the influences and outcomes of the process, and to identify all stakeholders involved. This information was then analysed at a high level in the context of citizen science and resilience literature, with the aim of highlighting some of the influences on the citizen science process for Orewa, and how these affected outcomes.

We discuss the case study in two phases, with Phase One representing the commencement of the citizen science project with a community-initiated quantitative survey in August 2015, and Phase Two representing the tsunami walk exercise, which occurred on 25 May 2016. Findings from the Phase One survey are presented as these were important for the rationale and development of Phase Two. We also document the interactions and co-production process that occurred between community leaders, higher education institutions, schools, and the local council before, during, and after these phases. Such documentation covers the process of undertaking the citizen science project, to identify lessons that can be applied to the development of future such activities, rather than reporting direct outcomes of these activities.

## Results

### *Phase One: Community-initiated Quantitative Survey*

**Survey development.** Rotary club members had identified Orewa was at risk from tsunami and wanted to understand their communities' perception and understanding of tsunami risk, as well as preparedness and intended behavioural responses to a potential future tsunami. The Director of Rotary's disaster awareness CHIP-In Project (**C**an **H**elp **I**f **P**ossible, **I**f **N**eeded) approached the Joint Centre for Disaster Research (JCDR) at Massey University in June 2015 for support

to assist in the design and implementation of a tsunami awareness survey within the Orewa community. Rotary intended to use the results of the survey to understand how they could best use their limited financial resources to assist in building community preparedness.

Following an initial scoping conversation in May 2015, Rotary's questions were captured in a survey drafted by JCDR research staff. The survey was then developed and refined further with input from members of the Rotary Group, to ensure their particular areas of interest were covered in the range of questions. Auckland Council were also recognised as partners in survey development and were invited to participate, with the understanding that this survey would be community-led and the JCDR and Auckland Council were advisors to the process, maintaining an ongoing relationship. By August 2015, the Rotary clubs of Orewa, Westhaven, and Auckland, in association with the JCDR and Auckland Council, had co-developed a survey aimed at understanding the tsunami risk perception of the Orewa community, how prepared they were for a tsunami, and what they were likely to do in a tsunami event (e.g., in terms of expectations of warning time and intended evacuation behaviour), as well as their awareness of all hazards likely to affect the Orewa area. The full survey can be found in Appendix 1. Low risk ethics notifications were submitted through Massey University of New Zealand.

**Data collection.** Rotary members suggested that the research project could involve volunteers from the Interact Club of Auckland Grammar School<sup>3</sup> to increase community participation. This group of volunteers are involved with various community projects and are sponsored by Rotary Clubs. Rotary members sought the availability of volunteers and provided context about the research project and what their involvement required.

The survey data collection was carried out on Saturday 22 August (see Appendix 2 for the press release issued by Rotary). On the day of the survey, volunteers were divided into groups of three or four and were accompanied by either a Rotarian or a researcher from the JCDR. Mobile technology devices (tablets) were used for survey data collection. The survey was uploaded onto Survey Gizmo, an online survey software tool, selected because of the offline setting that enabled local storage of results when an Internet connection was not available.

3 The Interact club is an initiative developed by Rotary to build their youth membership at secondary schools ([www.rotary.org/en/get-involved/interact-clubs](http://www.rotary.org/en/get-involved/interact-clubs)).

A 30-minute pre-survey role play exercise was undertaken before the students interviewed participants and collected data. Rotarians and researchers observed this training so they could assist the students when undertaking the interviews. The purpose of the role play was to train the students in how to approach members of the community, how to answer common questions about tsunamis, and provide information to participants regarding existing tsunami preparedness resources. Each group of students was also provided a hard copy of responses to common questions that participants might ask, such as, "What is a tsunami?" or "What is the tsunami risk in this area?". They could refer to these during the survey process to answer any questions posed by participants. The short role play exercise was an engaging way for the volunteers to understand survey dissemination and learn techniques for approaching members of the public.

Each survey team was provided with a tablet and all the devices were synced to the same Survey Gizmo account. Each group was also provided with hard copies of the survey for instances where the participant preferred to read through a hard copy or if either the technology or the survey tool was not working. Surveys were disseminated by approaching community members in public places (i.e., businesses, residents, and passers-by) and asking them to volunteer to answer a face-to-face survey.

A total of 94 surveys were collected with each survey taking approximately 10-15 minutes to complete. At the end of the survey, participants were also able to provide their contact details to the Rotary Club if they were interested in receiving further information regarding tsunami risk. The intention of Rotary members was to use the contact information to conduct a follow-up survey focused on business continuity. Additionally, the Chip-In Foundation set up a pop-up information centre for the day and provided residents and visitors with maps and reports on the tsunami risk for Orewa, a video, and assistance on planning personal, family, business, and school evacuations. These resources were available online via Auckland Council Civil Defence Emergency Management (CDEM).

**Survey findings.** Because the findings of the survey in Phase One informed the rationale and development of Phase Two, relevant findings are presented here. Analysis of the survey data was conducted by researchers at the JCDR. The results of the survey revealed that local residents in Orewa had a general understanding of the risk of various natural hazards

in their area. Flooding and tsunami were rated as the two most likely hazards to occur (55% and 51% respectively), followed closely by storms or cyclones with high winds (49%). It is noted that the title of the survey, "Orewa tsunami survey", may have led respondents to select tsunami as a likely hazard. Coastal erosion (27%) was selected by a smaller but still considerable proportion of participants. Earthquakes (7%), forest or bush fire (2%), and ashfall from a volcanic eruption (1%) were least likely to be selected.

Sixty five percent of respondents believed that a tsunami was likely to occur within their lifetimes, with the majority (58%) believing that tsunamis were not too destructive to prepare for. However, 28% believed that it was unnecessary to prepare for a tsunami as assistance would be provided by the local and regional councils or Civil Defence Emergency Management. Nearly a third (27%) of people believed that their property would never be damaged by a tsunami.

Knowledge of what to do, especially after experiencing the natural signal of a strong or prolonged earthquake, was relatively low, with only 13% of people indicating that they would evacuate immediately after shaking stopped. The majority of people indicated they would wait for official word from CDEM or other sources to be told what they should do. The majority also said they would evacuate by car rather than the recommended method of walking for all able-bodied people.

Seventeen percent of people indicated that an earthquake would be the warning for a tsunami arriving within the next 12 hours. Nearly two-thirds (63%) expected to hear radio and TV announcements, 61% expected to hear a siren, and 26% expected to hear loudspeaker announcements. Respondents also stated they expected to be warned by texting or other messaging systems (32%), word of mouth (21%), a door-to-door visit by emergency services or Civil Defence staff (19%), and flashing lights (9%). Six percent did not know how they would be warned. Currently, there are a number of alerting mechanisms across the Auckland region, including sirens<sup>4</sup>, digital signage, and SMS and email notification to subscribed users<sup>5</sup>, as well as other alerting systems such as broadcast radio and the Red Cross Hazards App<sup>6</sup>. In late 2018, Auckland

4 [www.aucklandemergencymanagement.org.nz/useful-information/#tsunami-warning-sirens](http://www.aucklandemergencymanagement.org.nz/useful-information/#tsunami-warning-sirens)

5 [www.aucklandemergencymanagement.org.nz/auckland-emergency-management/subscribe-to-emergency-alerts](http://www.aucklandemergencymanagement.org.nz/auckland-emergency-management/subscribe-to-emergency-alerts)

6 [www.redcross.org.nz/what-we-do/in-new-zealand/disaster-management/hazard-app/](http://www.redcross.org.nz/what-we-do/in-new-zealand/disaster-management/hazard-app/)

Emergency Management moved through the final stages of confirming a tsunami siren pilot for Orewa which will include both a Public Alerting (PA) siren system and electronic safe swim signs (“Orewa gets tsunami sirens pilot”, 2018).

While the survey results showed that awareness of tsunami was high, people’s knowledge of what to do following an earthquake was poor, making it a concern for future response to tsunami. The low understanding of what to do may stem from a range of factors including a lack of awareness of what behaviours are beneficial, the perception among some that a tsunami is too destructive to prepare for, or the expectation that agency help and guidance will be immediately available. The Orewa survey results are comparable to surveys undertaken in other areas in Aotearoa New Zealand, particularly with respect to reliance on agency support or warnings (Currie et al., 2014; Dhellemmes, Leonard & Johnston, 2016; Fraser et al., 2016; Johnston et al., 2016; Tarrant et al., 2016).

As part of the follow-up activities, members of the Rotary Club presented the lessons learned from the Orewa survey at the Auckland CDEM Group committee meeting on 25 August 2015. Feedback they received about this presentation was positive and there was an interest in the survey results, particularly regarding how the initiative could be replicated in other communities. The Interact volunteers from Auckland Grammar School were also recognised as making an excellent contribution.

**Interim activities.** Orewa Rotary Club continued their efforts after the survey with a variety of awareness projects, including talking to Auckland Council (mentioned above) and businesses in Orewa about developing an evacuation plan. Rotary used the results of the survey to develop, with the aid of the community, solutions to raise tsunami awareness and preparedness. For example, the concept of a co-developed dual-purpose visitor walkway that doubles as a tsunami evacuation route was explored as a potential way to increase awareness about appropriate evacuation behaviour.

Additional efforts to develop tsunami preparedness in Orewa following Phase One included the development of preparedness brochures which were distributed to businesses (approximately 400) and households ( $n = 3,300$ ) in Orewa via a door-to-door “pamphlet drop”. The face-to-face contact and conversations that occurred between the Rotarian volunteers and local community members during the pamphlet drop process was

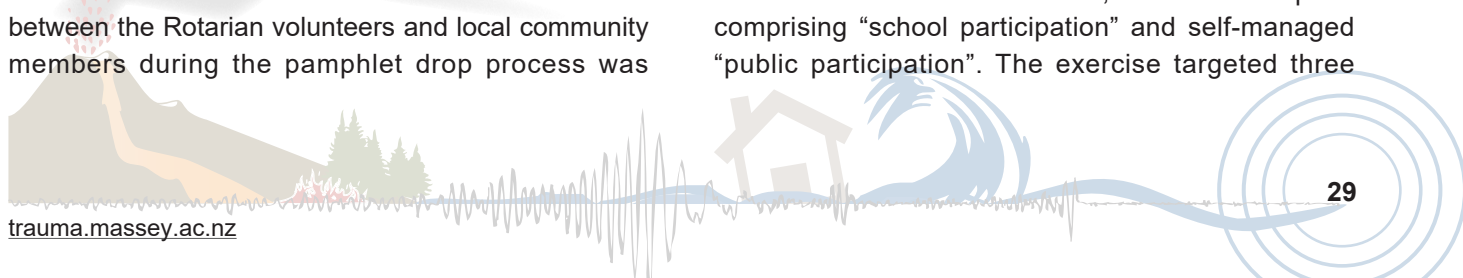
highlighted as being of particular benefit for community preparedness (Auckland Council, 2016), helping to also ensure the sustainability of tsunami-related activities in Orewa. The role of a trusted organisation such as Rotary visiting door-to-door cannot be underestimated since some people may not answer the door to other types of approaches.

### ***Phase Two: Tsunami Evacuation Exercise***

On 25 May 2016, a tsunami evacuation exercise was undertaken in Orewa (Rotary & Auckland CDEM, 2016). The development of the exercise built on the partnership between Rotary and Auckland Council that had been developed the previous year, discussed above, and was again supported by the JCDR. It was initiated jointly by Rotary and Auckland Council in response to the activities that had occurred in Phase One, with Auckland CDEM acting as “exercise control” on the day. The tsunami walk, called “Orewa: Ahead of the Wave” (see flyer in Appendix 3), was intended as a “tsunami public education preparedness event” to help individuals in the community identify and establish their quickest route to a safe location (Rotary & Auckland Council, 2016).

The overarching goals of the exercise were twofold. First, the exercise was designed to increase tsunami awareness and preparedness, which included raising local knowledge and understanding of evacuation zones, appropriate evacuation behaviour, tsunami evacuation signage and warnings, information boards, and blue lines (a line painted onto the road to identify safe zones from tsunami inundation; see Johnston et al., 2013 and Fraser et al., 2016 for details about “blue lines” projects) and encouraging household emergency plans and conversations with family members. It was important for the community to recognise that a felt earthquake could be the only warning which would require immediate evacuation and to understand the nature of official warnings and how to receive them. Achieving these goals required public meetings to socialise the nature of the event with the community and the involvement of the Orewa Business Association and greater Orewa community to engage local businesses and community members.

The second aim of the exercise was to support and monitor schools as they participated in the tsunami walk by collecting data on the timeframes and evaluating the success of the exercise. As such, it included two parts comprising “school participation” and self-managed “public participation”. The exercise targeted three



local schools (Orewa College: 1,900 students; Orewa North Primary: 280 students; and Orewa Primary: 450 students). The public were invited to join the schools on their walk or to walk their own route to tsunami safe zones<sup>7</sup>. Orewa College is in an orange zone, Orewa North Primary is in a yellow zone, and Orewa Primary is outside the inundation zone. Orewa Primary acted as the tsunami safe assembly area for Orewa College. All schools distributed tsunami information pamphlets to students prior to the tsunami exercise to initiate conversations with their families about tsunami preparedness.

Researchers from the JCDR offered support in a similar way to Phase One by providing assistance to Auckland Council and Rotary during the exercise plan development and as exercise observers and by supplying researchers to observe the walk and collect data. Social science involvement throughout the project also enabled an exercise evaluation methodology to be developed as a pilot for future citizen science self-evaluation that may be utilised in other community exercises. Three key elements to the pilot development included:

- 1) A self-completion survey for evacuation participants to evaluate their route, timing, and other aspects such as safety, accessibility, and welfare. The survey was completed during the pilot process by four key teachers at Orewa College. The blank survey form is included in Appendix 5.
- 2) The use of free GPS tracking applications by participating researchers walking the routes to log the route and timing along the route, and share this anonymously as a .GPX (GPS Exchange) file (example chart in Figure 2).
- 3) An observation questionnaire completed by researchers stationed at locations along and at the end of the evacuation route. It had the following components: location, weather conditions (open ended), a table to record the number of people passing the checkpoint each minute, observations of public behaviour (open ended), and any additional notes (open ended). The manual count of the number of people passing a given point each minute provided a cross check for the app data. The open-ended qualitative questions focussed on the

<sup>7</sup> As outlined in Appendix 4, there are three coloured zones. *Red shore exclusion zone*: Covers the beach and adjacent low-lying areas most likely to be affected by a tsunami. *Orange evacuation zone*: May need to be evacuated if there was a threat from a medium- to large-scale tsunami. *Yellow evacuation zone*: Covers the largest area that would need to be evacuated in the event of a maximum-impact tsunami.

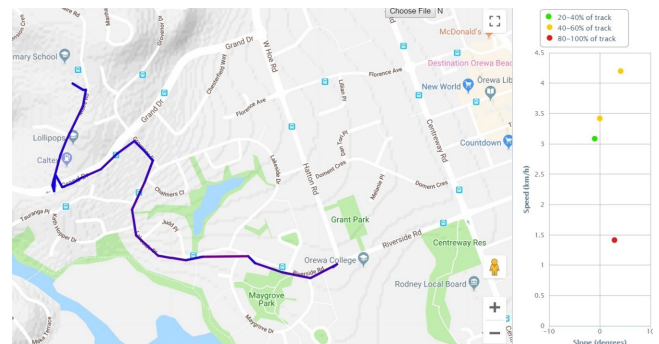


Figure 2. Anonymous file output from a free GPS application showing route and speed information for an individual following Route 2. This can also be reprocessed to show overall travel time.

behaviour of evacuees, the suitability of the route, and any issues seen in the evacuation.

On the day, exercise control resided with Auckland CDEM. A wide range of additional agencies and stakeholders were involved in a support capacity including: councillors from the Auckland CDEM Group; Hibiscus Coast Kindergarten; Early Adventures Child Care; Hibiscus and Bays Local Board; GNS Science; research staff and volunteers from Massey University, Otago University, and Auckland University; Orewa Surf Life Saving Club; More FM Rodney radio station; Hibiscus Coast Community Patrol; and East Coast Life at the Boundary (East Coast LAB<sup>8</sup>).

The exercise set-up, tsunami evacuation, and final debrief all occurred between 8 a.m. and 11.30 a.m., with the tsunami evacuation itself taking place between 9.30 and 10 a.m. A team of volunteers were located along the walk to ensure people could find their way and to observe and monitor the number of school participants as they passed the checkpoints. These volunteers also filled out the observer questionnaire. After practicing “Drop, Cover and Hold”, participants were encouraged to walk to their nearest identified tsunami route (either Route 1 or Route 2; see Appendix 4), following the tsunami evacuation signage, and continue this route until they reached the blue line and tsunami safe zone. It is important to note that in the event of a real tsunami threat, people should “Drop, Cover and Hold” and then immediately evacuate to high ground without waiting for any official warnings.

Route 1 of the exercise, illustrated in Appendix 4, mainly involved students and staff from Orewa North Primary

<sup>8</sup> East Coast Lab is a “collaborative programme that brings together scientists, emergency managers, experts and stakeholders across the East Coast to make it easy and exciting to learn more about the natural hazards that can affect [NZ’s East coast]” ([www.eastcoastlab.org.nz/](http://www.eastcoastlab.org.nz/)).



school, with some members of the public (totalling 340). The school undertook a spontaneous earthquake drill at 9.25 a.m. which was based on a potential earthquake scenario where the shaking may or may not have been felt at the school but would have triggered an official warning. During this scenario the children dropped, covered, and held on in accordance with earthquake best practice. When the tsunami evacuation message from Auckland CDEM was received by the principal at 9.30 a.m., classes immediately began to evacuate onto the playing field at the back of the school. It is important to note, however, that in a real event there may not be an official tsunami evacuation warning, particularly for a near source tsunami. Local radio station More FM Rodney also broadcast a message to initiate the start of the tsunami exercise. A gate had been installed 18 months earlier at the back of the school grounds as a way to more quickly access high ground (installed after previous evacuations required students to leave via the main gate, resulting in longer evacuation times). The youngest children evacuated first, with older classes following. This was subsequently considered a slower option, and in future the principal said he would begin evacuating each class as soon as it was ready to go rather than waiting for all classes to assemble in the playing field. In total, the evacuation took 11 minutes to complete from when the first class left school grounds to the arrival of the last class at the safe zone (i.e., 9.34 to 9.45 a.m.). As the children arrived at the safe zone, they sat down to wait for instructions.

Route 2 saw 1,825 students and members of the general public evacuate during the exercise, mainly from Orewa College. The evacuation began at 9.36 a.m., six minutes after the evacuation warning was issued. Teachers wearing high visibility vests assisted during the walk. Many students reported being unsure of the evacuation route and were unable to read the map with which they were provided. The first arrivals reached the end location at 9.54 a.m., while the last arrived at 10.23 a.m., 47 minutes after the evacuation began. Exercise observers noted that older adults and those with disabilities were amongst the slowest to reach the end point.

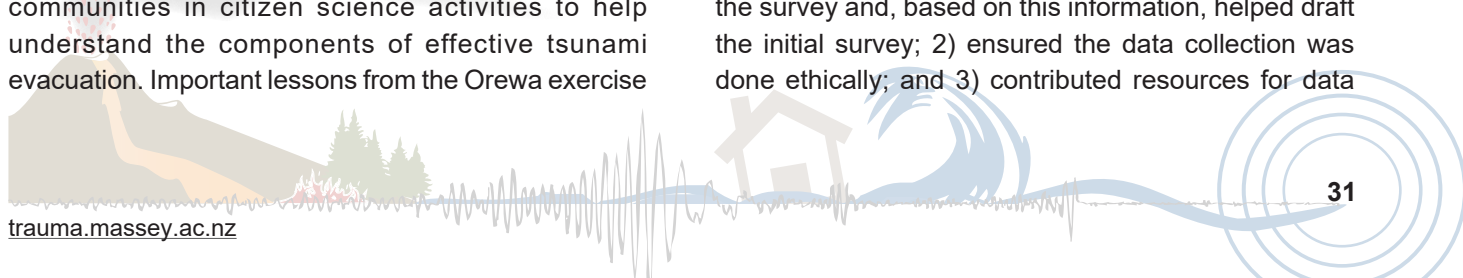
The three datasets collected for Phase Two (self-completion survey, GPS tracking application, and observation questionnaire) were considered viable in post-event analyses and could be used by other communities in citizen science activities to help understand the components of effective tsunami evacuation. Important lessons from the Orewa exercise

when using a mobile application such as the free GPS tracking application include the need to: a) access guidance on what to consider and plan before the exercise; b) provide a link to download a compatible free GPS application for some or all participants; c) provide instructions on using the application and anonymously sharing the GPX file back to the tool; d) provide a questionnaire to capture the participant and observer topics from the pilot (anonymised but linked to the GPX route); and e) incorporate a summary and reporting component to allow succinct citizen-participant self-analysis of how effective and fast the evacuation was, as well as what improvements could be made. A mobile tracking tool can also provide anonymous data to researchers which links demographics to speed and route data and can assist with refining evacuation behaviour models for both land-based and vertical building evacuation.

In the following section, we discuss the impact of the Orewa citizen science initiative, including its influence on the development of collaborative partnerships, the community's overall resilience, and the subsequent activities it inspired. We also highlight aspects of this initiative that could be successfully applied to future citizen science projects.

## Discussion

Successful community-led citizen science initiatives require a number of key elements to be in place. As illustrated in this case study paper, a range of key agencies played roles in ensuring the initiation and success of the Orewa tsunami project. For example, in Phase One, higher educational institutions played an important role in responding to the approach from the Rotary Club to co-develop a survey for the community to learn about their citizens' understanding of tsunami risk. Crucial to the success of many citizen science projects is the ability for research scientists to recruit citizens. However, because this project was citizen initiated and led, citizens were already engaged and motivated to take part. The inclusion of research scientists in this way also offered the opportunity to help guide residents and resident groups through the various methods of data collection and the ethics involved in gathering data in their communities. Specifically, the JCDR: 1) listened to the needs of the Rotary Club in developing the survey and, based on this information, helped draft the initial survey; 2) ensured the data collection was done ethically; and 3) contributed resources for data



collection, such as mobile technologies and the analysis of survey responses.

To empower community-led citizen science projects, higher education institutions can offer “train-the-trainer” sessions (e.g., via the role play in Phase One) on data collection methods and data analysis for community leaders of citizen science initiatives, thereby ensuring that collection of data has buy-in and is ethical, consistent, and reliable. Successful community-initiated citizen science projects also require support from trusted local leaders or groups to engage with their community, and often to take leadership of the project. These factors help to ensure that the process is personalised and relevant to the community and encourages equity between citizens and leadership in the process, factors identified as encouraging successful collaboration and knowledge transfer for building community resilience (Doyle et al., 2015).

Furthermore, involving existing local youth groups and other volunteer groups provides additional human resources for data collection. Providing volunteers with an orientation about the research and training them in data collection methods helps to increase their understanding of the “big picture” of the research and how their efforts contribute to address the wider context. For long-term data collection efforts, evaluation of volunteer experiences is essential to improving future citizen-initiated research projects and long-term engagement of volunteer support. For example, the question of how higher institutions might evolve the “train-the-trainer” immersive learning exercises to ensure core learning outcomes are achieved should be addressed.

Through the two phases of Orewa citizen science activities presented here, a number of key lessons and challenges were identified. First, collaboration and partnership between researchers and Rotary led to a co-design of Phase One via the school surveys, which then led to a much wider range of interest and participation in Phase Two from other organisations including schools, Auckland Council (particularly CDEM), local businesses, emergency service agencies, universities, and beyond. Second, the Rotary community-led citizen science project of Phase One acted as a catalyst for the much larger-scale agency-led tsunami walk in Phase Two that incorporated a more diverse group of participants. Rotary thus acted as a citizen-led hub for partnership

and collaboration between researchers, communities, and CDEM.

The evolution from Phase One to Phase Two of the citizen science project demonstrates that as the scope of an activity grows, it may require a greater level of facilitation (Diaz-Puente, Galleho, Vidueira, & Fernandez, 2014; Vidal, 2009). During Phase One, the science “generated” was collected by the school students through a co-produced survey with researchers, with the findings of this survey indicating the need for more involved community tsunami awareness activities. This led to Phase Two, during which the collaborative agency-led nature of the resilience building activity (tsunami walk) meant that the “science” of the event was less co-produced and was secondary to the multiple motivations of the different stakeholder groups. Individuals from schools and the public participated in the generation and collection of tsunami travel information, yet the core motivation was providing people with an experiential tsunami awareness event. However, there was still co-production of knowledge as Auckland Council and Rotary worked alongside a range of community groups, businesses, and agencies to identify key issues and solutions regarding tsunami preparedness, evacuation, and signage (including such issues as safely crossing major highways).

The different nature of these two phases of citizen science projects fits across all three of the citizen science categorisations of Bonney, Ballard, et al. (2009), Bonney, Cooper, et al. (2009), and Shirk et al. (2012), who define: 1) “Contributory projects” that are designed by scientists, where citizens contribute data; 2) “Collaborative projects” designed by scientists and where citizens contribute data, but may also help in project design, analysis, or dissemination; and 3) “Co-created projects” designed by scientists and citizens working together and where at least some of the participants are actively involved throughout all or most of the scientific process. The first phase was a “co-created” project, while the second phase was “collaborative” with some “contributory” elements.

Additional benefits from events such as these include not just the increased collaboration, trust and relationship building, awareness, empowerment, education, and the science itself (Becker et al., 2015), but also the range of resources that were developed and the “spin-off” community resilience projects which were subsequently developed. From an Auckland Council perspective,

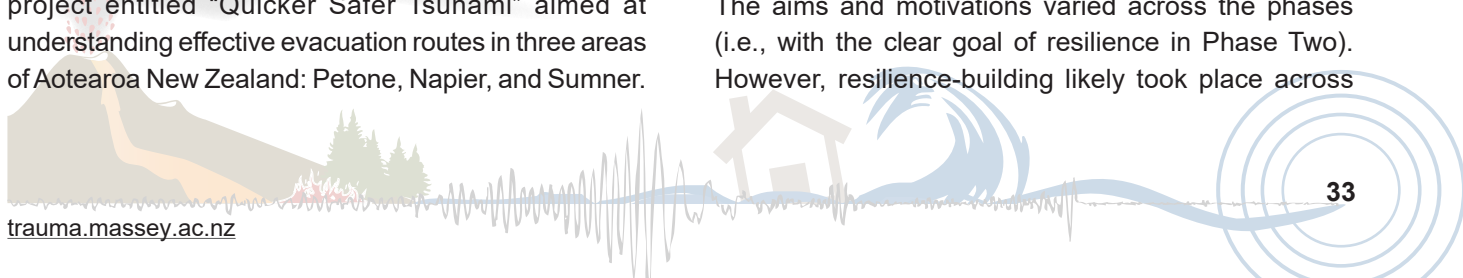
the tsunami walk and related activities significantly increased the awareness and understanding of tsunami risk and inspired locally-driven public education about tsunami in Orewa. For example, Auckland Council ran a tsunami preparedness competition within the schools that took part in the walk, to continue to develop conversations about preparedness. The experience of the tsunami evacuation exercise was used to inform the development of Auckland's public alerting and public education strategy and supported other work programmes. In addition, lessons from this program of work informed Auckland Council's support of the development of a national guideline on vertical tsunami evacuation (MCDEM, 2018). Future work by the council will continue to explore how to incorporate citizen science into future preparedness and resilience building work.

The activities in Orewa also acted as a catalyst for activities across Aotearoa New Zealand. The planning and logistics required to develop the tsunami exercise were documented in a tsunami evacuation planning project template which can be applied to other communities in Auckland and beyond. For example, East Coast LAB utilised resources from the Orewa project to generate a set of tsunami *hīkoi* ("walk") guidelines that also included lessons from their observations of the Orewa "Ahead of the Wave" walk and similar tsunami walk activities in the United States. These guidelines have been actively used as a resource by Hawke's Bay CDEM and Bay of Plenty CDEM within their communities. The Phase Two tsunami walk also resulted in the planning of a Cape Coast tsunami *hīkoi* by CDEM volunteers, supported by Hastings CDEM, and in partnership with East Coast LAB. This was unfortunately cancelled due to bad weather; however, the resources were utilised in a colouring and poster competition through social media, shops, schools, and community centres. The Phase One tsunami awareness survey in Orewa also now serves as a useful resource for other communities and schools and was used as a basis for a citizen science project on tsunami awareness and preparedness run by students at Napier Girls High School as part of their geography course work, in collaboration with East Coast LAB. Finally, the GPS tracking application activity in Orewa also formed the basis for a new researcher-led agent-based modelling project entitled "Quicker Safer Tsunami" aimed at understanding effective evacuation routes in three areas of Aotearoa New Zealand: Petone, Napier, and Sumner.

These spin-off events demonstrate how the initial community and agency relationships, leadership, and facilitation of a citizen science event acted as a catalyst for a suite of community resilience and knowledge transfer processes. As stated by Doyle et al. (2015), "both leadership and facilitation are often needed to start community resilience processes" (p. 64). For effective collaboration on disaster risk management to occur, particularly when community collaboration, knowledge transfer, and citizen science approaches are involved, there exists a challenging question: who and what is the catalyst for such collaborative activities? Key challenges in community collaboration include available time and resources, relevance, and willingness or interest from scientists, citizens, and relevant agencies to participate (see earlier; Bonney et al., 2014; Doyle et al., 2015; Kearney et al., 2013; Kelman et al., 2011; Orchiston et al. 2016; Soleri et al., 2016). Effective facilitation should thus empower communities to identify and solve their own problems (Vidal, 2009) by providing guidance and facilitation at an equal level that ensures the initiative is still a community-driven project (Doyle et al., 2015). For community resilience building, it is also vital that relevant agencies and practitioners are involved to provide support and guidance to ensure expectations are met and practical initiatives that are identified can be implemented.

The different nature of the two phases presented here also highlights the importance of recognising that any project may have multiple requirements and motivations and that researchers working in the citizen science space must recognise the different motivations of organisations and individuals. The first phase of activities was motivated by a clear citizen science goal and the co-generation of "science" through community-led surveys, where a community organisation wanted to develop a greater understanding of their community's tsunami awareness and preparedness. Meanwhile, the second phase of activities was motivated primarily as a community resilience building activity, was not initially planned as an output of Phase One, and had a secondary goal of data collection by the research community. Phase Two aimed to enhance community awareness and preparedness while the citizen science element identified the speed and effectiveness of trial tsunami evacuations.

The aims and motivations varied across the phases (i.e., with the clear goal of resilience in Phase Two). However, resilience-building likely took place across



the whole initiative. For example, collective efficacy, or the belief that people can work together effectively to prepare for an event, has been found to be key to motivating people to undertake preparedness actions (Paton et al., 2010). This effect tends to be stronger in countries that share cultural beliefs about the utility of collectivism (e.g., Japan, Taiwan; Paton, 2018) whereas countries which have higher levels of individualism (such as Aotearoa New Zealand) are less likely to have a collective efficacy belief (Paton, 2018). This means that more focus is required on the development of positive outcome expectancy (i.e., the belief that undertaking a certain action beforehand will be beneficial in a subsequent disaster, for example in terms of survival or safety) before collective efficacy can be built (Paton, 2018). Citizen science initiatives such as that for Orewa presented here can have multiple components that address such issues. The role-plays, surveys, and tsunami exercise used in this case study all had critical roles in raising awareness about the issue of tsunami risk through collective and experiential learning. Additionally, the process provided practical solutions for preparing for, and responding to, such an event and thus targeted outcome expectancy beliefs. The activities also provided a means for developing collective efficacy as they brought people together in a participatory fashion to discuss and solve issues, thus likely helping develop the belief that by working together they could prepare and respond to a future event. As mentioned previously, the various activities were facilitated by a number of different agencies, highlighting both the importance of leadership in the process (e.g., Doyle et al., 2015; Paton 2006; Paton & Johnston, 2006) and the interactive nature of resilience.

Engagement in communities with high risk from hazard events is challenging to initiate and to sustain. Rotary and Auckland Council acknowledged “it is the people who live in Orewa and Rotarians who are passionate about volunteering in the community who will drive the Orewa Tsunami Preparedness project – without the involvement of Rotary to coordinate this, tsunami preparedness will not be sustainable” (Rotary and Auckland Council 2016, p. 1). However, while challenging, the benefits of such events include individual and community empowerment and agency, understanding of risk and expected or ideal behaviours and actions, and the strengthening of partnerships and relationships between individuals, communities, and agencies (Bonney et al., 2016; Kearney et al., 2013; Soleri et al., 2016).

Citizen science and collaborative resilience-building activities also provide opportunities for scientists to ensure the science they (co-)develop and communicate is useful, useable, and used (Aitsi-Selmi, Blanchard, & Murray, 2016; Rovins, Doyle, & Huggins, 2014) and that research is “socially responsible” (Daedlow et al., 2016) in terms of societal goals and values, where the “transparent information and involvement of stakeholders during the research process can mitigate uncertainties and risks and is a morally responsible action” (p. 4; see also Hudson-Doyle, Paton, & Johnston, 2018).

### **Limitations and Future Work**

This paper presents our observations and experiences of the evolution of a citizen science activity into a suite of community resilience building activities. Evaluation of the efficacy of such activities was not the focus of this study and is recognised as a limitation. Future activities that integrate citizen science and community resilience building should thus include evaluation, as advocated for by Johnson et al. (2014), Tipler, Tarrant, Johnston, and Tuffin (2016), and Johnston et al. (2016). For example, evaluation should consider how the tsunami walk increased people’s awareness of their evacuation route, the degree to which the initial survey in Phase One motivated people to identify tsunami preparedness activities, and the degree to which these activities influenced community resilience building factors (such as self and collective efficacy). Such evaluation tools can be part of the citizen science process. As researchers we also identified that future research would benefit from qualitative interviews with members from across the agencies, organisations, and schools that participated, to identify their experiences and perceptions of the process, within a time window when such views are still “fresh”. Unfortunately, due to limited resources, this was not possible for these events.

In addition, future research should consider the role of funding, leadership, and ethical standards as well as codes of practice and professional guidelines for participatory approaches to science, engagement, and citizen science (e.g., Beven, Lamb, Leedal, & Hunter, 2015; Faulkner, Parker, Green, & Beven, 2007; Janssen, Petersen, van der Sluijs, Risbey, & Ravetz, 2005). This is particularly important as such values can vary significantly between agencies, individuals, and disciplines (Austin, Gray, Hilbert, & Poulson, 2015; Hudson-Doyle et al., 2018), differences which could damage future relationships and activities.

The community survey in Orewa (Phase One) was seen as the forerunner to similar community awareness projects to be undertaken throughout Aotearoa New Zealand. Rotary will use their natural hazard awareness to extend the programme into other communities throughout Aotearoa New Zealand. They will continue to work closely with university research partners to gather data and help build detailed knowledge of existing awareness within communities and, more importantly, their change over time. Such results will be used to improve their community outreach and public education efforts about tsunami risk and to help local businesses refine their pre-event planning and evacuation response procedures. Rotary also intend to share these results with other agencies, and researchers working with these communities will use these results to identify effective actions and methodologies to guide volunteer-based efforts for future community engagement initiatives and citizen science activities.

Finally, future work includes the opportunity to develop a disaster-relevant citizen science framework. Much work has been done in an environmental context to identify key components of citizen science (as discussed earlier), but how those concepts could be deliberately applied in the hazard space is still relatively unexplored. Such a framework would provide guidance on how to develop effective citizen science initiatives that reflect desired levels of participation and meet the goals of citizens and stakeholders in terms of outcomes.

## Conclusion

This paper considered the case study of a two-phase citizen science project initiated by community leaders from Rotary Clubs and facilitated by a number of agencies including Massey University via the Joint Centre for Disaster Research and the Auckland CDEM Group, as well as involving students from Auckland Grammar School. Both Phase One and Phase Two aimed to understand the community's knowledge of tsunami risk and involve them in the development of appropriate and practicable responses to tsunami. The community survey in Phase One showed that the community had a low understanding of tsunami risk in terms of warning time, an unrealistic expectation of support from authorities, and low awareness of appropriate evacuation actions to take. Phase Two demonstrated that while some schools are located within easy walking distance to tsunami safe zones, others have a longer walk and require quick action to

keep their students safe. Overall, these results were used by community leaders and groups to inform further community activities to build awareness of tsunami risk and address misconceptions. In our experience, Phase One was a catalyst for Phase Two and led to ongoing community initiatives within Orewa as well as across Aotearoa New Zealand. This case study highlights the importance of such catalyst events for resilience building processes. A wider outcome of this initiative will be to develop a community-based framework that provides tools such as community surveys, training, and education. These tools will increase the potential for community-led resilience building for tsunami risk, as well as for risks from other natural hazards.

## Acknowledgments

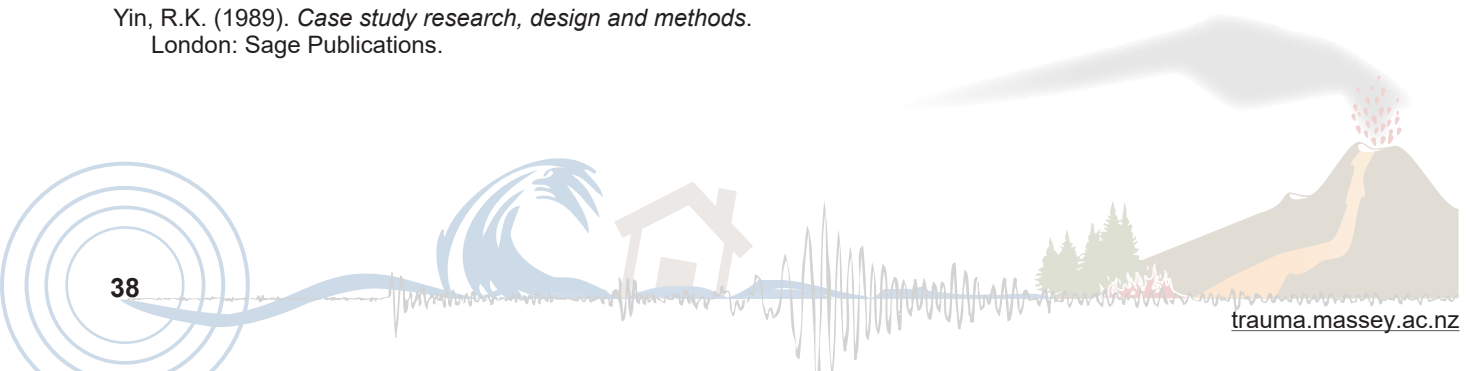
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## Appendix 1: Orewa tsunami awareness survey

### TSUNAMI AWARENESS SURVEY –

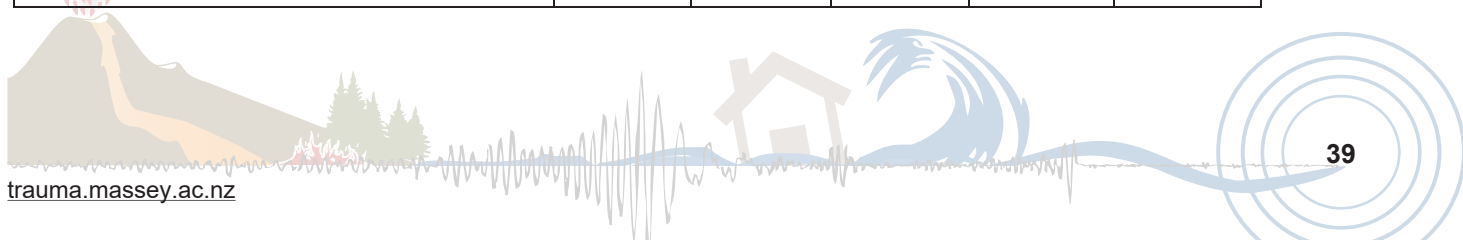
**1. Which are the two natural hazards that you think are most likely to affect Orewa? (Tick only two)**

- |                            |                                  |                            |                                  |
|----------------------------|----------------------------------|----------------------------|----------------------------------|
| <input type="checkbox"/> 1 | Flooding (river or sea)          | <input type="checkbox"/> 5 | Ashfall from a volcanic eruption |
| <input type="checkbox"/> 2 | Storm or cyclone with high winds | <input type="checkbox"/> 6 | Tsunami                          |
| <input type="checkbox"/> 3 | Forest or bush fire              | <input type="checkbox"/> 7 | Coastal erosion                  |
| <input type="checkbox"/> 4 | Earthquake                       | <input type="checkbox"/> 8 | Landslide                        |

**2. To what extent do you agree that?** Please use the scale below to show much each statements matches your views:

Strongly disagree    Disagree    Neither Agree nor disagree    Agree    Strongly agree

	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Tsunami are too destructive to bother preparing for	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
A serious tsunami is unlikely to occur during your lifetime	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
It is unnecessary to prepare for tsunami as assistance will be provided by local/regional councils or Civil Defence	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Your property will never be damaged by a tsunami	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Preparing for tsunami will improve my everyday living conditions	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Preparing for tsunami will help save lives	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
I do not know how I can prepare for tsunami	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5



**3. When do you expect the next damaging tsunami to hit Orewa? (Tick only one)**

- 1 Never
- 2 In the next 10 years
- 3 In the next 100 years
- 4 In the next 1000 years
- 5 In the next 10 000 years
- 6 Don't know

**4. Have you heard or received any information about preparing for tsunami hazards from any of the following? (Tick all that apply)**

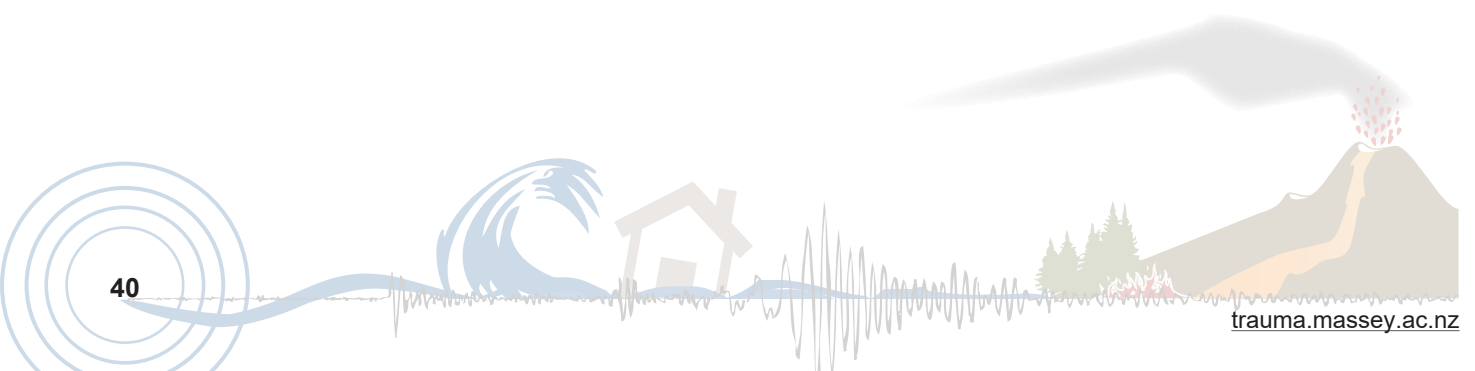
- 1 I haven't heard or received any information
- 2 Friends
- 3 Neighbours
- 4 Relatives
- 5 Central Government agencies
- 6 Regional Council
- 7 Local Council
- 8 Local Civil Defence group
- 9 Business establishments
- 10 Research organisations  
e.g. GNS Sciences
- 11 My workplace
- 12 My child's school
- 13 Other, please specify\_\_\_\_\_

**5. Do you have a 'getaway kit' or items ready to evacuate your home quickly?**

- 1 Yes
- 2 No

**6. What is in that kit/ what are those items? (Tick all that apply)**

- 1 First aid kit / supply of any medicines needed
- 2 Food
- 3 Water
- 4 Torch
- 5 Portable radio
- 6 Spare batteries
- 7 Warm clothes
- 8 Important documents
- 9 A household plan
- 10 Other (please specify)\_\_\_\_\_



**7. How do you expect to be warned that a tsunami is coming within the next 12 hours? (Tick all that apply)**

- |   |  |
|---|--|
| <input type="checkbox"/> 1 Earthquake   | <input type="checkbox"/> 6 Radio and TV announcements  |
| <input type="checkbox"/> 2 Sirens   | <input type="checkbox"/> 7 Word of mouth               |
| <input type="checkbox"/> 3 Loud speaker announcements   | <input type="checkbox"/> 8 Don't know                  |
| <input type="checkbox"/> 4 Flashing lights  | <input type="checkbox"/> 9 Other (please specify)_____ |
| <input type="checkbox"/> 5 Door-to-door visit by emergency services<br>or Civil Defence staff |  |

**8. How do you expect to be warned that a tsunami is coming within an hour?**

- |   |  |
|---|--|
| <input type="checkbox"/> 1 Earthquake   | <input type="checkbox"/> 6 Radio and TV announcements  |
| <input type="checkbox"/> 2 Sirens   | <input type="checkbox"/> 7 Word of mouth               |
| <input type="checkbox"/> 3 Loud speaker announcements   | <input type="checkbox"/> 8 Don't know                  |
| <input type="checkbox"/> 4 Flashing lights  | <input type="checkbox"/> 9 Other (please specify)_____ |
| <input type="checkbox"/> 5 Door-to-door visit by emergency services<br>or Civil Defence staff |  |

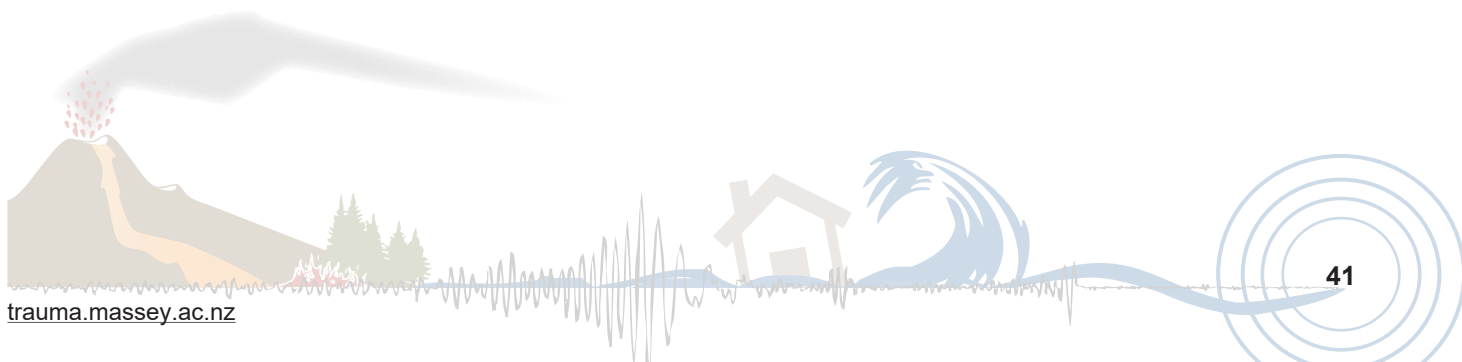
**9. If you feel a strong earthquake while at the beach (or anywhere on the coast),**

**a. Would you evacuate?**

- 1 Yes  
 2 No

**b. How much time do you think will you have to move to safety from any approaching tsunami it may cause? (Tick only one)**

- |   |  |
|---|--|
| <input type="checkbox"/> 1 A few minutes            | <input type="checkbox"/> 4 1 – 3 hours       |
| <input type="checkbox"/> 2 10 minutes to 30 minutes | <input type="checkbox"/> 5 More than 3 hours |
| <input type="checkbox"/> 3 30 minutes to 1 hour     | <input type="checkbox"/> 6 Don't know        |



**10. Do you have a specific evacuation destination in mind if you had to evacuate after a tsunami warning?**

- <sub>1</sub> Yes, within Orewa  
 <sub>2</sub> Yes, outside of Orewa  
 <sub>3</sub> No

**11. If yes, how do you plan to evacuate?**

- <sub>1</sub> Walk  
 <sub>2</sub> Drive  
 <sub>3</sub> Cycle  
 <sub>4</sub> Use a mobility scooter  
 <sub>5</sub> Taxi  
 <sub>6</sub> Other (please specify) \_\_\_\_\_

**12. What would you do before evacuating? (Tick all that apply)**

- <sub>1</sub> Nothing  
 <sub>2</sub> Assist others in evacuation  
 <sub>3</sub> Get life essentials (Food, water, medicine, etc.)  
 <sub>4</sub> Valuables (jewelry, money, etc.)  
 <sub>5</sub> Call family or friends  
 <sub>6</sub> Gather family  
 <sub>7</sub> Seek further information (from radio, TV...)  
 <sub>8</sub> Other (please specify) \_\_\_\_\_

**13. Are there any factors that would impair your ability to evacuate?**

- <sub>1</sub> I am mobility impaired but I can self-evacuate  
 <sub>2</sub> I am heavily mobility impaired and require assistance to evacuate  
 <sub>3</sub> I have health issues and require assistance to evacuate  
 <sub>4</sub> Other (please specify) \_\_\_\_\_  
 <sub>5</sub> None of the above

**Why are you in Orewa today?**

- <sub>1</sub> I live in Orewa
- <sub>2</sub> I live and work in Orewa
- <sub>3</sub> I work in Orewa but live elsewhere on high ground
- <sub>4</sub> I am a visitor and live beside the coast on ground less than 5 meters above sea level
- <sub>5</sub> I am a visitor and live inland higher than 5 meters above sea level

**14. What is your gender?**

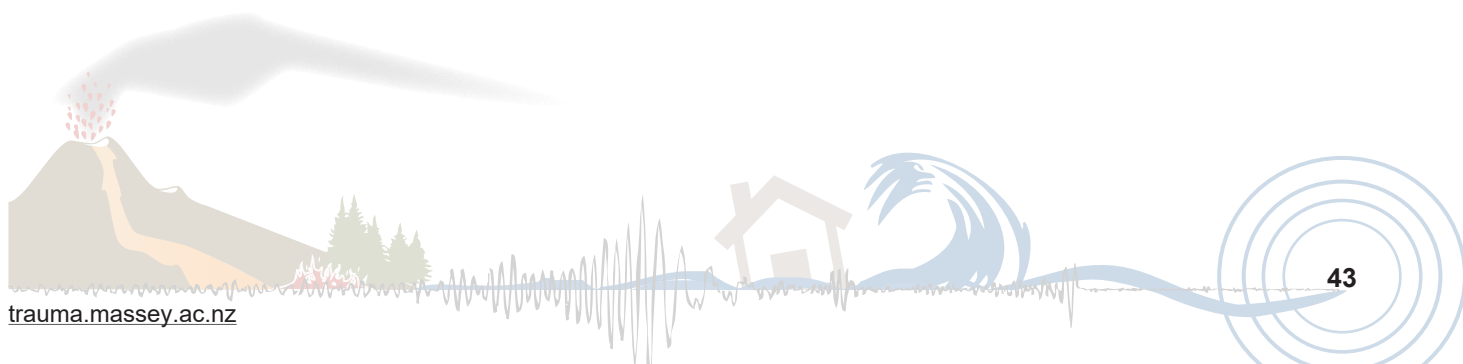
- <sub>1</sub> Male
- <sub>2</sub> Female

**15. Please indicate your age**

- <sub>1</sub> > 18 years
- <sub>2</sub> 18- 30 years
- <sub>3</sub> 31-40 years
- <sub>4</sub> 41- 50 years
- <sub>4</sub> 51- 60 years
- <sub>5</sub> 61- 70 years
- <sub>6</sub> < 71 years

**16. Would you like follow up assistance from Rotary as community coordinators in terms of assisting you plan your evacuation?**

- <sub>1</sub> Yes
- <sub>2</sub> No



## Appendix 2: Rotary Clubs media release

22 August 2015

MEDIA RELEASE



Orewa community research into tsunami awareness

Research into disaster awareness in the seaside community at Orewa was conducted by Massey University today (Saturday 22 August).

The research is sponsored by the Chip-In Foundation, which is the disaster awareness section of the Rotary Clubs of Orewa, Auckland and Westhaven, and was carried out by the Massey University Joint Centre for Disaster Research, with assistance from Auckland Council.

“We have identified the Orewa centre as a high-risk spot for a tsunami disaster event,” says Tom Morton, Director of the Chip-In Foundation.

“Orewa is one of the east coast areas that would be in a direct line of a tsunami caused by an earthquake in the Kermadec Trench, which runs almost parallel to the coastline.

“We are keen to find out just how aware people in the Orewa community are about what they should do if a tsunami struck their area, and that is the reason we are partnering with Massey to carry out today’s research.”

The survey was carried out by Rotary volunteers and and post-graduate scholars from Massey University. It can also be completed on-line.

Chip-In set up a pop-up information centre for the day, and provided residents and visitors with maps and reports on the tsunami risk for Orewa, a video and assistance on planning home, business and school evacuation.

Chip-In will report back to the community with its findings from today’s research.

*For further information please contact*

Tom Morton, Chip In Director

Phone 0274 751 800

CHIP-In Foundation, [chip-in.org.nz](http://chip-in.org.nz)

Sponsored by the Rotary Clubs of Orewa, Auckland and Westhaven and Auckland Council

### Appendix 3: “Orewa: Ahead of the Wave”, Auckland CDEM Flyer



#### Orewa tsunami preparedness and evacuation project

**The only warning you may get from a tsunami caused by an earthquake is the earthquake itself.**  
**If you feel a long or strong earthquake, one that is hard to stand up in or that continues for a minute or more, walk past the blue lines!**  
**If you see any strange sea behaviour, such as a sudden rise or fall in sea level, or hear unusual noises such as roaring like a jet plane, evacuate immediately.**

Auckland Council, Civil Defence and Emergency Management has been working with the Orewa community and Rotary to make Orewa tsunami ready.

A large earthquake could cause a tsunami in Orewa, similar to the one that hit Japan in 2011. Because the first tsunami wave could arrive within an hour, it is important that you have an evacuation plan and know your nearest safe zone location.

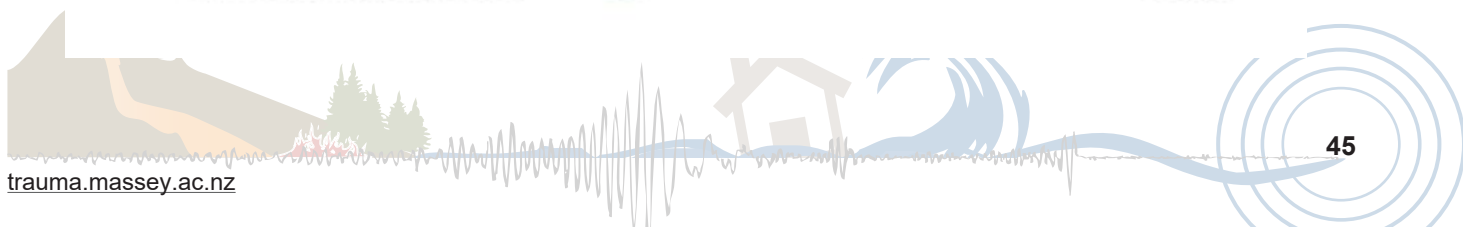
We have identified safe zones and evacuation routes for you to take in the event of a tsunami.

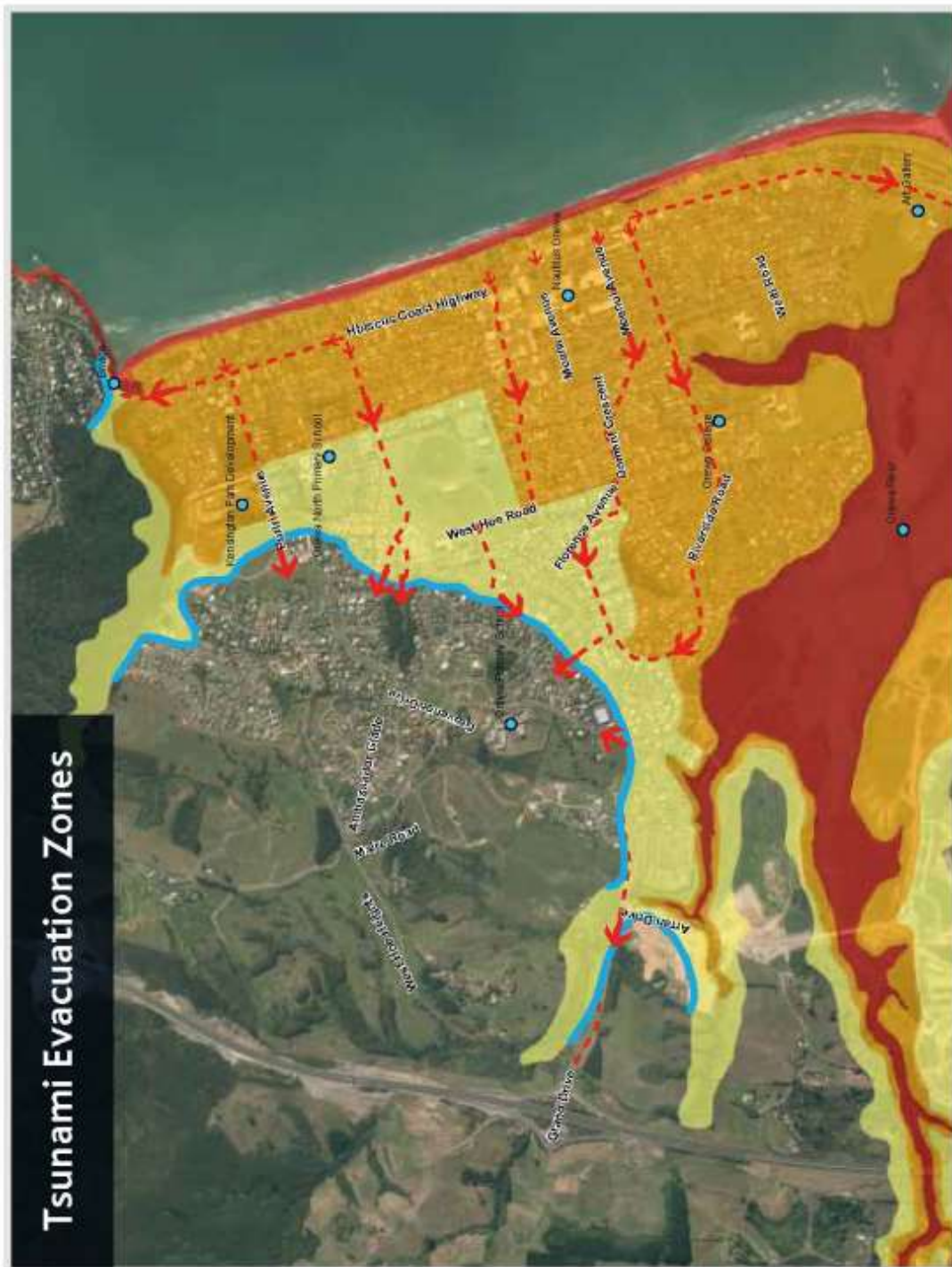
Evacuation signs will be installed to indicate the quickest routes to the safe zones. Painted blue lines show where the largest tsunami could reach and indicate the safest zone.

Once you have walked or cycled past the blue line, keep going and stay away until the official all-clear has been given.

Others may need help to evacuate – remember those who might need extra assistance.

► **For more information:**  
download the Civil Defence app for real-time alerts or call Auckland Council on 09 301 0101.



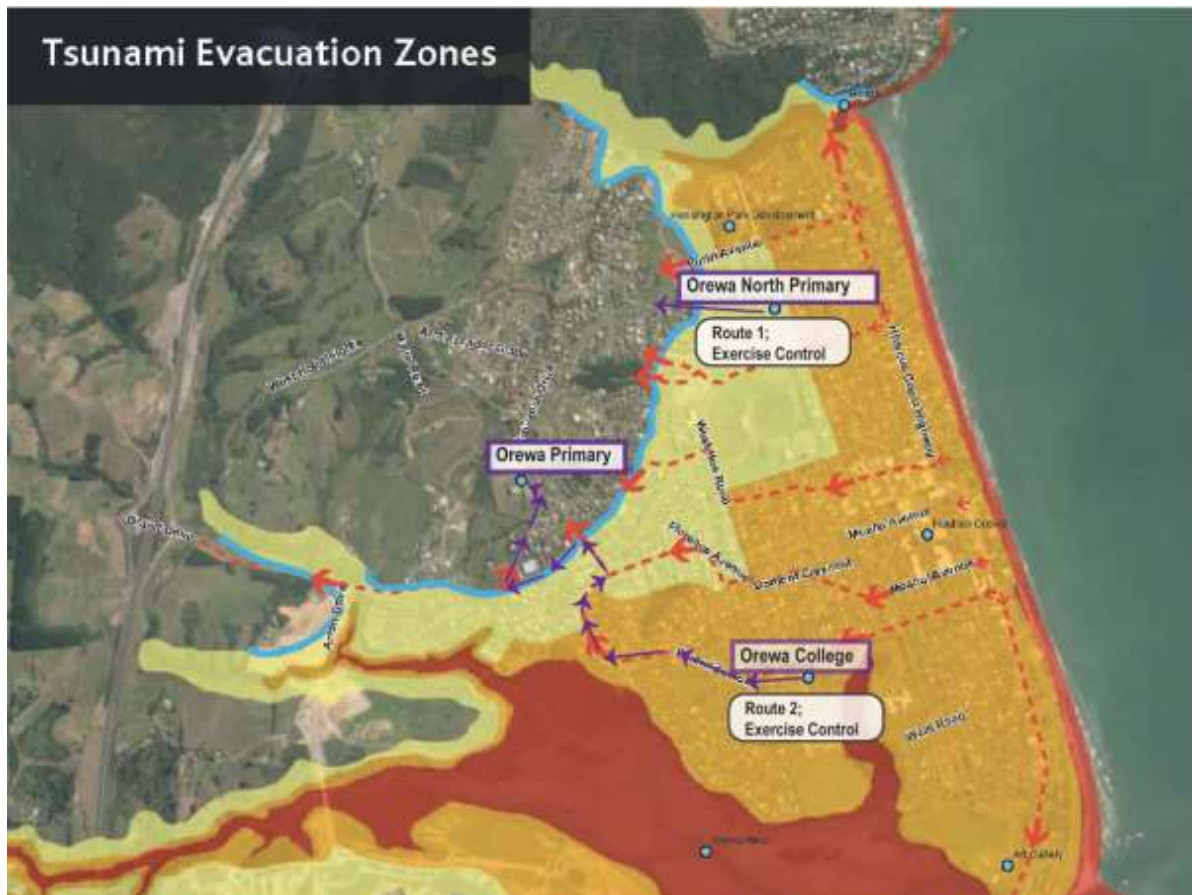




## Appendix 4: Orewa Tsunami Walk locations

Final map for the tsunami walk and school locations, adapted from the Orewa tsunami walk general instruction (Rotary & Auckland Council, 2016).

**Key:** **Red** shore exclusion zone: Covers the beach and adjacent low-lying areas most likely to be affected by a tsunami. **Orange** evacuation zone: May need to be evacuated if there was a threat from a medium- to large-scale tsunami. **Yellow** evacuation zone: Covers the largest area that would need to be evacuated in the event of a maximum-impact tsunami<sup>1</sup>. The **blue line** indicates the safe zone, the **red lines** the potential evacuation routes, and the **purple lines** illustrate the two official routes taken by the schools on the day: Route 1, from Orewa North Primary School, and Route 2 from Orewa College.



<sup>1</sup> See also Auckland's Hazard Viewer for latest tsunami evacuation zone maps  
<https://aucklandcouncil.maps.arcgis.com/apps/MapSeries/index.html?appid=81aa3de13b114be9b529018ee3c649c8> (last accessed 28/8/2019)

## Appendix 5: Orewa tsunami evacuation exercise: Participant survey form

### Orewa Tsunami Evacuation Exercise: Participant Survey Form

25<sup>th</sup> May 2016

**Q1a.** Where did you start the walk from?

- <sub>1</sub> Orewa North Primary School    <sub>2</sub> Orewa College    <sub>3</sub> Other (Please specify the street address) \_\_\_\_\_

**Q1b.** What was your final evacuation destination?

- <sub>1</sub> Kensington Park Hill    <sub>2</sub> Orewa Primary school    <sub>3</sub> Other (Please specify the street address) \_\_\_\_\_

**Q2a.** Time of departure: \_\_\_\_\_

**Q2b.** Time of arrival at blue line: \_\_\_\_\_

**Q2c.** Time you reached your final destination: \_\_\_\_\_

**Q2d.** Were you aware that you needed to walk past the blue line?

- <sub>1</sub> Yes    <sub>2</sub> No

**Q3.** Did you know about the initiative 'Orewa: Ahead of the wave' ahead of time?

- <sub>1</sub> Yes    <sub>2</sub> No

**Q4.** If yes to Q3, how had you heard/read about it?  
\_\_\_\_\_

**Q5.** Have you already practiced a tsunami evacuation route in Orewa before the 'Orewa: Ahead of the wave' project?

- <sub>1</sub> Yes    <sub>2</sub> No

**Q6.** If yes to Q5, when was the last time you practiced? (Approximate date): \_\_\_\_\_

**Q7.** If yes to Q5, did you follow the same route as today?

- <sub>1</sub> Yes    <sub>2</sub> No

**Q8.** If no to Q7, what was the route you followed last time?  
\_\_\_\_\_

**Q9.** Was the terrain easy for mobile people?

- <sub>1</sub> Yes    <sub>2</sub> No    <sub>3</sub> None in our party

**Q9a.** If no, please describe the issue: \_\_\_\_\_

**Q10.** Was the terrain easy for mobility impaired people?

- <sub>1</sub> Yes    <sub>2</sub> No    <sub>3</sub> None in our party

**Q10a.** If no, please describe the issue: \_\_\_\_\_

**Q11.** Did you (or someone in your group) travel with a pushchair/stroller or wheelchair?

- <sub>1</sub> Yes (which) \_\_\_\_\_    <sub>2</sub> No

**Q12.** What item(s) did you take with you during the evacuation drill?  
\_\_\_\_\_

**Q13.** What item(s) would you want to take with you in the event of a real tsunami evacuation?  
\_\_\_\_\_



**Q14a.** How easy were the tsunami evacuation signs to follow?

- <sub>1</sub> Very easy                      <sub>2</sub> Easy enough  
<sub>3</sub> Not easy                      <sub>4</sub> Didn't see any signs

**Q14b.** Was it useful having the blue lines on the footpath?

- <sub>1</sub> Yes                      <sub>2</sub> No                      <sub>3</sub> None in our party

**Q15.** Would you be able to use the evacuation route in all weather conditions?

- <sub>1</sub> Yes                      <sub>2</sub> No

**Q16.** Would you be able to use the evacuation route in the dark?

- <sub>1</sub> Yes                      <sub>2</sub> No                      <sub>3</sub> Yes, if carrying a torch

**Q17.** What would you like to have at your final destination if staying there?

---

**Q18.** What additional information do you need to evacuate safely?

---

---

**Q19.** Any suggestions for improving the evacuation arrangements in a real event?

---

---

**Q20.** Do you think you are more prepared now than before the 'Orewa: Ahead of the wave' project? (Please explain)

---

---

**Q21.** How many people in total in your party/group? (including you) \_\_\_\_\_

How many are:

- **Q21a.** Less than 10 years old          \_\_\_\_\_
- **Q21b.** Over 65 years old                  \_\_\_\_\_
- **Q21c.** Disabled                              \_\_\_\_\_

**Q22.** Would anybody in your household need special assistance in case of real tsunami evacuation?

- <sub>1</sub> Yes                      <sub>2</sub> No

**Q23.** Are you:   <sub>1</sub> A resident                      <sub>2</sub> A visitor

**Q23a. Residents:** How long have you lived in this community? (even with gaps)

- <sub>1</sub> First year          <sub>2</sub> 2-10 years          <sub>3</sub> 11-20 years          <sub>4</sub> 21+ years

**Q23b. Visitors:** How many days do you expect to visit this community this year?

- <sub>1</sub> 1 day                  <sub>2</sub> 2-5 days          <sub>3</sub> 6-10 days          <sub>4</sub> 11+

**Q23c. All:** Where do you normally live?: Town/Country: \_\_\_\_\_

**Q23. Are you:**

- <sub>1</sub> Male                  <sub>2</sub> Female                  <sub>3</sub> Gender diverse          <sub>4</sub> Prefer not to disclose

**Q24.** In what year were you born? \_\_\_\_\_

