TSUNAMI AWARENESS AND PREPAREDNESS

IN THE GREATER WELLINGTON REGION

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ABSTRACT

Tsunami caused by earthquakes pose a risk to New Zealand coastal communities due to its location on major fault lines. It is unknown whether coastal inhabitants are adequately prepared or even aware of the tsunami threat. Our goal was to assess and augment the awareness and preparedness of residents and visitors of the Greater Wellington Region (GWR). To meet our goal, we developed and conducted a pilot study in collaboration with the Crown Research Institute GNS Science. Based on the results of almost 400 face-to-face interviews with the GWR population, we developed a set of awareness and education proposals to support the efforts of the Wellington Regional Emergency Management Office.

EXECUTIVE SUMMARY

Introduction

New Zealand is comprised of two main islands, the North Island and South Island, with over 15,000 km of coastal area (Bell & Gibb, 1996). Located in the Pacific region, about a third of all New Zealand's shallow earthquakes occur offshore. Subduction zones occur at a convergent boundary where one tectonic plate moves under another and sinks into the earth's mantle. Submarine faults and subduction zones create earthquakes that can cause tsunami and pose serious hazards for coastal cities and towns. The east coast of New Zealand lies in close proximity to the Hikurangi subduction zone.

The last major tsunami to hit New Zealand, however, was the 1868 Peru-Chile tsunami, which caused substantial damage to the country's infrastructure. Due to the historic infrequency of tsunami in New Zealand, natural hazard mitigation organizations such as the Institute of Geological and Nuclear Sciences (GNS), fear that public concern may be low. The recent disasters in the Indian Ocean regions, Samoa, and Japan have illustrated the importance of disaster planning and awareness to mitigate damage.

Wellington, the capital of New Zealand, lies on the south coast of the North Island and currently has developed an evacuation map (Figure A) suggesting various escape routes in the event of a tsunami. This map features the locations of the tsunami blue-line, which represents the maximum distance a tsunami will reach inland.

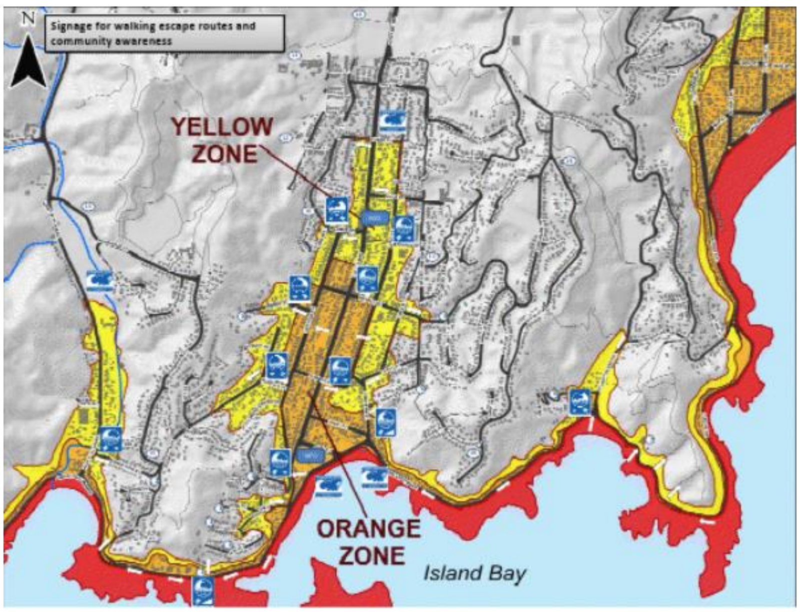

Figure A - Island Bay tsunami danger zones. Grey land indicates safe elevation (Wellington Region Emergency Management Office; Wellington City Council, 2012)

The Wellington Region Emergency Management Office (WREMO) provides extensive information regarding earthquake and tsunami preparation on their website and through their "Get Ready Get Thru" public readiness program. The city also utilizes civil defense sirens to alert the public of potential tsunami. However, proper warning systems and evacuation plans are only as effective as residents are aware, willing, and able to adhere to them. Long or strong earthquakes occurring at the subduction zone and local fault lines can produce tsunami that can arrive in Wellington within minutes; which does not give local authorities enough time to utilize the warning system. Residents can learn that long or strong earthquakes can produce tsunami, and respond to the threat immediately, saving valuable time for evacuation.

The purpose of our research was to design and test a pilot study to assess the awareness and preparedness of the Greater Wellington Region on tsunami threat. The results of our research will contribute to the framework for a future, nation-wide study sponsored by GNS Science. Our research will also assist the Wellington Region Emergency Management Office (WREMO) to develop enhanced programs to improve emergency response.

Methodology

To accomplish our goal, we developed an optimal interview location guide (Figure B) that targeted communities with high tsunami risk. This included tsunami blue-line communities such as Owhiro Bay and Island Bay. Porirua and nearby high-risk Wellington Harbour communities, such as the Wellington Central Business District, Petone, and Lyall Bay, were also targeted.

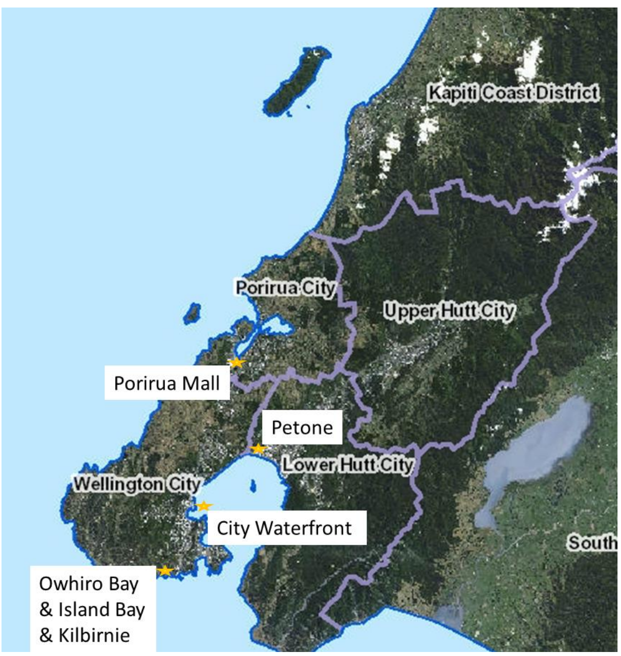

Figure B - Interview location guide

We implemented a sample of convenience to identify interview participants. We used this strategy to rapidly identify subjects from locations with high human foot traffic. In certain localities with low foot traffic, face-to-face interviews were conducted with residents at their homes. We conducted short (10-15 minute) face-to-face interviews with pedestrians in well-populated public areas in the targeted communities (Figure C). We designed the interviews to quickly cover demographic information as well as to generate in-depth responses. We explained to participants that they would remain anonymous and their responses would not be used to identify them. Once the interview was completed, we provided information sheets that outlined the interview goal and contact information of GNS representatives. Additionally, to improve our interview design, we requested feedback from participants who provided inappropriate or irrelevant responses.

Figure C - Gaining a community perspective through public face-to-face interviews

Our interview included questions designed for open-ended responses. This inherently yielded varied responses from participants. In order to analyze our data quantitatively and qualitatively, we developed representative categories into which we could sort our responses. Based on our review of our data, we established a coding guide to ensure accurate categorization. The coding guide was developed by identifying key tsunami awareness concepts that we want to capture, and then reviewing raw responses and generating or modifying representative categories based on relevant themes. Once the guide was developed, the categories were reviewed a second time against all interview responses to ensure their accuracy.

We initially analyzed our data qualitatively by reviewing collected responses and forming an overall impression of the participant's awareness, preparedness, attitudes, and general knowledge. We formed these impressions for our entire sample as well as for specific communities that we were interested in understanding independently. We were able to form impressions based on the content and tone of participant's responses.

To support our qualitative analysis, our team developed a collection of algorithms to analyze our data quantitatively, using the Haskell Programming Language™. We used these algorithms to analyze theme frequencies of coded data as well as identify correlations on all individual variables. After analyzing the frequencies, we used the information to produce graphs in Microsoft Excel to highlight main themes of our data set. The qualitative analysis was simultaneously supported by quantitative analysis to deduce implications, which were essential in generating recommendations. Throughout the analysis, we employed a grounded theory approach to develop a hypothesis about the underlying phenomena driving the observed trends. These hypotheses affected our interview content and strategy, which improved the quality and accuracy of our responses.

We then studied responses and evaluated the awareness of participants and compared the findings of separate communities. Specifically, it was important to understand if the presence of tsunami blue-lines affected risk perception and preparedness. Additionally, we compared social status and geography across communities in order to explain differences in awareness and preparedness.

Findings and analysis

Interview design and testing

The design and testing of the interview itself underwent several iterations that served to strengthen participant response. The interpretation of terminology in our interview varied depending on location and cultural background, requiring that we rephrase certain questions to some participants. Overall we encountered a general reluctance to be interviewed from the public. Cited reasons include interview length and suspected affiliations with religious and political organizations.

Categorization (coding) of responses

Originally attempting to use IBM's SPSS packages to analyze data, we found manual categorization of responses to be more accurate and concise than SPSS Text Analytics. An iterative method of categorization through group input proved critical in developing complete and consistent categories by eliminating individual bias.

Analysis of responses from the GWR

Earthquakes and tsunami are the most-cited natural disasters from our research. However, most participants either failed to recognize the threat of tsunami due to local earthquakes or could not effectively recognize local warning signs of a tsunami. Since the recent occurrence of the devastating 2011 Christchurch earthquake, most individuals seem more concerned about this natural disaster rather than a possible tsunami. This was evident when our studies revealed that only half of the respondents expected a tsunami in their lifetime. Furthermore, less than 7% of respondents could recognize the natural warnings of a local tsunami: an earthquake too strong to stand during or an earthquake lasting more than a minute. Even for those interviewees who recognized earthquake warnings, most expected confirmation from an official source in the form of an alarm or radio before considering evacuation. Though an official alarm is unlikely to be sounded during tsunami generated close enough to arrive within an hour, over two thirds of those who expected an alarm warning also expected no more than 30 minutes of notice prior to impact.

While many would evacuate immediately if prompted, the most common source of delay was a desire to remain and assist others in evacuation. Cars were a common form of transportation in evacuation scenarios, with more respondents claiming to evacuate by car when given more warning time, which can cause dangerous traffic jams and delay evacuation. It appears that most participants are concerned about the risk of earthquake damage to roads, but do not recognize the danger of mass evacuation traffic.

There appears to be a general lack of tsunami awareness from individuals visiting coastal areas of New Zealand from more inland locations of New Zealand. Though individuals from more inland regions of New Zealand recognize tsunami as a potential hazard, they are much more focused on the earthquake threat and base their evacuation behavior around more immediate earthquake dangers such as falling objects and broken roads. Visitors from other countries generally do not identify tsunami as a threat and are unaware of tsunami warning signs.

Compare responses of communities within the GWR

Residents of blue-line communities such as Owhiro Bay and Island Bay were more acutely aware of tsunami threat than the residents of non-blue-line communities, though it was not evident that they were also better prepared. We found no significant difference in preparedness between blue-line and non-blue-line communities, with the exception that almost all blue-line residents knew of the blue-line program. Even in blue-line communities, there seemed to be confusion about the placement of the blue-line and general distrust of the program. The distrust of the program seems to have resulted from a misunderstanding of how the placement of the blue-line was calculated.

Additional Observations

While interviewing, we observed participants displaying varied levels of confusion regarding question phrasing and terminology between locations. Class and education may have played a role in understanding but overall, the issue of class distinctions is a complicated one, and we could identify no strong associations between wealth and tsunami preparedness regardless of confusion with terminology. It seems that the perception of tsunami risk and initial reactions to disaster derive from a deep human response, which is common between people.

We also feel that the inability of the inhabitants to recognize a tsunami threat when presented with the earthquake scenarios is likely because of two reasons. Disaster survivors doubt reoccurrences and those who experience frequent earthquakes are desensitized to their danger. The frequency of earthquakes and tendency to draw on past experiences are likely causing individuals to perform only standard earthquake evacuation behaviors, despite an earthquake's potential to induce a tsunami.

Through our observations, we have realized that individuals have been conditioned to expect confirmation of tsunami threat from authority. A possible explanation is that New Zealand residents do not trust their own instincts to judge natural warnings since they have not experienced a devastating tsunami induced by a local earthquake. By seeking confirmation, people feel more in control of the situation.

Recommendations

Based on our analysis, we have generated recommendations for GNS Science and WREMO. The recommendations are categorized under the following two tiers:

- Recommendations for improving future interview/survey response rate and data quality
- Recommendations for improving awareness and preparedness of tsunami in the GWR

These recommendations are derived from the analysis of data collected in this pilot study as well as available supplemental information and programs available to residents and visitors through WREMO's website.

To improve survey/interview design and implementation

GNS, WREMO/CD (Civil Defence) logos could be present on surveys or interviewer clothing to help establish the credibility of the study. Clearly presenting logos also distinguishes the theme of the study.

Carefully worded survey questions are essential to the success of the study. A simpler format will avoid confusion or random guessing from participants. A sample of our final interview questions is listed in Appendix A: Version 2. Future surveys and interviews could omit the distinction between questions related to “earthquakes that last more than one minute” and “earthquakes that are difficult to stand in”. Participants did not provide distinct responses between these two scenarios. This will decrease survey time and reduce the burden on participants.

Mail-in surveys can be used to conduct a larger study where face-to-face interviews are infeasible. We have developed suggestions for a pre-coded mail-in survey based on the responses to our original interviews (Appendix G).

To improve awareness and preparedness in the GWR

WREMO's effort to develop public awareness with the blue-line program is a strong commitment to tsunami awareness. Our work supports the idea that the agency should continue to implement blue-lines in communities. Our team discovered that blue-lines raise awareness and therefore more blue-lines would increase awareness. Additionally, WREMO could provide information to homes in blue-line communities or static information (such as signs) near the blue-lines explaining their purpose to resolve misconceptions.

Educating communities on alarm sounds and when they would be sounded could reduce confusion surrounding alarm usage. This can be performed though alarms clips provided on emergency websites as well as audio messages with an alarm preview sent to homes.

To help protect less informed waterfront visitors, emergency officials could work with Wellington city waterfront stores and restaurants to train employees on proper earthquake and tsunami response. Another idea is to develop official stickers on buildings in tsunami danger zones indicating if the building is tsunami safe (Figure D).

Figure D - A draft illustration of the "tsunami safe" building sticker

Given the success of the "duck, cover, hold" slogan, it could be beneficial for WREMO to develop a slogan in a similar vein that emphasizes the dangers of earthquakes that last more than one minute and earthquakes that are difficult to stand in. The slogan could possibly be "Long? Strong? Gone!" This recommendation has arisen from the overwhelming failure to recognize long and strong earthquakes as tsunami threats.

We recommend that WREMO continue to stress evacuation by foot or bicycle. Specifically, WREMO could include images indicating proper evacuation methods on tsunami warning signs or could designate specific cars as tsunami transportation vehicles. This recommendation has arisen from the large number of participants stating that they would flee by vehicle, especially in lengthier tsunami warnings. Figure E below shows an illustration of a possible sign we created.

Figure E - A draft illustration signage conveying specific warning signs and transportation methods
Image of bicycle and car inspired by (Map symbols bike clip art, 2013) and (Bednell holiday homes, 2013)

Lastly, WREMO could distinctly outline personal evacuation responsibility for residents so that they can feel confident in the actions they should take before evacuating. This suggestion has resulted from the numerous participants who stated that they were unsure of how much time they should spend assisting others before evacuating. GWR inhabitants could adopt a self-preservation belief similar to Japan's "tsunami tendenko" or another belief that appeals more to Kiwi values.

Conclusion

This study has confirmed low tsunami preparedness in the GWR. We have also piloted, tested, and revised questions for a greater survey to be distributed by GNS Science related to tsunami awareness and preparedness. Lastly, we have assessed the impact of education efforts such as the tsunami blue-line and its influence on communities' awareness and preparedness.

New Zealand's position on seismically active ground establishes the importance of conducting research to ensure the preparedness and safety of communities. Using what has been learned from this pilot study, a larger study could evaluate the awareness and preparedness of a greater portion of the GWR. Similar pilot studies can be conducted in areas where little is known about preparedness and awareness in order to prepare for a larger study. Once levels of awareness and preparedness have been measured, WREMO can develop or improve education programs to address the gaps in tsunami awareness and preparedness of GWR residents and visitors. Developing effective disaster education programs is vital in saving lives during earthquakes and resultant tsunami in countries with large coastal areas such as New Zealand.

Without proper education in threatened areas, individuals will not be able to react quickly enough to a locally induced tsunami, potentially leading to severe damage and loss of life as reflected in the 2004 Indian Ocean Tsunami. Improving education efforts has been proven to help mitigate the loss of life, as seen in the Great East Japan Tsunami in 2011. As research is conducted on tsunami awareness and preparedness, education programs can properly evolve to minimize the loss of life during natural disasters.

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CHAPTER 1. INTRODUCTION

According to a report by the United States National Academies, nearly two-thirds of the world's population (approximately 3.6 billion people) lives within 100 miles of the coastline (The National Academies, 2007). Recent occurrences of major earthquakes and tsunami, such as the Indian Ocean tsunami in 2004, the 2009 Samoa earthquake, and the Japan tsunami in 2011 have challenged the resilience and preparedness of the affected nations, with many communities still recovering from the disasters. The Indian Ocean tsunami demonstrated how unpreparedness made regions vulnerable, as it resulted in the death of at least 230,000 individuals and 2.9 billion dollars in damages (Athukorala & Resosudarmo, 2005)

New Zealand is vulnerable to natural hazards such as earthquakes and tsunami, with more than 15,000 km of coastline and its proximity to the Hikurangi subduction zone (Bell & Gibb, 1996). The last major tsunami to hit New Zealand, however, was the 1868 Peru-Chile tsunami, which caused substantial damage to the country's infrastructure. Due to the historic infrequency of tsunami in New Zealand, natural hazard mitigation organizations such as GNS Science, fear that public concern may be low. The recent disasters in the Indian Ocean regions, Samoa, and Japan have illustrated the importance of disaster planning and awareness. Although earthquakes and tsunami cannot be fully predicted or prevented, the possible resulting damages and casualties can be mitigated if the community is sufficiently prepared.

Currently, Wellington has a color-coded evacuation plan in place in case of tsunami warning. This plan utilizes evacuation maps (Figure 1) with suggested evacuation routes from different zones; each zone indicates how severe the threat of tsunami is based on the location’s height above sea level. In the event of a severe earthquake, people are expected to immediately follow the closest evacuation route outlined on the map, leading them to a safe zone. Wellington utilizes civil defense sirens mounted on vehicles and helicopters to alert the public.

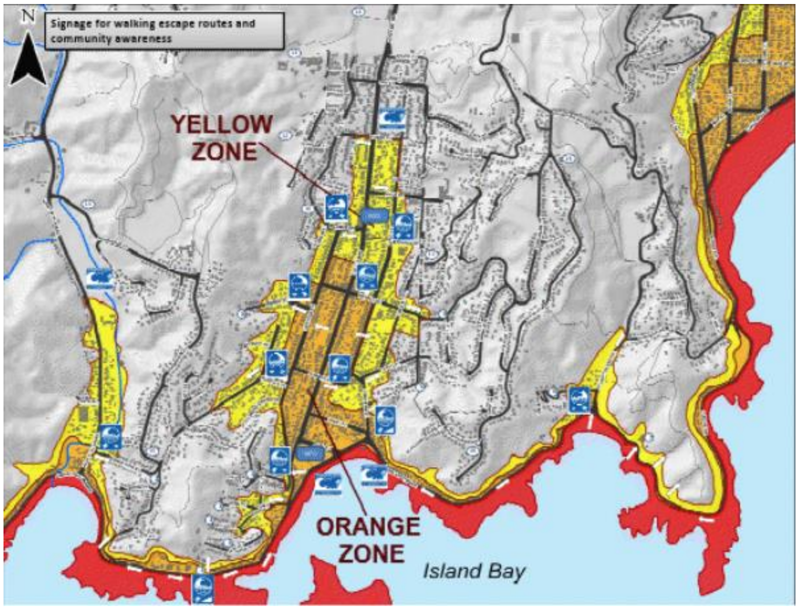

Figure 1 - Island Bay tsunami danger zones. Grey land indicates safe elevation (Wellington Region Emergency Management Office; Wellington City Council, 2012)

However, in the case of tsunami produced from long or strong local earthquakes, there may not be enough time to utilize this system. Individuals would be forced to evaluate the strength of an earthquake and decide whether to immediately travel above the blue-line. The blue-line, an evacuation boundary implemented in two Greater Wellington Region (GWR) communities, indicates the maximum distance a tsunami will reach inland. However, evacuation tools such as the blue-line are only as effective as residents are aware and willing to adhere to them.

GNS Science is a New Zealand research institute that is heavily involved in many areas of environmentally- related research including natural hazards. Given the catastrophic tsunami that have occurred in the last 10 years, GNS has taken an interest in understanding how prepared the residents of New Zealand are for a possibly devastating earthquake and tsunami. Accordingly, GNS has commissioned us to conduct a pilot study to assess the Greater Wellington residents' awareness and preparedness in the event of a local subduction zone earthquake and resulting tsunami, as well as in the event of warnings from distant sources. We wanted to determine if residents understand the difference between an earthquake that last more than a minute and one that is too strong to stand in, and if this understanding affects resident's preparedness. Additionally, we intended to evaluate the effectiveness of education efforts such as the tsunami blue-line, and make suggestions for possible improvements. Lastly, we wished to assess the current public attitude towards the likelihood and severity of possible local natural disasters.

The insight into the level of understanding of the Greater Wellington Region population related to potential tsunami and earthquake threat provided by our pilot study will set the framework for a larger study to be conducted by GNS. Ultimately, our study will allow risk management agencies such as the Wellington Region Emergency Management Office (WREMO) to more effectively identify areas of nescience on which to focus tsunami education efforts.

For WREMO to improve its risk management system, it is prudent to assess the current public attitude towards the likelihood and severity of possible local natural disasters. To that end, risk communication and perception are two important factors that aided in the evaluation of the Greater Wellington Region tsunami preparedness. Designing a survey that can measure these factors is challenging because it is difficult to predetermine possible responses without a deeper understanding of the communities' attitudes. Ultimately, the process of evaluation contributed to better sense the research questions needed to understand attitudes and knowledge of residents towards the risk of tsunami and earthquakes. This understanding helped to assess the effectiveness of Wellington's risk communication and make recommendations for a larger study to be conducted by GNS.

CHAPTER 2. LITERATURE REVIEW

This chapter considers tsunami risk perception and communication in greater depth. First, we outline tsunami risk mitigation factors through studies conducted on communities that recently experienced tsunami generated by earthquakes measuring a magnitude of 8 or above. Second, we study the fundamentals of risk perception and communication, and attempt to explain people's behavior during disasters. Finally, we study survey theory and design to guide our methodologies.

2.1 Tsunami response and risk mitigation factors

Earthquakes and tsunami are natural disasters that can result in death and severe damage to a country's infrastructure. Earthquakes first occur by the shifting and breaking of the Earth's tectonic plates, most frequently in or near a subduction zone. These subduction zones are areas at the plate boundaries where one tectonic plate moves under another, with one plate sinking into the mantle as it pushes the other plate up. Under these conditions, tsunami can occur when an offshore earthquake displaces the seafloor, creating a series of large waves. The size of a tsunami is dependent on the strength, distance to shore, and shallowness of the earthquake. Tsunami can occur anywhere in the world along a coastline and can travel over a long distance across the ocean.

Since 2004, the world has experienced several devastating tsunami resulting from earthquakes, including the Sumatra-Andaman Earthquake in 2004, the Samoa Earthquake in 2009, and the Tohoku Earthquake in Japan in 2011, responsible for numerous deaths and a great deal of destruction. When attempting to minimize deaths from a tsunami, communities have the option of implementing protective structures such as evacuation buildings and sea walls, or less costly evacuation plans. According to the Journal of Comparative Policy Analysis, disasters cannot be fully prevented by the structural measures and technology invested with enormous budget emphasizing the importance of alternative disaster prevention methods such as evacuation protocols (Okada, 2012, p. 371). Therefore, addressing the problem of tsunami disaster mitigation through evacuation is a more effective and less costly alternative to the use of evacuation buildings.

We have identified three factors that impact the success of an evacuation: communication, education, and the human response. Communication determines how effectively the community is informed when there is an impending disaster. Education, in the broadest sense, provides residents and visitors with information about how to respond and where to go given an imminent disastrous situation. Education can refer to information disclosed by governments or emergency management offices, and can also refer to community experience or exposure to tsunami. Surviving a tsunami can give experience to a community, preventing future tsunami-related casualties. Lastly, the human response describes how people actually react during a disaster, and what causes their reactions. We will outline how these factors impacted the communities affected by the tsunami generated by the Sumatra-Andaman Earthquake, the Great East Japan Earthquake, and the Samoa Earthquake.

2.1.1 Communication

Communicating warnings is necessary for evacuating populations. When there is advanced notice that a tsunami is approaching, warnings can be sent out in time for people to evacuate. However, in the case of New Zealand, an earthquake can occur at the local Hikurangi subduction zone and produce a tsunami that can arrive within minutes. This presents a challenge to the Ministry of Civil Defence and Emergency Management (MCDEM), which is responsible for sending out warnings for evacuation. According to Wei, et al (2012, pg. 1), "most near-field tsunami warnings and forecasts rely primarily on preliminary information of earthquake location, depth, and magnitude, which are routinely computed within minutes." When a tsunami wave can reach shore in a few minutes, the few minutes it takes to get a forecast for the severity of the tsunami can be too late.

The Sumatra-Andaman Earthquake, the cause of the Indian Ocean tsunami in 2004, reportedly struck at a magnitude of 9.2, but it was originally underestimated. The tools used to determine the magnitude of the earthquake are designed for speed, and tend to underestimate any earthquake with a magnitude larger than 8.5 (Kerr, 2005). The Pacific Tsunami Warning Center (PTWC) released its warning for a magnitude 8 earthquake 15 minutes after the earthquake. After an hour, the PTWC determined that it was an 8.5 magnitude earthquake, 5.6 times stronger, but again an underestimate. By that time, many of the surrounding island nations had already been struck, and the risk of the tsunami traveling across the Bay of Bengal was considered insignificant. The Harvard Centroid Moment Tensor (CMT) project was able to determine the earthquake was a magnitude 9.0, five hours after the earthquake, and days later, further analysis found that it was between 9.2 and 9.3 in magnitude. GPS methods could have accurately determined the magnitude of the Sumatra-Andaman earthquake within 15 minutes. This still would have been too late to produce an effective warning for the islands close to the epicenter, such as Gizo (Blewitt, et al, 2006).

Tsunami have hit the Japanese coastline frequently throughout history, most recently by the 2011 tsunami responsible for thousands of deaths. Japan, like New Zealand, is located in a subduction zone and earthquakes produced off shore can result in large tsunami that can arrive in minutes. In such cases, warnings would need to be issued rapidly. The Japan Meteorological Agency (JMA) monitors seismic activity and gives tsunami warnings, but is challenged with transmitting alerts before the tsunami waves arrive. The current system uses the Geostationary Meteorological Satellite (GMS) to broadcast warnings in a matter of minutes to those near the shore (Tsuchiya and Shuto, 1995). During the 2011 tsunami, JMA initially sent out a warning for waves of 3-6 m height, three minutes after the earthquake. Twenty-eight minutes later, they sent a revised warning for waves of 6-10 m or more in some areas. After forty-five minutes, the warning was updated for waves over 10 m along coastal areas (Tsushima, et al, 2011). This is a similar situation to the Indian Ocean tsunami described earlier. The tool used to determine the magnitude of the earthquake underestimated it (Kerr, 2005). Japan may have one of the most robust tsunami warning systems in the world but the technology they rely on still has the potential to fail or produce inaccurate data.

A magnitude 8.1 earthquake and two sub-events of magnitude 7.8 occurring in the Kermadec-Tonga subduction zone caused a series of tsunami that struck Samoa, American Samoa, and Tonga, killing 192 people in 2009 (Okal et al., 2010). The PTWC issued a warning 16 minutes after the earthquake, but in some areas, the tsunami hit within 15 minutes of the earthquake (Okal et al., 2010). On the island of Futuna, no warning was issued, and their coast was hit by tsunami over an hour after the earthquake. Fortunately, there were no casualties. The PTWC issued a tsunami warning for Wallis and Futuna, however in the confusion, the authorities on Wallis (whom controlled the tsunami warning sirens on Futuna) did not sound the sirens (Lamarche, Pelletier, and Goff, 2010).

The New Zealand Ministry of Civil Defence and Emergency Management recommends that individuals heed "natural" warnings, such as earthquakes (Ministry of Civil Defense and

Emergency Management, 2008). If there is a strong earthquake (defined as an earthquake in which it is difficult to stand up), a long earthquake (defined as an earthquake lasting more than one minute), unusual noises coming from the sea, or the sight of the ocean rushing in or out, all threatened zones should evacuate immediately because a tsunami may be approaching. If a tsunami is coming from across the Pacific, there may be enough time to release an official warning and evacuate only particular zones that are in danger. In these cases the PWTS and GNS Science feasibly have enough time to provide information about the tsunami to MCDEM, so that they can issue warnings. If a tsunami is generated locally, as stated previously, a resident's or visitor's safety will rely on their prior training for tsunami warning and proper evacuation procedure.

2.1.2 Community education and experience

Ultimately, a warning system cannot replace education, as in some locations a warning after 15 minutes is too late. In an article written in *The Lancet*, Pincock (2007) quotes Gerard Fryer, a geophysicist at the Pacific Tsunami Warning Centre, "for the people within the source region of the earthquake, they basically have to be educated. If the ground shakes, get away from the ocean". The three cases described here demonstrate the importance of education. In all three cases, there was a delay in administering a tsunami warning because of uncertainty of the tsunami predictions. This left only minutes between the warning and when the first tsunami waves hit. Education is vital, especially when a tsunami is generated from a local earthquake, because the tsunami may reach the shores before the warning reaches the community. If members of a community are trained, people can respond to a long or strong earthquake more quickly than a warning can be communicated. Individuals can learn to evacuate to higher ground immediately after an earthquake with the assumption that a tsunami may be imminent.

The Indian Ocean earthquake and tsunami resulted in widespread and overwhelming damage to Indonesia, Sri Lanka, India, Thailand and eight other countries. About a month after the tsunami struck, a team of social science researchers from the Disaster Research Center of the University of Delaware, and the Emergency administration and Planning Program of the University of North Texas participated in a research expedition in some affected areas of India and Sri Lanka. The team found that there was a general lack of awareness regarding tsunami. In fact, one elementary school teacher reported that none of her students knew what a tsunami was (Rodriquez, Wachtendorf, Kendra, and Trainor, 2006). The communities that were being investigated had never experienced a tsunami and therefore most of the people of those communities could not describe how a tsunami occurs, what to do in the event of a tsunami, or what the typical warning signs were of a tsunami (Rodriquez, Wachtendorf, Kendra, and Trainor, 2006). A separate international tsunami survey team that was dispatched to Sri Lanka after the Indian Ocean earthquake and tsunami in 2004 discovered a small village in which all but one villager survived. They found that there was one merchant fisherman in the village that had experienced a tsunami previously in Chile and identified the natural warning signs, which allowed him to evacuate the village (Liu et al., 2005). Records like these emphasize the importance of education in tsunami-vulnerable regions. In the case of Sri Lanka, the Indian Ocean tsunami was the first instance of an earthquake-induced tsunami affecting Sri Lanka (Inoue et al., 2007). Because of this, Sri Lanka had never expected a tsunami and no evacuation information was ever prepared (Inoue et al., 2007).

The Tohoku earthquake, and resulting tsunami that struck Japan in March, 2011, resulted in 19,000 dead or missing people (Aarup, Alaiga, Elliot, Kodijat, and Yamamoto, 2012). Despite this high figure, 96% of residents living in inundated areas of communities visited survived, according to a report by GNS Science (Fraser, Leonard, Matsuo, and Murakami, 2012). These high survival rates were attributed to effective education and evacuation procedures (Fraser, Leonard, Matsuo, and Murakami, 2012). Disaster preparedness education is promoted by both the Japanese government and the local disaster management offices. The Japanese cabinet office released disaster management guidelines in February of 2011, which obligates communities to conduct regular disaster reduction drills. Large-scale disaster reduction drills are conducted in every region across the country on September 1st, also known as Disaster Reduction Day. Recent drills have challenged the participants by providing no information about the simulation until after the drill has begun, much like in a real emergency state (Cabinet Office, Government of Japan, 2011). In cities such as Kesennuma and Kamaishi, local residents and officials have given even more attention to tsunami disaster preparedness. Volunteers within these towns have distributed hazard maps prepared by the government to each household. The communities have also encouraged discussions and practices to locate evacuation sites and routes (Mimura, Yashuhara, Kawagoe, Yokoki, and Kazama, 2011).

One factor related to education that has been shown to effectively minimize tragedy is experience. The Sanriku coast in Japan is an area that has experienced large tsunami in the past

37 years that have resulted in a lower death ratio with each new tsunami. The power of experience to encourage evacuation is demonstrated by questionnaire results collected in 2011. The survey concerning the Great East Japan Tsunami found that 90% of residents in Kamashi City (located in the Sanriku coast) evacuated quickly and 60% evacuated within ten minutes after the earthquake. The Sendai plains, however, have had little experience with serious tsunami and the results from the same questionnaire found that only 60% evacuated quickly and 30% evacuated within 30 minutes of the earthquake (Suppasri, 2012). Some locales have established public events to commemorate these devastating experiences. The festival of Wakayama encourages residents, especially children, to reflect on past tsunami and to become more aware of the possibilities and dangers (Suppasri, 2012). "Tsunami Stones" are stone tablets as old as 600 years that are situated along Japans northern coasts and attempt to warn people of tsunami threats. Some stones display messages that instruct people to seek higher ground after a strong earthquake while other stones list past death tolls and mark mass graves. The village of Aneyoshi in particular, heeded the warning from one of their stones instructing them to build houses on higher ground, which spared the village from tsunami damage (Fackler, 2011). Possibly the most powerful education tool that is used by the Japanese is the legend of the "tsunami tendenko". Tsunami tendenko encourages individuals to ignore their belongings and their families and focus only on saving themselves. In one instance, the practice of tsunami tendenko led a group of children to begin evacuation on their own, which saved their lives in the event known as the "Miracles of Kamaishi" (Suppasri, 2012).

During the Samoan Earthquake in 2009, the education efforts and evacuation exercises that had been initiated in the Pacific over many years saved the lives of many Pacific Islanders. Many Samoans and Tongans knew to evacuate to higher ground the moment that they felt the earthquake or saw the ocean recede. This was essential in saving the lives of these people, as they were aware that the earthquake would result in a tsunami (Okal et al., 2010).

2.1.3 Human response to tsunami threats

Because of the lack of education and warning systems in the Indian Ocean area, many people were completely unaware of the dangers posed to them after the Sumatra-Andaman earthquake struck in 2004. The recession of the ocean due to the tsunami did not alarm many residents, instead there were reports of people taking pictures of the receding ocean and collecting stranded fish (Levy and Gopalakrishnan, 2005). The residents' only realization of danger came when the large tsunami waves rushed the shore. This behavior can be seen in several tsunami witness videos (Texas A&M University, 2009).

The response of the Japanese during the Great East Japan tsunami and earthquake however, was much more organized and beneficial than the response of the victims of the Indian Ocean tsunami. Although most people successfully evacuated before the tsunami struck Japan as demonstrated by the 96% survival rate, those who did not survive failed to evacuate for several reasons (Fraser, Leonard, Matsuo, and Murakami, 2012). According to a report from GNS Science, people delayed their evacuation or simply did not evacuate due to familial responsibility, lack of education, or skepticism of warnings. Residents and visitors also used inappropriate modes of transportation, such as motor vehicles, which resulted in traffic congestion. In some cases, individuals returned to the evacuation zone before it was safe because they were unaware of when the series of tsunami waves would arrive or the duration of the event (Fraser, Leonard, Matsuo, Murakami, 2012). A report by Miguel Esteban, coastal engineer, boasts of the well-developed early warning and evacuation systems implemented by Japan, stating that "only three minutes after the earthquake, a tsunami warning was issued in Tohoku, arguably the fastest response of any such system in any country in the world" (Esteban, Tsimopoulou, Shibayama, Mikami, and Ohira, 2012). Despite these claims, the report admits that many people neglected to evacuate initially because the first warning underestimated the severity of the incoming tsunami. By the time the second corrected warning had been issued, it was too late for many people to escape. This report is consistent with the account from GNS Science suggesting that attempting to flee by motor vehicle caused traffic jams. In a report from Pure Applied Geophysics, the authors emphasize how certain Japanese communities that regularly experienced tsunami sustained significantly fewer fatalities than other communities during the Great East Japan earthquake and tsunami (Suppasri, 2012). We believe that this is because of their familiarity with evacuation procedure and their accessibility to safety areas.

Communities in Samoa, American Samoa, and Tonga responded well to the natural signs of a tsunami. Many Samoans and Tongans knew from experience and education to get to higher ground after an earthquake, which was instrumental in saving lives. However, during the evacuation, there were cases of unnecessary deaths from confusion and panicked attempts to escape in cars. If the victims had evacuated by walking, running, or cycling, they could have escaped. A surprising number of victims went towards the dangerous areas. On the island of

Niuatoputapu in Tonga, seven victims went closer to shore to evacuate the principal of a school. The individuals were caught by the tsunami, while the principal had already evacuated (Okal et al., 2010). Education must be tailored to ensure individuals know how to properly evacuate, and what not to do. Had these individuals evacuated properly, their deaths could have been avoided.

The factors discussed above demonstrate successful and unsuccessful reactions to devastating earthquakes and tsunami. Success relied on the quality of warnings communicated, the education of affected residents, and the response of the residents and visitors during the tsunami event. Although New Zealand has not experienced a devastating tsunami in the recent past, local emergency management organizations still provide several resources to help communicate warnings and educate the public on tsunami hazards.

2.2 New Zealand's risk communication and emergency planning system

The Greater Wellington Region provides information and functions to support the awareness and preparedness of hazards through the Wellington Region Emergency Management Office (WREMO) by carrying out Civil Defence and Emergency Management (CDEM) functions. WREMO offers information regarding how to act during different types of natural hazards including tsunami, and a forum for how people can learn more. WREMO offers residents an emergency preparedness information packet, offers businesses presentations of hazards and preparedness, and offers schools advice on proper evacuation procedures and responses (Wellington City Council, 2012). WREMO recently launched the blue-line campaign, which painted blue-lines on the streets in the Island Bay, and Owhiro Bay. As mentioned previously, the blue-line indicates the highest level water will reach in the worst possible tsunami. It is stressed that if people experience an earthquake that is difficult to stand in or lasts for more than one minute, then they should evacuate from any threatened zones above the blue-line. The blue-line in Owhiro Bay is seen below in Figure 2.

Figure 2 - The tsunami blue-line in Owhiro Bay

The “Get Ready Get Thru” program is available as a resource providing information related to natural hazards (including earthquakes and tsunami) and actions people should take before, during, and after a disaster. The guide suggests that individuals move inland after an earthquake if they are on a beach or near the coast. The guide also outlines three different types of threatening tsunami including distant, regional, and local tsunami and the differences between them. Distant tsunami refers to those generated from across oceans in which New Zealand will have three or more hours of warning time. Regional tsunami are generated from in locations such as the Kermadec Trench, which can lead to a tsunami in one to three hours. Local tsunami are generated very close to New Zealand and can produce a tsunami that leads to only a few minutes warning. Natural, official, and unofficial warnings are discussed as well, including the tsunami threat caused by earthquakes lasting more than one minute and earthquakes that make it difficult to stand. WREMO notes that official warnings, such as those issued by local councils through sirens and local media, are only possible during regional and distant tsunami. This means that official warnings such as sirens are only likely in the event when a tsunami arrives in an hour or more. WREMO stresses that individuals should evacuate by foot or by bicycle and to only evacuate by vehicle if absolutely necessary (New Zealand Government, Civil Defence, 2012).

In addition to these resources, the Ministry of Civil Defence and Emergency Management (MCDEM) promotes exercises that are performed multiple times a year, which simulate real life situations. New Zealand has performed tsunami exercises in 2006, 2009, 2010 and 2011 in which tsunami simulations of varying distance and severity were tested. The MCDEM also uses mass media campaigns, advertising, and promotional activities to raise awareness and teach preparedness. Through local offices and government programs discussed above, information is extensively available to the public. The practice of familiarizing residents with tsunami evacuation procedures through drills and interactive activities occurs infrequently, however, because MCDEM focuses on many hazards, not only tsunami (New Zealand Government, Civil Defence, 2012).

New Zealand is similar to Japan given that they both have significant coastal vulnerability. Although Japan experiences tsunami more frequently, both Japan and New Zealand are at risk for a devastating tsunami because are they both are located near active faults. Therefore, Japan's highly-regarded tsunami disaster mitigation procedures provide a good model for consideration when improving New Zealand's existing mitigation efforts. As discussed previously, regular experience with evacuation drills helps to keep residents aware and prepared. Because residents of the Greater Wellington Region have not experienced a severe tsunami in the recent past, they have not been able to demonstrate their preparedness of tsunami hazard. Given that community wide preparation activities are less common in New Zealand, community preparedness is in question. GNS Science is conducting ongoing surveys that attempt to gauge the preparedness and perception of risk in the Greater Wellington Region, as understanding risk perception and communication is critical to focusing and improving tsunami education.

2.3 Risk perception and communication

If we are to design surveys or interviews to assess risk perception related to tsunami, we must consider the extensive literature devoted to understanding how this is measured. An individual's risk perception of an event is their subjective understanding of its attributes and severity (Douglas & Mary, 1985). Risk communication is the task of ensuring that a population's perception of risk matches the true risk presented. Risk communication is a critical component of disaster preparation, as the effects of a natural disaster on an unaware population can be devastating.

In the case of the 2012 Hurricane Sandy, although many meteorologists had predicted that this hurricane would be devastating and New York government officials declared state of emergency three days in advance, many people failed to heed these warnings as they believed that the government and the media were exaggerating its severity. Consequently, when Hurricane Sandy struck, it ravaged the city of New York, leaving behind USD $60 billion worth of damages. Furthermore, Sandy was the second most deadly hurricane to hit the state. Risk perception plays a key role in evaluating the preparedness and awareness of a community in the event of a natural disaster (Faler, 2012).

In the event of emergency, many people, particularly young adults, are inclined to an emotional response, which can cloud an individual's logic (Lerner et al., 2003, Carstensen, 2006). Thus, understanding emotional responses to risk and communication in a population is critical to improving risk communication. Risk perception can also be influenced by demographic factors, such as age and income. Older individuals tend to have more concern of risk in their immediate future, while younger adults tend to respond more emotionally to risk (Cartensen, 2006). Additionally, low-income families are more reluctant to evacuate before natural disasters, citing distrust of authority and financial burden as more dominant factors than those of the general population (Elder et. al, 2007).

There are some common factors involved in how people perceive risk. Individual control is a significant factor in risk perception. Risks perceived to be under the individual's control are more readily accepted, while those that are unfamiliar or uncontrollable are considered greater, but more distant. Paradoxically, natural disasters are perceived to be less of a threat than corresponding human-caused disasters such as global warming (U.S. Department of Health, 2002). Thus, it is important to communicate the present tsunami threat, and particularly, to convey that residents can be safe by taking appropriate action in the event of a tsunami.

The main purpose of risk communication is to align a community's perception of risk with the real risk, thus eliminating incorrect responses in natural disasters. Officials can maximize the effectiveness of their communication by following certain key principles (Fischhoff, 1995). Initially, it is important for officials to facilitate trust and partnership with the public. To maintain this trust, it is vital for official sources to communicate explicit and accurate information to the public. Providing accurate and complete information will eliminate public criticism and suspicion. It is also important that risk assessors and managers make their assessments explicit and clarify any uncertainty that recipients may have. This will maintain the risk assessors' credibility and allow the recipient to better understand the degree of risk.

Fischoff (1995) proposed that an "individual's beliefs are elicited using a mixture of open-ended and structured procedures" through a study using influence diagrams to display factors involved in managing hazards (pg.140). With this information, "communication can then be crafted to fill in gaps, reinforce correct beliefs, and correct misconceptions - with some assurance that the messages are to the point and can be comprehended by the recipients" (Fischhoff, 1995, pg. 140). It is helpful to compare unfamiliar risks to familiar risks, and to encourage people to draw on their past experience in handling the unfamiliar risk. Because there are many factors affecting risk perception and communication, which vary between populations, it is important to understand how a specific population perceives risk before effective risk communication can be implemented.

2.3.1 Measuring perception of risk

Surveys and interviews are primary tools for acquiring detailed and specific information about a sample population, where the information cannot be readily extracted from public sources. Survey and interview design theory is an expansive field of research in its own right and no "perfect" formula for survey design is established that covers all applications. Nevertheless, there is a deep body of established practices from which to draw on in the design of our study. Here we give a brief overview of the general theory of survey and interview design, and address the specific tools that have proven effective in recent disaster awareness studies. There are many factors to consider when designing and evaluating a survey or interview, such as the choice of a quantitative or qualitative focus, response analysis and bias elimination.

The single biggest initial decision in the design of a survey-based study is the choice between using a Hypothesis-Testing or Hypothesis-Generating approach. A hypothesis-testing approach is appropriate when a reasonably confident hypothesis can be formulated from the existing literature alone, and is mainly driven by quantitative techniques. Contrastingly, a hypothesis-generating approach is more favorable when a confident hypothesis cannot be generated from the existing data, and is mainly driven by qualitative techniques (Auerbach & Silverstein, 2003).

One can categorize both their qualitative and quantitative data via coding into a form amenable to analysis before they can validate a hypothesis. According to Statistics Canada

(2003, pg. 3), "Coding is the process of assigning a numerical value to responses to facilitate data capture and processing in general." Closed-ended questions are pre-categorized, allowing the respondent to choose from a pre-selected set of categories. "Multiple-choice" questions and those prompting for a numerical answer are both examples of closed-ended questions. These have the benefit of straightforward analysis to gain precise statistics such as “32% of respondents are "very concerned" about tsunami, 90% of which live in urban areas.” As useful as closed questions are, they are not suitable for all quantitative applications. Particularly, they can often introduce bias, and do not capture the full range of possible responses, pigeonholing potentially significant distinct viewpoints into the same response category (Statistics Canada, 2003).

Open-ended questions, those that prompt the responder to answer in their own words, can capture the additional context necessary to facilitate accurate interpretation of the responder's intent. However, the task of coding open-ended questions, breaking down written paragraphs into concrete categories, becomes more difficult than the closed-ended analog. Some problems involved are biases introduced by the difference in writing styles and skill between respondents, and inconsistencies in interpretation between different surveyors. Many have attempted to tackle this dilemma, and there are established open-ended coding techniques that are suitable for many situations (Popping & Roberts, 2009).

Some generally established guidelines for open-ended coding include the following: the chosen categories should be mutually exclusive and exhaustive; classifications should cover a range from general to specific, and adaptation to the situation and respondent's frame of reference (Montgomery & Crittenden, 1977; Lazarsfeld and Barton 1955). After data collection, coding methods may involve both the design of initial categories (a priori) and analysis after the final categories have been designated (a posteriori). Montgomery and Crittenden (1977) observe that a priori methods prove most effective for small pilot studies, where reliability is a concern given the small sample size, when compared with common a posteriori.

The purpose of research is to answer questions, and questions do not naturally come equipped with testable hypotheses; they must be carefully generated. In many cases, particularly when beginning to tackle a complicated issue, a suitable hypothesis cannot be concluded from the relevant literature alone. In these situations it is necessary to conduct a qualitative hypothesis-generating study, with a focus on "questioning rather than measuring" (Auerbach & Silverstein, 2003). Because of the inherently qualitative nature of open-ended questions, they often fit better in a qualitative hypothesis-generating study where their contexts can be fully considered, than in a strictly quantitative approach.

Analysis of hypothesis-generating studies is based in grounded theory, a general theory of "ground up" hypothesis generation. It is generally conducted by first identifying the issues and concerns, primarily through a literature review. It is then prudent to develop a short narrative interview or survey, addressing the key concerns in an open way, and distribute it to an initially small sample group. The sample group should be expanded gradually via theoretical sampling, choosing new participants who have a new perspective to offer, until the sample group covers the complete range of perspectives. (Auerbach & Silverstein, 2003; Birks & Mills, 2011).

An important concept of grounded theory to consider throughout the process, occasionally seen elsewhere, is the notion of concurrent data generation, whereby data is gathered (via surveys, in our case) based on a working descriptive theory, which is continually revised as new data is collected. This is in contrast to other popular approaches, which collect a large amount of data based on a strong hypothesis, and then subsequently analyze all of the data. It is also critical to the process for researchers to record memos of their thought process throughout the study. Because the working theory changes so frequently, it is important to be able to trace the train of thought leading to a conclusion backwards, possibly across weeks or months, to be able to reason about its correctness. The general characteristic of hypothesis-generating research is that it is a much more dynamic process than other approaches, and functions best on initially small testing groups (Birks & Mills, 2011).

Of course, there is no reason for these two approaches, hypothesis-generating and hypothesis-testing, to be in conflict. Along the course of hypothesis-testing research, many hypotheses are discarded, and must be replaced by new ones. Thus, there is a natural cycle between generating hypotheses and testing them. Further, much of the quantitative data can be gathered concurrently with qualitative data by recording demographic and summary information from each respondent as well as their open-responses (Morgan 1998; Auerbach & Silverstein, 2003; Bryman, 2006; Tashakkori & Teddlie, 1998). The three most popular media for combining qualitative and quantitative methods are self-administered questionnaires, semi-structured interviews, and open-response questionnaires. Mixed methods can also be used to regulate each other, using qualitative methods to verify quantitative results, as it is often easy to spot an inconsistency between numeric results and a more detailed interpretation of responder's intention. A qualitative understanding of perception helps design categories for coding quantitative surveys (Bryman, 2006).

2.4 Summary

Our preliminary research has enabled us to develop a greater understanding of factors surrounding the attitudes and response to tsunami disaster. These factors are based on risk perception and risk communication. The review of the studies related to tsunami disasters have revealed that countries in vulnerable geographic locations with poor risk communication experience significant mortality during a tsunami disaster. Evaluating the community's risk perception is vital to developing effective risk communication. We seek to develop methodologies to accomplish this evaluation.

CHAPTER 3. METHODOLOGY

Our goal was to conduct a pilot study to evaluate the awareness and preparedness of residents and visitors of the Greater Wellington Region (GWR) for tsunami caused by earthquakes. GNS Science will use this information to implement a larger study to improve the Wellington Region Emergency Management Office's (WREMO) emergency preparedness plans. To accomplish our goal, we designated the following objectives:

- To design and conduct interviews in the GWR related to tsunami threat
- To categorize (code) responses from GWR residents and visitors
- To analyze the responses from GWR residents and visitors
- To compare responses of communities within the GWR

Here we outline the key strategies we used to gather our data.

3.1 To design and conduct interviews in the GWR related to tsunami threat

In order to assess the awareness and preparedness of GWR residents and visitors, we designed and conducted interviews. Two weeks before surveying, we piloted the interview with the GNS Science social science staff as well as out in the field. We also considered mail-in surveys to improve response levels. However, in our study, we opted for open-ended face-to-face interviews rather than primarily closed-ended mail-in surveys for three main reasons: (a) Inability to predict the wide range of possible responses. Leaving responses open-ended prevents depth from being lost to ill-fitted categories. (b) Concern about misinterpreted questions. Face-to-face interviews allow questions to be rephrased on demand to clarify misinterpretations. (c) Concern about biasing questions. Face-to-face interviews allow us to present questions to participants in a predetermined order, one at a time, preventing the phrasing of later questions from affecting the responses of earlier questions. This ordering principle cannot be guaranteed in general for mail-in surveys.

3.1.1 Interview design

To develop an optimal interview location guide, we determined communities at high tsunami risk using the recommendations of GNS Science and WREMO. The responses from these communities were used to measure the awareness and preparedness of GWR residents and visitors in general, as well as to compare the results between communities. This includes communities with tsunami blue-lines such as Owhiro Bay and Island Bay, and nearby high-risk Wellington Harbour communities such as the Wellington Central Business District (Figure 3), and Petone. Additionally, we chose Porirua because it is a high tsunami risk community and there is limited information about the awareness and preparedness of Porirua residents. From this initial assessment, we mapped interview locations, and planned our interview route.

Figure 3 - The Wellington Harbor's proximity to the sea and high population density put it at high risk for tsunami

We employed open-ended interviews as the primary method of data acquisition to provide a more detailed understanding of individuals' knowledge and concerns about earthquake-triggered tsunami. Additionally, this interview format forces the interviewee to produce responses without time to prepare or research, often yielding a more accurate assessment (Doyle, n.d.). We conducted short (10-15 minute) face-to-face interviews with pedestrians in well-populated public areas in the targeted communities. In certain localities with low foot traffic, face-to-face interviews were conducted with residents at their homes. The interview location guide can be seen in the figure below.

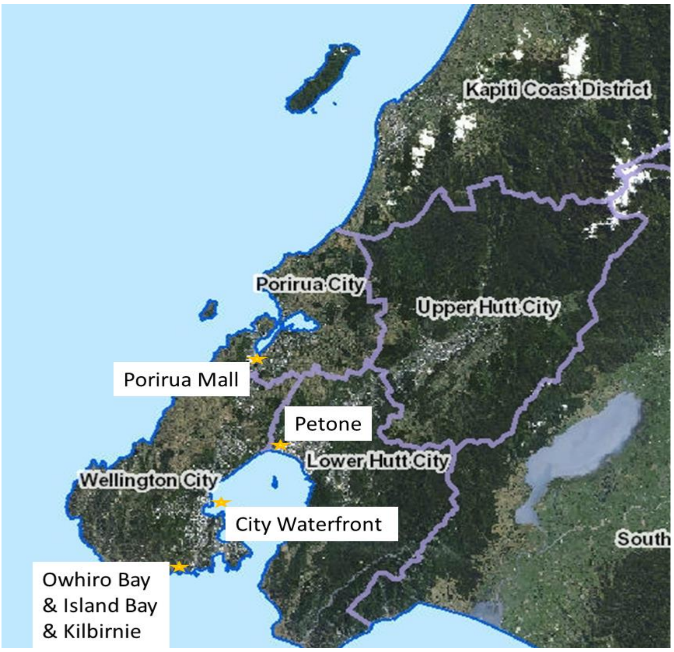

Figure 4 - Interview location guide

3.1.2 Interview strategy

We implemented a sample of convenience to identify interview participants. A sample of convenience features a part of the population that is most easily accessible or convenient. We used this strategy to rapidly identify subjects from locations with high human foot traffic. Upon arrival in targeted communities, we determined interview locations to maximize sample size by observing areas and determining those with consistently high foot traffic. Adhering to New Zealand's laws and regulations, we only requested interviews of nearby individuals who were above the age of sixteen years. Upon stopping a potential candidate for our interview, we would explain our purpose in the area as well as a basic overview of the interview and how long it takes. In an attempt to increase response rate, we altered our dress code and utilized the logos of GNS, WREMO, and WPI on our clipboards to reinforce our credibility (Figure 5).

Figure 5 - Usage of official logos during interviews

Responses were often paraphrased or written using abbreviations in order to maximize information collected without burdening the participant by increasing the duration of the interview. We often collected information that was not especially relevant to interview questions but were interesting and worth noting, for example, when participants gave their opinion on the blue-line. These responses were either represented by quotations, or as observed themes. Figure 6 below depicts a discussion between interviewer and respondent that lends itself to a deeper understanding of the participant’s outlook. In most cases, attitudes and beliefs of participants were only noted once we observed them reoccurring frequently. These attitudes and beliefs were recognized based on the content of participants’ responses, as well as their tone (sarcasm, anger, suspicion, etc.) and body language (facial expressions, engagement with interviewer, etc.).

Figure 6 - Discussing past experiences with earthquake survivor, given only 6 months to live

We kept the interviews brief so that we could obtain a representative set of interviews and decrease any burden presented to the interviewees. We designed interviews to quickly cover demographic information as well as to generate in-depth responses. We structured the interviews to give participants the opportunity to mention key ideas, such as tsunami, before prompting questions related to those key ideas, to avoid leading the questions.

After piloting the interviews for the first couple of days, we observed common inappropriate responses to questions. To better understand perceptions of the participants, we requested feedback from those who provided the inappropriate responses. We inquired whether or not specific interview questions were explicit and if they accurately portrayed our intention for the questions. In order to elicit accurate responses, we altered question phrasing and ordering while continuing to avoid leading key topics. A brief evolution of the interview questions can be seen in Appendix A.

3.1.3 Disclaimers, data storage and management

Before interviews were conducted, we briefly summarized the content and purpose of the interview. Specifically, we would explain that the questions were related to natural hazards and that the results would be used for public safety. We explained that none of the information would be used to identify an individual and names (if names were mentioned) would not be recorded.

Upon request, we informed participants that they could terminate the survey at their leisure and that they were not obligated to answer any questions. If participants inquired about further information, or the future results of the study, information sheets were provided to the participants. The information sheet (Appendix B) outlines the organizations involved in the study (GNS, WREMO, and WPI) as well as GNS contact information and related websites. Data was frequently transferred from paper interviews to a Microsoft Excel file, which was stored on password secured computers.

3.2 To categorize (code) responses from GWR residents and visitors

In order to analyze our data quantitatively, we needed to utilize a program to categorize and analyze data. Our team developed a collection of algorithms using the Haskell Programming Language™ (Appendix C). These statistical programs perform frequency analysis with the ability to apply constraints to group related questions. Additionally, the program calculated correlations on all individual variables, allowing us to identify thematic trends. After analyzing the frequencies, we used the information to produce graphs in Microsoft Excel to highlight main themes of our data set.

Our interview included questions designed for open-ended responses, inherently this yielded varied responses from participants. Therefore, we established a coding guide to group our collected responses into categories before analyzing our data using the collection of algorithms. In the development of our coding guide, we initially recorded the raw responses from our data collection into a Microsoft Excel file. As a team, we reviewed the data and identified recurrent themes from the responses. We then generated multiple representative categories to encapsulate the reoccurring themes from the data. We also included static categories that would represent the ideal response from participants. For example, question number two of the interview regarding what hazards and dangers people associate with earthquakes was intended to measure whether or not the participant associated earthquakes with tsunami. However, the reoccurring responses were related to falling or collapsed buildings. Therefore, in addition to creating a category representing these reoccurring responses, we included a static category for ideal responses pertaining to tsunami. Before finalizing and applying the categories, we added, condensed, or expanded them as deemed appropriate. The complete coding guide can be seen in Appendix D.

3.3 To analyze responses from GWR residents and visitors

We analyzed information from interviews to determine an overall impression of preparedness and risk perception of the residents and visitors of the GWR, as well as to identify correlating factors. Specifically, evacuation behavior was a primarily theme used to determine the preparedness and perception of risk in the GWR.

We investigated correlations between participants by calculating covariance with respect to all measured variables, including demographic information such as age, occupation, and income level. We used the covariance information produced by our program to map related concepts, as seen in Appendix E, and identify trends in responses. We also considered deeper qualitative patterns with respect to their personal state of mind towards tsunami risk. We studied raw data from interviews during the data input process and formed an overall impression of different aspects we were keen in understanding. We formed an overall impression representing our sample as a whole, as well as formed impressions representing specific communities we were interested in understanding more about. We considered participant awareness, preparedness, attitude, and general knowledge when forming an impression of our sample. Occasionally, participants directly expressed their attitudes, preparedness, awareness, or knowledge towards certain topics such as tsunami and the blue-line and further interpretation became unnecessary. These instances were most influential in forming overall impressions of our sample. Throughout the analysis, we employed a grounded theory approach to develop a hypothesis about the underlying phenomena driving the observed trends. Given the limited sample size of this pilot study as well as the convenience sampling methods, all quantitative results were evaluated with caution, and used as a complement to the underlying qualitative evaluation, in preparation for a larger future study that will be conducted by GNS.

3.4 To compare responses of communities within the GWR

In order to understand how factors such as blue-line placement, geography, and general social status affect awareness and preparedness, we compared our findings from different communities. We studied responses and the resulting awareness and compared the findings of separate communities. Specifically, it was important to understand if presence of tsunami blue-lines affected risk perception or preparedness. Additionally, we compared social status and geography across communities in order to explain differences in awareness and preparedness. Figure 7 below shows Owhiro Bay, one of the two blue-line communities.

Figure 7 - Owhiro Bay, a blue-line community

During our time collecting data, we conducted 400 interviews across our six targeted locations within the GWR. The interviews were conducted in the street with pedestrians as well as door-to-door in areas with insignificant foot traffic. Some areas yielded more interviews than other areas, due to a heightened level of interest and higher sample pool. We will present the key findings and a discussion of those findings as they relate to our previously stated objectives. We will also present and discuss relevant anecdotal information we have collected as a team throughout our time conducting interviews.

CHAPTER 4. FINDINGS AND ANALYSIS

During our time collecting data, we conducted almost 400 interviews across our six targeted locations within the GWR. The interviews were conducted in the street with pedestrians as well as door to door in areas with insignificant foot traffic. Some areas yielded more interviews than other areas, due to a heightened level of interest and higher sample pool. We will present the key findings and a discussion of those findings as they relate to our previously stated objectives. We will also present and discuss relevant anecdotal information we have collected as a team throughout our time conducting interviews. Additional supportive figures for this chapter can be seen in Appendix F.

4.1 To design and conduct interviews in the GWR related to tsunami threat

Our team faced several challenges while attempting to conduct our interviews. The most prevalent issue was our group was repeatedly mistaken as an affiliate of a religious group or a charity organization. Participants often mentioned that they came to these conclusions based on our attire and that there were clipboards present. Coincidentally, a respondent representing Jehovah’s Witnesses informed us that they were also trying to raise awareness related to natural disasters and the rapture. These concurrent efforts may have increased participants’ confusion surrounding our intentions. When we attempted to approach participants we would often encounter individuals who would refuse to be interviewed until GNS Science was mentioned, and would then decide to accept. In some cases, individuals would ignore our team entirely and avoid eye contact. Based on these challenges, it was clear that some individuals judged our cause as uninteresting before learning what our research entailed. The main reason for individuals’ reluctance to participate in our survey is likely the oversaturation of solicitors who also carry clipboards and approach pedestrians on public grounds. We also discovered that altering our clothing proved to have no significant effect on the response rate of our interviews. Potential participants continued to behave with skepticism until we mentioned phrases such as "natural disaster" or “GNS Science”.

In our interview structure, we encountered other challenges related to the phrasing of our questions. Participants admitted to us that they did not recognize certain terminology; this was especially prevalent in the Porirua area. This may have inhibited their ability to answer questions properly, as many questions could not be answered, or guessed, without recognition of the terminology. Specifically, words like “profession” and “hazards” needed to be defined during some interviews. Additionally we observed a lower response rate when we advertised interview lengths longer than 10 minutes. Despite those who decided to participate upon hearing “GNS Science”, many refused to participate even when they were informed that the theme was natural disasters and it was for public safety. In general, we discovered a lack of interest in participating in interviews related to natural disasters in the GWR.

Other individuals were reluctant to participate in the interview or were not confident that our interviews would assist in public safety because of distrust towards the council. One individual stated hopelessly “we (New Zealanders) are too blasé towards preparation ... the city council sits on their hands.” Another scenario arose after a team member conducted an interview and an uninvolved resident approached the team member asking, “Are you working with the council?” When he responded “no” the resident replied, “Oh that's good, I was just making sure.” This encounter implied negative associations with council-related business.

4.2 To categorize (code) responses from GWR residents and visitors

While categorizing our responses in preparation for analysis, we encountered a few issues related to our categorizing methods. Most importantly, we discovered that IBM SPSS and IBM SPSS Text Analytics were not suited to organize data as intricately as the data we collected. Specifically, SPSS was encountering difficulties capturing themes from complicated responses involving multiple related questions. We found that it would be more time consuming to organize the categories generated by SPSS rather than categorize them by hand.

During the categorizing of our data by hand, we found some drawbacks to our approach. We discovered that categories tended to develop to suit a single researcher's findings. We eventually discovered that certain categories needed to be revised because of this bias, and the categories were reviewed for accuracy a second time. This is because of the influence that individual member's category selection had on the category selection of other members and was accounted for in the review of the categories.

4.3 Results from analysis and correlations of interview responses

During analysis, we discovered four major themes: tsunami risk perception, responses to evacuation behavior interview questions, tsunami training, and tsunami awareness and preparedness of residents versus visitors. This section is of our analysis and discussion of each of these major themes.

Tsunami risk perception

Though many participants identified tsunami as a potential threat, the perception of the risk seems to be low. When asked to describe tsunami anticipation, a prevailing and concerning theme of complacency in tsunami preparation has emerged. This feeling is well summarized by one participant, "we haven't had a disastrous tsunami in over 100 years. Earthquakes maybe, but I don't think we're much worried about tsunami". It makes sense that many individuals would focus on earthquake preparedness at the expense of tsunami preparedness, as New Zealand has not experienced a severe tsunami since 1855, but recently experienced the devastating Christchurch earthquake. We found this theme mirrored in our survey results; only half of residents expect a tsunami in their lifetime, indicating a general lack of concern. Additionally, many participants mentioned that they did not believe tsunami were a serious threat, or that a tsunami could not reach their current location. This was despite the fact that all interviews occurred within tsunami threatened locations.

Inexperience with tsunami in certain areas in Japan and Sri Lanka led to slower evacuation times or a lack of evacuation altogether as discussed in section 2.1.3. Similar responses to those of Japan and Sri Lanka related to evacuation behavior have been observed in New Zealand communities during our studies. Specifically, we noted uncertainty related to tsunami events and proper evacuation procedure, with many respondents seeking confirmation during the interview as one particular respondent, “I think I would go up Taranaki St. - the water can't get up that high, right?” Another respondent even stated that after experiencing a strong earthquake that could cause a tsunami, she would gather all of her emergency supplies and sit next to the radio and then wait for a warning that would tell her what to do. It is likely that residents and visitors are more likely to seek confirmation or wait for instructions because they are confused or inexperienced with disaster scenarios.

Responses to evacuation behavior interview questions

In our observation of individuals' evacuation behavior responses, a significant proportion of the population indicated that they would travel up the closest hill on foot in the event of an official warning of a tsunami. However, when participants were presented with the scenarios of an earthquake that lasted for more than a minute and one strong enough that they would be unable to stand up, a majority of them claimed they would not evacuate. Some also insisted that they would seek confirmation from an official warning (via television, radio, or simply waiting for a siren) after an earthquake before considering evacuation. Surprisingly when engaged further, many participants revealed that they recognized that earthquakes cause tsunami, but did not recognize the threat of tsunami when presented with the earthquake scenarios. Given most participants would evacuate during an official warning, it is likely that their reluctance to evacuate and desire to seek confirmation after an earthquake is due to their lack of education surrounding natural warnings. Failing to evacuate was a common issue in the 2004 Indian Ocean tsunami, which was caused by a lack of education due to tsunami infrequency.

Despite the fact that both earthquakes and tsunami are well known disasters in the Wellington region (Figure 8), it appears that tsunami hazard is overshadowed by what respondents perceive as more severe earthquake hazards, such as falling buildings, debris, and ground fissures.

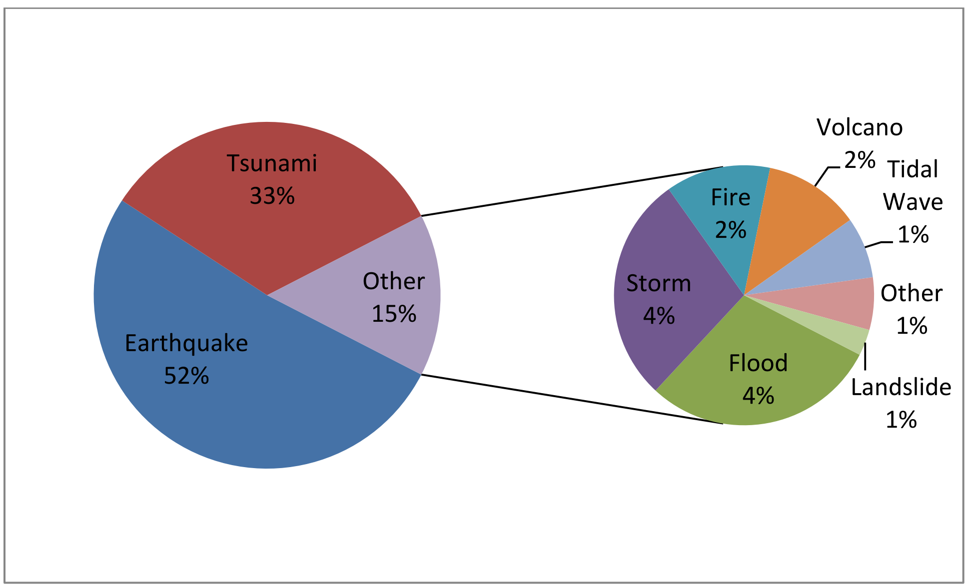

Figure 8 - Frequently cited natural disasters

This is evidenced by the differences between the responses in our final question wording and our original question wording, which did not explicitly prompt for earthquakes that could cause a tsunami. In the original question, respondents would take effective earthquake response behaviors, such as moving to open spaces or under tables to avoid falling debris, without mentioning movement to higher ground afterwards. After rewording our interview to include direct reference to tsunami caused by earthquakes, we received a significant increase in intention to evacuate to high ground. However, the fact remains that most people may forget about the potential for tsunami in the panic of a severe earthquake. Additionally, although most people were able to identify that strong earthquakes may cause tsunami, they were consistently unable to identify that long earthquakes pose the same danger (Figure 9). This implies that individuals assume that the perceived intensity of an earthquake is a direct indicator of the intensity of the resulting tsunami.

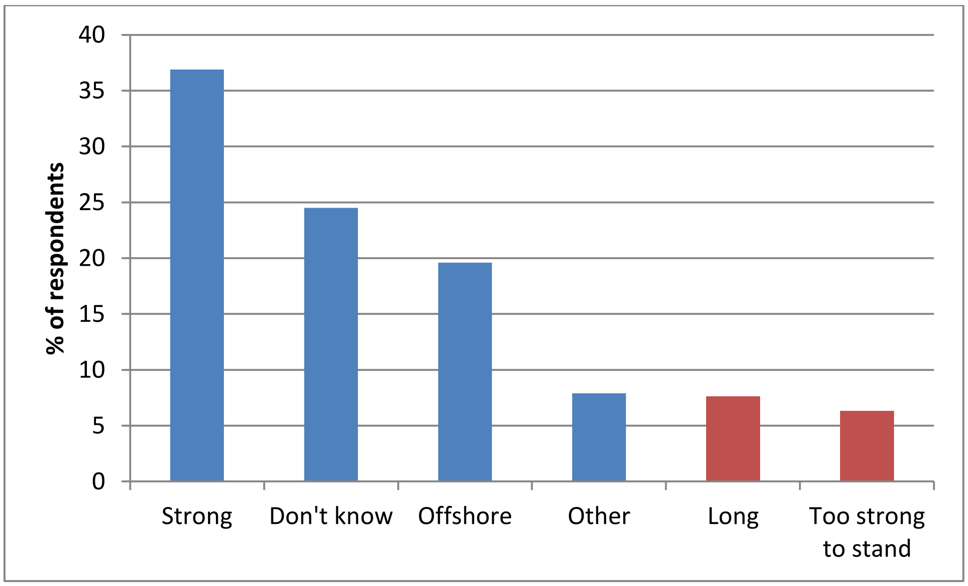

Figure 9 - How a tsunami generating earthquake would feel

In fact, over a quarter of the population surveyed was confused with under what conditions an earthquake could cause a tsunami, citing vague, immeasurable, or incorrect indicators such as simply "scary".

WREMO wants individuals to use strong or long earthquakes as a warning that a tsunami may be incoming because of the unreliability of tsunami warning systems as discussed earlier in section 2.1. The agency specifically states, that in an earthquake lasting more than one minute or is difficult to stand up in, residents should evacuate to high ground or as far inland as possible. An excerpt from a WREMO brochure “Get Ready Get Thru” is featured in Figure 10.

Tsunami warnings

Warning messages and signals about a possible tsunami can come from several sources – natural, official or unofficial.

Natural warnings

For a local source tsunami which could arrive in minutes there won't be time for an official warning. It is important to recognise the natural warning signs and act quickly.

If you are at the coast and experience any of the following:

- *Feel a strong earthquake that makes it hard to stand up, or a weak rolling earthquake that lasts a minute or more*
- *See a sudden rise or fall in sea level*
- *Hear loud and unusual noises from the sea*

Move immediately to the nearest high ground, or as far inland as you can.

Figure 10 - Tsunami natural warnings sampled from "Get Ready Get Thru" brochure

Despite the information presented by WREMO, most participants in our interviews identified sirens or alarms as the most common warning to tsunami though some were unaware of what it would sound like and assumed that it would sound in all tsunami threats. Although many expect sirens, there is a significant amount of confusion surrounding them. Some participants expressed concern that the sirens would be ineffective in a tsunami emergency. One respondent suggested having the current sirens replaced with sirens that are more powerful because people may not be able to hear the warnings. We feel that these concerns are driven by uncertainty of who would be issuing the siren warnings and what the siren would actually sound like, as reported by several respondents. There is also a concern of being able to identify the difference between the current siren and common alarm noises such as vehicle alarms. Residents seem unsure about the sound of alarms and the issuing agency because alarms are seldom sounded. When asked how long one would expect a tsunami to occur after a siren was sounded, responses varied from "immediately" to more than 9 hours. The vast majority of participants expected a tsunami less than an hour after hearing an alarm (Figure 11), despite the fact that official alarms are only reliably sounded for warnings one hour or longer according to WREMO information pamphlets. This misunderstanding can be hazardous if people take the absence of an alarm after an earthquake to mean there is no immediate tsunami threat.

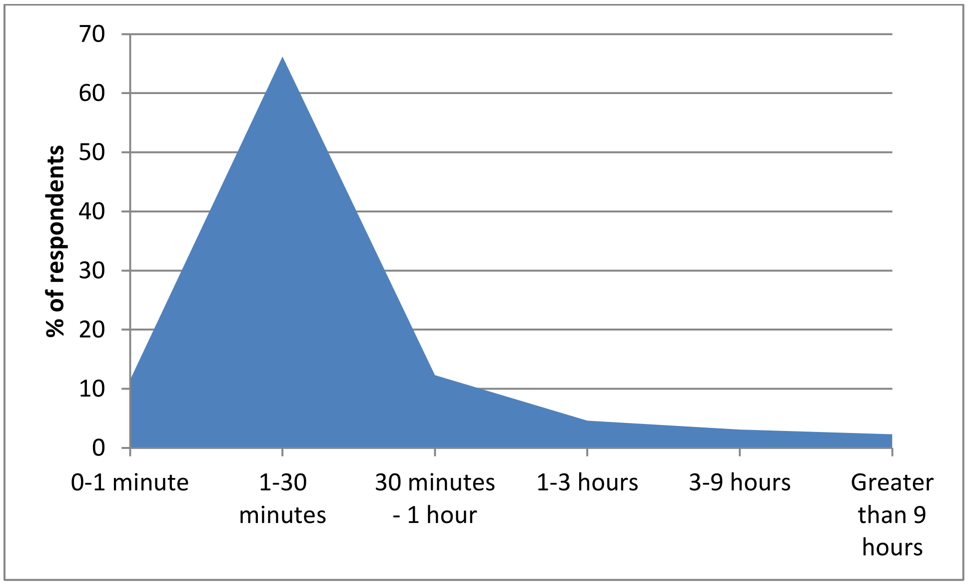

Figure 11 - Expected tsunami alarm warning time

When our interview respondents recognize an imminent danger of tsunami, most intuitively know to find high ground as soon as possible, though many do not have a prepared tsunami evacuation plan or escape route. Over 40% of respondents will travel by foot to what they identify as the highest point; this response is by far the most common course of action encountered in our interviews. While some individuals stated that before leaving they would grab essentials, and call friends and family, the majority stated that they would not delay and would immediately travel to higher ground.

However, a significant number of respondents claimed that they would attempt to assist people around them. This assistance included helping injured, elderly, children, and attempting to warn and gather people for evacuation. Other than a few respondents we interviewed who were a part of emergency services, most were unsure of how much time they would spend helping others. Residents and visitors seem unsure of what course of action they should take regarding the people around them before evacuating and to what extent they should take those actions. A few respondents even claimed that they would spend an indefinite amount of time helping others before evacuating. We have observed that the desire to assist others is likely due to either an attempt to make a positive impression on the interviewer or a natural desire to preserve human life. It is unclear which of these two explanations is the main purpose for their intention to assist, or whether their intention to assist will translate in a disaster situation. This sort of behavior, while hard to condemn, led to several deaths in Japan as discussed in section 2.1.3 Human response to tsunami threats. These actions were what led to the idea of "tsunami tendenko."

Though most participants claimed that they would evacuate on foot, a significant number of respondents reported that they would attempt to evacuate by vehicle initially if road conditions permitted (Figure 12).

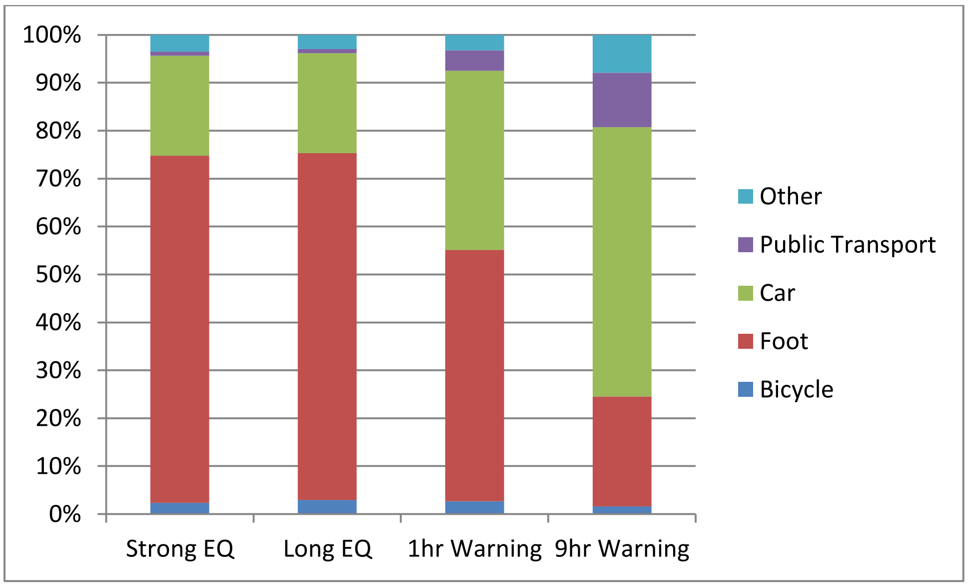

Figure 12 - Evacuation methods

A fifth of participants would evacuate by car in long or strong earthquake scenario, not identifying the danger in attempting to evacuate by car in severe traffic jams. For example, those who claimed that they would abandon their cars if driving conditions were unfavorable mentioned nothing about the consequences of leaving a motor vehicle in roads. Further, the proportion of people who would evacuate by car increased for longer tsunami warnings. It seems that respondents are more concerned with roads damaged by earthquakes than with traffic caused by mass evacuation. Individuals are also likely to evacuate by vehicle in longer warnings because they tend to evacuate far distances to ensure their safety. Attempted evacuation by car caused a significant number of deaths in the 2011 Japanese tsunami because abandoned cars caused traffic congestion and therefore prevented evacuation.

Evacuation training amongst residents and visitors

During our study, we observed that many participants had evacuation training. Interestingly, the majority of trained residents in our sample received training through their place of work or another institution with which they regularly associate. However, when we questioned individuals on whether or not they had received any tsunami evacuation training or participated in any tsunami evacuation drills, many indicated that their evacuation training was mostly related to fires and/or earthquakes rather than tsunami. This indicates to us that the workplace is the most likely location for inhabitants to receive training, though tsunami training is less common amongst businesses in New Zealand than fire or earthquake training.

Tsunami awareness and preparedness of residents versus visitors

There appears to be a general lack of tsunami awareness from individuals visiting coastal areas of New Zealand from more inland locations of New Zealand. Though individuals from more inland regions of New Zealand recognize tsunami as a potential hazard, they are much more focused on the earthquake threat and base their evacuation behavior around more immediate earthquake dangers such as falling objects and broken roads. Visitors from other countries generally do not identify tsunami as a threat, are unaware of tsunami warning signs, and generally attribute their unawareness to living in areas with little to no earthquake or tsunami threat. Not surprisingly, visitors from countries other than New Zealand do not know what the blue-line is unless they have visited communities with the blue-line.

4.4 Awareness variations between communities

We discovered differences between responses from communities located in the blue-line areas and those located in non-blue-line areas in terms of individual risk perception. In areas where the blue-line is located such as Owhiro Bay and Island Bay, we observed that tsunami appeared more frequently in conversation and that it was discussed more seriously. Contrastingly, in areas where officials did not implement the blue-line, such as the CBD, Petone and Porirua, individuals tended to speak less often about tsunami.

Figure 13 - The distinctive tsunami blue-line in Island Bay serves as a tool for both education and awareness

Particularly, some residents of blue-line areas expressed a feeling that the introduction of the blue-line had raised tsunami awareness in general. The blue-line appears to clearly identify tsunami danger, as a significant portion of blue-line community residents were able to deduce the purpose of the blue-line by sight, without additional explanation (Figure 13).

Many participants expressed their feelings towards the blue-line during interviews. Interestingly, when the concept of the blue-line was explained to those who were unfamiliar with it, they claimed it was a great idea. Many residents within blue-line communities had very different opinions of the blue-line. The most overwhelming belief associated with the blue-line is that its placement in communities was determined arbitrarily. Many claim that the blue-line is a representation of exactly where the water level will rise in a tsunami event. One individual supported these claims by stating “if my foot is on this side of the blue-line (inland side), I am dry. If my foot is on this side of the blue-line (seaside), I am wet.” There appears to be confusion about why the blue-lines were placed where they were and how their placement was calculated.

This leads to distrust of the blue-line and many only describe the blue-line as being a good tool for promoting awareness.

Additionally, another factor influencing the perception of tsunami risk in different communities is the belief that the shape of the Wellington harbor protects the region from tsunami. Some participants believe that a tsunami cannot enter the harbor, or that the large shallow coastline of New Zealand dissipates tsunami waves. This is a misconception, because a major tsunami has been produced within the harbor in the 1855 Wellington earthquake. Our data supports this misconception because in the harbor communities, tsunami was not listed as a major natural disaster as often as in the coastal communities facing the Cook Strait. The coastal communities are considered more at risk by participants because they are not protected by the harbor.

4.5 Additional Observations

While interviewing, we observed participants displaying confusion regarding question phrasing and terminology, especially prevalent in Porirua, a lower socioeconomic area. This may be a result of poor education in these locations. However, we believe this is not necessarily a class specific problem. There may have been confusion amongst more privileged classes, but due to social pressures to reflect a certain level of intelligence, they may have been less willing to admit ignorance. Initially we received the impression that wealth and general education would strongly affect tsunami concern and knowledge. The more educated could be more likely to become exposed to natural disaster training. Additionally, wealthier populations may be more concerned about tsunami as they have more property investments in the area. Contrastingly, lacking the financial stability to recover from a disaster, it is plausible for those of lower socioeconomic background to have greater concern of natural disasters in general. Overall, the issue of class distinctions is a complicated one, and we could identify no strong associations between wealth and tsunami preparedness. It seems that the perception of tsunami risk and initial reactions to disaster derive from a deep human response, which is common between people.

We also feel that the inability of the inhabitants to recognize a tsunami threat when presented with the earthquake scenarios is likely because of two reasons. First, natural disaster survivors tend to have an optimistic outlook on the likelihood of similar disasters occurring in the future; they believe that they will never experience another severe disaster. Second, it is plausible that the frequent occurrence of earthquakes has desensitized individuals to this event.

During our time interviewing, this was predominantly discovered in older generations. It seems as though those that have experienced natural disasters draw on their past experience to help them judge how to react during the earthquake-tsunami scenarios. The frequency of earthquakes and tendency to draw on past experiences are likely causing individuals to perform only standard earthquake evacuation behaviors, despite an earthquake's potential to induce a tsunami. Comparatively, we discovered individuals who were inexperienced with natural disasters often stated that they would follow what they learnt through media or officials, or they would just follow what other people were doing.

Through our observations, we have realized that individuals have been conditioned to expect confirmation of tsunami threat from authority. After considering the reasons why people seek confirmation, a possible explanation is that residents do not trust their own instincts to judge natural warnings since they have not experienced a devastating tsunami induced by a local earthquake. By seeking confirmation, people feel more in control of the situation.

4.6 Summary

After conducting almost 400 interviews, the results from our analysis and correlations of interview responses revealed themes related to human behavior and the perception of risk. In this section, we will review some key findings and analysis. In summary, we discovered the following:

- Residents and visitors are reluctant to engage with interviewers wielding clipboards on public grounds.
- Some participants do not understand interview questions and require rephrasing.
- Tsunami are considered to be a possible threat but there is a general lack of concern for tsunami due to their infrequency.
- Residents and visitors know to evacuate to higher ground during a tsunami but cannot identify natural earthquake warning signs as tsunami threats and are unsure of how official disaster sirens sound.
- Individuals are unsure of what their responsibilities are during an evacuation.
- Residents tend to evacuate by foot during shorter warnings but as warning times increase more tend to evacuate by car .
- Most residents learn evacuation training from their work place.

- Visitors from outside New Zealand usually are unaware and unprepared for tsunami and have a low perception of risk towards tsunami threat.
- Individuals cite distrust of the blue-lines' placement because of the misconceptions surrounding its purpose.
- Residents and visitors believe that the shape and location of the Wellington Harbor will protect the harbor communities from tsunami. In addition, some participants believe that the Bay communities are safe from tsunami because the shape of the shoreline.

CHAPTER 5. RECOMMENDATIONS AND CONCLUSION

Based on the findings and analysis of our pilot study, we developed some recommendations that we felt could improve interview or survey structure and data collection methods for the study as it moves forward. Furthermore, based on considerable feedback from residents and visitors all over the GWR, we have suggestions that might improve the awareness and preparedness in the event of a tsunami.

5.1 Recommendations for improving interview and data collection

The recommendations made in this section are based on the interview and data collection techniques practiced during this pilot study. In order to make distinctions between interviewers and different solicitors, future interviewers could utilize the logos of sponsoring organizations such as GNS, WREMO, and CD. Preferably, the logos would be located on clothing or on a nearby sign in order to allow the logos to remain large and visible.

In future surveys or interviews, questions could be phrased more simply in order to avoid confusion and random guessing from participants. This will reduce the burden on interviewers and increase response rate. Specifically, for questions involving earthquake evacuation scenarios, the distinction between long and strong earthquakes is negligible and can be omitted.

Mail-in surveys can be used to conduct a larger study where face-to-face interviews are infeasible. Originally, we opted for open-ended face-to-face interviews rather than closed-ended mail-in surveys for three main reasons:

a) Inability to predict the wide range of possible responses.
b) Concern about misinterpreted questions.
c) Concern about biasing questions.

However, based on the findings of this study, we have developed a solution to remedy these problems and will allow for an improved volume of data and reduced human effort granted by mail-in surveys.

Appendix G depicts our suggestion for a pre-coded mail-in survey. The chosen categories are based on the thematic trends in responses to the associated open-ended question posed in our interviews. From our observations and through the coding process, we have identified these categories as both covering the majority of common responses, and providing the fidelity to prevent pigeonholing intended responses into improper categories. The phrasing of these questions is based on what we have identified, after many iterations, as the most easily understood and unbiased for the specific questions. Finally, we have observed that most of the questions with which there is a concern of biasing order are unaffected by ordering. To mitigate the remaining ordering bias, we have opted to place the first two questions regarding hazard identification on a separate page from the other questions. While proper ordering cannot be guaranteed, this reduces the chance of the respondent looking ahead.

5.2 Recommendations for improving tsunami awareness and preparedness

Based on the strong start to WREMO's tsunami campaign, we encourage WREMO to continue implementing the tsunami blue-lines in communities. Our analysis indicates, however, that some individuals believed that the blue-line was an "arbitrary point" and that they would not rely on it. Also, we found that there was a statistical insignificance between the level of awareness and preparedness in the blue-line communities versus the non-blue-line communities. This was evident in our findings when we discovered communities in blue-line areas had almost equal knowledge about appropriate tsunami evacuation behavior as communities in non-blue-line areas. Despite these statistical findings, we do believe that the presence of the blue-line contributes somewhat significantly to the level of awareness in the communities based on anecdotal findings. To improve this finding, WREMO could provide information to communities either directly to homes within the community or by static means; in order to change the prominent misconception and beliefs community members may have about the blue-line and its function and to improve its credibility.

It is evident that there is uncertainty amongst residents regarding official tsunami warnings. Most reported that they would expect a siren to sound but many admitted that they do not know what it would sound like or expressed concern about the presence of alarms in their community. It may prove useful to educate the public on what emergency alarms sound like and under what circumstances alarms are used. To avoid desensitizing residents to the sound of the alarm by conducting frequent drills, Civil Defence and organizations involved with sounding the alarm could place audio clips on their website, or send messages to geolink subscribers with a preview of the alarm. In the largely populated CBD of Wellington, we discovered that visitors were significantly less prepared than residents were. Therefore, we suggest officials work in alliance with businesses and restaurants in the CBD waterfront and teach the employees in this area appropriate tsunami evacuation. We also suggest implementing official stickers on buildings indicating whether it is in a tsunami danger zone or a tsunami safe building. Finally, we recommend developing an awareness tool similar to the blue-line along the waterfront to promote awareness amongst visitors and non-CBD residents. A sample of this sticker is featured below in Figure 14.

Figure 14 - A draft illustration of the proposed "Tsunami Safe" sticker

As discussed previously, a significant portion of the population failed to identify earthquakes that lasted for more than one minute and earthquakes that are difficult to stand in as possible tsunami threats. This can result in a sole focus on earthquake response leaving residents and visitors vulnerable to tsunami. In order to raise awareness to these tsunami warnings, we suggest developing a slogan in a similar vein to "duck, cover, hold" but in relation to long or strong earthquakes. This slogan could possibly be "Strong? Long? Gone!" In addition, because of the large quantity of respondents who insisted that official warnings would be released in all tsunami events, it could be worth clarifying in that campaign that there will not always be an official warning.

Regarding responses related to attempting to evacuate by vehicle, we suggest focusing efforts on encouraging residents to never attempt to flee by car. Many residents realized that the conditions of the roads may be bad or that there may be significant traffic congestion but would still attempt to flee by vehicle regardless. Many visitors tend to travel on foot because they do not own vehicles here. A possible solution would be to designate specific cars to be driven in possible tsunami threats using bumper stickers, much like how Japan marked their vehicles. This would warn drivers in everyday life to leave their car during an evacuation. Alternatively, existing education methods such as signs could be modified to include more specific information regarding evacuation means (Figure 15).

Figure 15 - A draft illustration signage conveying specific warning signs and transportation methods
Image of bicycle and car inspired by (Map symbols bike clip art, 2013) and (Bednell holiday homes, 2013)

In response to our evacuation related questions, respondents tended to claim that they would help or assist people around them before evacuating. This generates a lot of uncertainty regarding how much time they should spend assisting before evacuating. Outlining the responsibilities of residents during an evacuation will likely reduce confusion, allowing them to focus on adhering to only those responsibilities before evacuating. Alternatively, Wellington can adopt a belief similar to Japan's "tsunami tendenko" to teach responsibilities during an evacuation. This raises a question: can residents adopt this kind of approach, or does a new set of responsibilities, more harmonious with Kiwi values, need to be decided.

5.3 Conclusion

The research conducted in this pilot study has helped confirm suspicions of low tsunami preparedness in the GWR. Because New Zealand sits on a seismically active region of the world, research dedicated to evaluating and promoting preparedness in the event of an earthquake or tsunami is vital. In an age where societies are frequently threatened by disasters, both natural and man-made, accurately aligning a community's perception of risk to actual threats is an important step in lowering mortality rate. The questions and methods involved in our study have been refined so that appropriate responses can be acquired from a broad demographic. Recommendations have also been generated to improve survey quality for future studies to be conducted in the GWR and a suggestion for mail-in surveys has been developed. Education efforts must also be effective in communities to properly align perception of risk. Threatened communities must implement proper risk communication to prevent life-threatening behaviors during disastrous events. Studies such as this one assist in isolating factors of low risk perception and developing tools to improve risk perception and disaster preparedness. Education efforts such as the blue-line are a step towards stronger tsunami education and can be utilized in a broader section of New Zealand and other countries in danger of tsunami.

Given that this pilot represented a small portion of the GWR, a larger study could be conducted to assess a greater demographic over a broader area. Similar studies can be conducted in the future in other threatened locations where little is known about tsunami preparedness and awareness in order to prepare for a larger study in that area. Once awareness and preparedness of an area has been measured, emergency management offices such as WREMO can develop or improve education programs to address the gaps in tsunami awareness and preparedness of the area. Developing effective disaster education programs is vital in saving lives during earthquakes and resultant tsunami in countries with large coastal areas such as New Zealand. As stated previously, a significant portion of the world lives near the coast, putting them at risk for tsunami. Without proper education in threatened areas, individuals will not be able to react quickly enough to a locally induced tsunami, potentially leading to severe damage and loss of life as reflected in the 2004 Indian Ocean Tsunami. Improving education efforts has been proven to help mitigate the loss of life, as seen in the Great East Japan Tsunami in 2011 and the Samoan earthquake of 2009. As research is conducted on tsunami awareness and preparedness, education programs can properly evolve to minimize the loss of life during natural disasters.

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APPENDICES

Appendix A: Interview versions 1-3

Version 1

Natural Disaster Survey

Survey Questions [red = instructions to interviewer]

1. [whathaz]What two natural disasters do you believe are most likely to affect your current location?

   ____

2. [eqhaz]What life-threatening hazards and dangers do you associate with an earthquake? [prompt to exhaustion: "what others, what others,…" until "no others"]

   ____

3. [warnings]What would warn you of an incoming tsunami? [prompt for more]

   ____

   a. [source][if some form of official warning(s) mentioned:] Who would this come from? How did you receive that warning?

   ____

   b. [time]How long would you expect the tsunami after that/those warning(s)? [ask about time frame from each type of warning that they present]

   ____

4. [eqfeel]Describe earthquakes in which you would find it necessary to evacuate because of the threat of tsunami? [prompt for as many details as possible - check if they say long AND strong, vs long OR strong] ~~Skip if answered in question 3~~

   ____

5. (context) I'm now going to ask you four questions each about four different scenarios.

   If there were **an earthquake it was hard to stand up in** and you were to evacuate right here & now:

   a. [evacto]Where would you evacuate to from here? [prompt for nearest intersection/city)]

   ____

   b. [evacact]What would you do before evacuating?

   ____

      i. About how long would it take?

      ____

   c. [evacmeans] How would you travel to your intended destination?

   ____

   If there were **an earthquake of more than a minute** and you were to evacuate right here &now:

   d. [evacto]Where would you evacuate to from here? [prompt for nearest intersection/city)]

   ____

   e. [evacact]What would you do before evacuating?

____

i. About how long would it take?

____

f. [evacmeans] How would you travel to your intended destination?

____

If there were **an official warning of a tsunami in 1 hr** and you were to evacuate right here &now:

g. [evacto]Where would you evacuate to from here? [prompt for nearest intersection/city)]

____

h. [evacact]What would you do before evacuating?

____

i. About how long would it take?

____

i. [evacmeans] How would you travel to your intended destination?

____

If there were **an official warning of a tsunami in 9 hrs** and you were to evacuate right here &now:

j. [evacto]Where would you evacuate to from here? [prompt for nearest intersection/city)]

____

k. [evacact]What would you do before evacuating?

____

i. About how long would it take?

____

l. [evacmeans] How would you travel to your intended destination?

____

6. [blue]Do you know what the blue line is? Describe what you know about it. Where did you learn about it? [prompt for as many details as possible]

____

____

7. [nexttsu] When do you expect the next damaging tsunami to hit the Greater Wellington Region? (Circle One)
a) *Within the next year* b) *Within the next 10 years* c) *Within your lifetime* d) *Not within your lifetime*
8. [origin] What place or places do you think tsunami that threaten this location would originate from? [prompt for geographic location]

____

____

Demographic Questions/ Residential Status

1. [prof]What is your profession?
   a. How severely would you expect a tsunami to affect your livelihood? [Prompt for as much explanation as possible] ____

   ____
2. [age]In what year were you born? 19___
3. [gender]What is your gender? (Circle One) *M/F*

Version 2

Natural Disaster Survey

The findings from this study will be used to help local communities better prepare for future natural disasters

Main

1. **What two natural disasters do you believe are most likely to affect your current location?**

2. **What life-threatening hazards and dangers do you associate with an earthquake?** [!]

3a. **What would warn you of an incoming tsunami?** [!]

3b. [if some form of official warning(s) mentioned:] **Who would this come from? How would you receive that warning?**

3c. **How long would you expect the tsunami after that/those warning(s)?** [ask about time from each type of warning they present]

4. **Describe properties of an earthquake that you believe could cause a tsunami severe enough to evacuate?** [!]

Mention that four (4) different scenarios will be presented

What would you do after an earthquake that lasted for more than a minute? Evacuate? Y / N

(If no) If there was an earthquake that lasted for more than a minute and could cause a tsunami?

5a. Where would you evacuate to from here? *[nearest intersection/city]*

5b. What would you do before evacuating?

5b i. About how long would this take? ______

5c. How would you travel to your intended destination? ______

What would you do after an earthquake where it was hard to stand up? *Evacuate? Y / N*

(If no) If there was an earthquake where it was hard to stand up and could cause a tsunami?

6a. Where would you evacuate to from here? *[nearest intersection/city]*

6b. What would you do before evacuating?

6b i. About how long would this take? ______

6c. How would you travel to your intended destination? ______

If there were an official warning of a tsunami in 1 hour and you felt it necessary to evacuate...

7a. Where would you evacuate to from here? *[nearest intersection/city]*

7b. What would you do before evacuating?

7b i. About how long would this take? ______

7c. How would you travel to your intended destination? ______

If there were an official warning of a tsunami in 9 hours and you felt it necessary to evacuate...

8a. Where would you evacuate to from here? *[nearest intersection/city]*

______

8b. What would you do before evacuating?

______

______

8b i. About how long would this take? ______

8c. How would you travel to your intended destination? ______

9. Have you recieved any tsunami information? evacuation training? Participated in any drills? Please describe each

______

______

10. Do you know what the blue line is? Describe what you know about it. Where did you learn about it *[!]*

______

______

11a. When do you expect the next damaging tsunami to hit the Greater Wellington Region?

- ☐ *Within 1 year*
- ☐ *Within 10 years*
- ☐ *Within your lifetime*
- ☐ *Not within your lifetime*

11b. What place or places do you think a tsunami that threatens this location would originate from? *[geographic locations]*

______

Demographic

12. What is your profession?

______

13. How severely would you expect a tsunami to affect your livelihood?

______

14. In what year were you born? *19* ___

15. What is your gender? ☐ *Male* ☐ *Female*

16. What is the highest level of education you have completed?
☐ *School* ☐ *Trade* ☐ *Qualification*
☐ *Undergraduate (e.g. Bachelor)*
☐ *Postgraduate (e.g. Masters,PhD)*

17a. Are you a resident in this city or visiting? ☐ *Resident* ☐ *Visiting*

17b. If resident, how long have you lived here? ______

17c. If visiting, what where are you visiting from? *[suburb AND city AND Country]*

______

17d. How regularly do you visit this area?
☐ *More Often* ☐ *Monthly* ☐ *Annually* ☐ *Less often*
☐ *First Visit*

17e. Where do you live? *[address or at least nearest intersection]*

______

______

18. What is your household income category?
☐ *LT $20,000* ☐ *$20,001-$30,000* ☐ *$30,001-$50,000*
☐ *$50,001-$70,000* ☐ *$70,001-$100,000* ☐ *Over $100,000*

Version 3

Natural Disaster Survey

The findings from this study will be used to help local communities better prepare for future natural disasters

Main

1. **What two natural disasters do you believe are most likely to affect your current location?**

   ______

2. **What life-threatening hazards and dangers do you associate with an earthquake** [!]

   ______

   ______

3a. **What would warn you of an incoming tsunami?** [!]

______

______

3b. [if some form of official warning(s) mentioned:] **Who would this come from? How would you receive that warning?**

______

3b. **How long would you expect the tsunami after that/those warning(s)?** [ask about time from each type of warning they present]

______

______

4. **Describe earthquakes in which you would find it necessary to evacuate because of the threat ot tsunami?** [!]

   ______

   ______

If there were an earthquake where it was hard to stand up in...

5a. **Would you evacuate?** ☐ Yes ☐ No

5b. **If you were to evacuate, would you leave immediately? What would you do in the meantime?**

______

______

5c. **Where would you go to?** [nearest intersection/city]

______

5d. **How would you travel to your intended destination?** ______

If there were an earthquake that lasted for more than a minute...

6a. **Would you evacuate?** ☐ Yes ☐ No

6b. **If you were to evacuate, would you leave immediately? What would you do in the meantime?**

______

______

6c. **Where would you go to?** [nearest intersection/city]

______

6d. **How would you travel to your intended destination?** ______

If there were an official warning of a tsunami in 1hr...

7a. **Would you evacuate?** ☐ Yes ☐ No

7b. **If you were to evacuate, would you leave immediately? What would you do in the meantime?**

______

______

7c. Where would you go to? [nearest intersection/city]

7d. How would you travel to your intended destination? ____________________

If there were an official warning of a tsunami in 9hrs...

8a. Would you evacuate? ☐ Yes ☐ No

8b. If you were to evacuate, would you leave immediately? What would you do in the meantime?

8c. Where would you go to? [nearest intersection/city]

8d. How would you travel to your intended destination? ____________________

9. Do you know what the blue line is? Describe what you know about it. Where did you learn about it [!]

10a. When do you expect the next damaging tsunami to hit the Greater Wellington Region?

☐ Within 1 year

☐ Within 10 years

☐ Within your lifetime

☐ Not within your lifetime

10b. What place or places do you think a tsunami that threatens this location would originate from? [geographic location]

Demographic

11. What is your profession?

---

12. How severely would you expect a tsunami to affect your livelihood?

---

13. In what year were you born? 19 __

14. What is your gender? ☐ Male ☐ Female

15. What is the highest level of eduacation you have completed?
☐ School ☐ Trade ☐ Qualification
☐ Undergraduate (e.g. Bachelor)
☐ Postgraduate (e.g. Masters,PhD)

16a. Are you a resident in this city or visiting? ☐ Resident ☐ Visiting

16b. If resident, how long have you lived here? ____________________

16c. If visiting, what where are you visiting from? [suburb AND city AND Country]

16d. How regularly do you visit this area?
☐ Monthly ☐ Annually ☐ Less often ☐ First Visit

16e. Where do you live? [address or at least nearest intersection]

---

17. What is your household income category?
☐ Under $20,000 ☐ $20,001-$30,000 ☐ $30,001-$50,000
☐ $70,001-$100,000 ☐ Over $100,000

Appendix B: Information presented to participants

Thank you for taking time to complete this survey!

GNS Science and Wellington Region Emergency Managemen
Office (WREMO) are interested in what people know about
tsunami and warnings,
to help improve education

This survey is being conducted by visiting students from
Worcester Polytechnic Institute in collaboration with GNS
Science and WREMO

Further information regarding tsunami hazard, warnings and
evacuation in Wellington Region can be found on WREMO's
web pages:
http://www.gw.govt.nz/tsunami-2/
https://www.facebook.com/WREMOnz

WREMO's core tsunami preparedness message is:

"In an earthquake longer than 1 minute,
OR in which it is hard to stand up,
evacuate all zones, beyond the blue line"

If you have any questions please contact Graham Leonard or
Julia Becker at GNS Science:
04 570 1444 or g.leonard@gns.cri.nz

Appendix C: Algorithms for data analysis

The following is a collection of Haskell functions employed for analyzing statistical frequencies, calculating correlations, and filtering misscoded data. These functions were used in tandem with the GHCI interactive environment throughout, to process data and generate graphs, reading data from our coded response table ‘datan.csv’. Statistical correlation was calculated by assigning all coded responses to sequential integers, and calculating by the formula below, where Cov(X,Y) is the covariance between question X and question Y.

$$\frac{Cov(X,Y)}{Cov(X,X) * Cov(Y,Y)}$$

```
{-#LANGUAGE ParallelListComp #-}
import Text.ParserCombinators.Parsec
import Data.Char (isDigit,toLower)
import qualified Data.Set as S (fromList)
import System.IO.Unsafe (unsafePerformIO)
import Data.List
import Control.Applicative ((<$>))
import Data.Function (on)
import Data.Array
import Control.Arrow ((&&&))
import Data.List.Split (splitOn)
type CSV = [Record]
type Record = [Field]
type Field = String
csv :: Parser CSV
csv = do x <- record `sepEndBy` many1 (oneOf "\n\r")
eof
return x

record :: Parser Record
record = (quotedField <|> field) `sepBy` char ','

field :: Parser Field
field = many (noneOf ",\n\r\"")

quotedField :: Parser Field
quotedField = between (char '"') (char '"') $
many (noneOf "\"" <|> try (string "\"\"" >> return '"'))

-- | Given a file name (used only for error messages) and a string to
-- parse, run the parser.
parseCSV :: FilePath -> String -> Either ParseError CSV
parseCSV = parse csv

-- | Given a file name, read from that file and run the parser
parseCSVFromFile :: FilePath -> IO (Either ParseError CSV)
parseCSVFromFile = parseFromFile csv

-- | Given a string, run the parser, and print the result on stdout.
parseCSVTest :: String -> IO ()
parseCSVTest = parseTest csv

-- | Given an object of type CSV, generate a CSV formatted
-- string. Always uses escaped fields.
printCSV :: CSV -> String
printCSV records = unlines (printRecord `map` records)
where printRecord = concat . intersperse "," . map printField
printField f = "\"" ++ concatMap escape f ++ "\""
escape '"' = "\"\""
escape x = [x]

readCSV f = do; f' <- parseCSVFromFile f;case f' of;Right x ->  return x
toResponse (x:xs) = transpose [map (R q) r | q <- x | r <- transpose xs]
```

```
data Response = R {question :: String, response :: String} deriving (Eq,Ord)
instance Show Response where
show (R x y) = "("++x++":"++y++")"
sfield q x = [r | x' <- x, R q' r <- x',q'==q]
selectAll ps x = [x' | x' <- x, all p' x']
where p' (R q' r) = and [p r | (qq,p) <- ps,qq==q']
select qs ps x = [[r | R q' r <- x', q' `elem` qs] | x' <- x, all p' x']
where p' (R q' r) = and [p r | (qq,p) <- ps,qq==q']
cluster x = reverse . sortBy (compare `on` fst) . map (length &&& head) . group . sort $ x
fcluster q x = cluster $ sfield q x
clusterM x = let x' = cluster x in mapM_ print x' >> return x'
fclusterM q x = (clusterM $ sfield q x)
fclusterM_ q x = (clusterM $ sfield q x) >> return ()
recluster x = reverse $ sortBy (compare `on` fst) [(sum [n | (n,qq) <- x,isInfixOf q qq],q) | q
<- lbs] where
lbs = nub $ (map snd x) >>= split
fclusterSplit q x = recluster $ cluster $ sfield q x
fclusterSplitM_ q x = mapM_ print cl >> return (sum $ map fst cl) where
cl = fclusterSplit q x
clusterTotal q x = sum `fmap` map fst `fmap` fclusterM q x
x & f = f x
f |.| g = \x -> f x || g x

mainnn = do
a <- toResponse <$> map (map (map toLower)) <$> readCSV "datan.csv"
let b = a & recode "whathaz" ["eq"] "earthquake" &
recode "sex" ["male"] "m" &
recode "whathaz" ["typhoon","wind","tornado","storms","huricane","cyclone"] "storm" &
recode "whathaz" ["asteroid","solar flare"] "other" &
recode "whathaz" ["flooding","floods"] "flood" &
recode "whathaz" ["landslides"] "landslide" &
recode "whathaz" ["tunsami"] "tsunami" &
recode "whathaz" ["not sure"] "?" &
recode "eqhaz" ["liquefication","liquefation"] "liquefaction" &
recode "eqhaz" ["drowning into sea","volcano","sea","damage","falling"] "other" &
recode "eqhaz" ["landlside","landslides"] "landslide" &
recode "eqhaz" ["tusnami"] "tsunami" &
recode "eqhaz" ["confusion"] "hysteria" &
recode "eqhaz" ["collape","collapsing"] "collapse"  &
recode "eqhaz" ["sewage"] "sanitation"  &
recode "eqhaz" ["debri"] "debris"  &
recode "eqhaz" ["essentials"] "essential"  &
recode "eqhaz" ["fault"] "faulting" &
recode "eqhaz" ["gas"] "gas leak"  &
recode "whatwarn" ["people","panic"] "human"  &
recode "whatwarn" ["newspaper"] "other"  &
recode "whatwarn" ["tsunami"] "sea" &
recode "whatwarn" ["news"] "media" &
recode "whatwarn" ["siren/news","tws","siren"] "alarm" &
recode "whatwarn" ["govt","cd"] "?"  &
recode "feeleq" ["very strong eq lasts for more than a few seconds","cd","stronglong"]
"strong,long" &
recode "feeleq" ["landslide"] "earth"  &
recode "feeleq" ["any earthquake that last longer than 10seconds"] "long" &
recode "feeleq" ["building falling/ far out earthquake in the crook strait"] "building,offshore"
&
recode "feeleq" ["not sure how it would be different than another quake","all"] "?" &
recode "feeleq" ["offshore eq","off shore"] "offshore" &
recode "feeleq" ["4.0 or 5.0 richter scale"] "richter" &
recode "feeleq" ["terrifying"] "other" &
recode "feeleq" ["no"] "cannot determine" &
recode "feeleq" ["unsure"] "?" &
recode "feeleq" ["immeasruable","immeasurbale"] "immeasurable" &
recode "minprior" ["fill up the fridge for 3 days of food"] "food" &
recode "minprior" ["warning others on way","check","do what you can to help from
safety","assisy","people you're with are safe","help elderly neighbors"] "assist" &
recode "minprior" ["supermarket","warm stuff","grab essential supplies","grab pack","grab
stuff","supplies","emergency bags","get gas","pack bags","clothes"] "essential" &
recode "minprior" ["passports"] "documents" &
```

```
recode "minprior" ["quick prayer","pick up coffee","grab a few things","and bits and
pieces","no","local"] "other" &
recode "minprior" ["photos","videos of family"] "valuable" &
recode "minprior" ["just go home","run","shelter","home"] "nothing" &
recode "minprior" ["radio"] "tuned" &
recode "minprior" ["grab children","family"] "gather" &
recode "minprior" ["phone family","txt everybody","call family"] "phone" &
recode "minprior" ["close windows"] "secure" &
recode "minprior" ["?"] "unsure" &
recode "minprior" ["pets"] "pet" &
recode "standprior" ["inform","check"] "assist" &
recode "standprior" ["pets"] "pet" &
recode "standprior" ["essentials","basic essentials","grab stuff at home - clothes"] "essential"
&
recode "standprior" ["carry children","family"] "gather" &
recode "standprior" ["call family"] "phone" &
recode "standprior" ["no","local"] "nothing" &
recode "1hrprior" ["fone","call family","text"] "phone" &
recode "1hrprior" ["essentials"] "essential" &
recode "1hrprior" ["check"] "assist" &
recode "1hrprior" ["no"] "nothing" &
recode "9hrprior" ["turn off utilities"] "secure" &
recode "9hrprior" ["check"] "assist" &
recode "9hrprior" ["call family"] "phone" &
recode "9hrprior" ["essentials"] "essential" &
recode "minevacwhere" ["school (o'haro bay school)"] "evac point" &
recodes ["minevacwhere","standevacwhere"] ["if tsunami go to kawhehi/ if not go to work"] "stay"
&
recodes ["minevacwhere","standevacwhere"] ["go home then up valley"] "inland" &
recodes ["minevacwhere","standevacwhere"] ["home (maragaki motor cross)"] "home" &
recodes ["minevacwhere","standevacwhere"] ["northwest hills (away from buildings)"] "hill,open" &
recodes ["minevacwhere","standevacwhere"] ["uphill","up hill"] "high ground" &
recode "standevacwhere" ["towards (karwhehi)"] "inland" &
recode "standevacwhere" ["hospital"] "evac point" &
recode "standevacwhere" ["palmerston north area"] "leave" &
recode "standevacwhere" ["blue line"] "blue" &
recode "standevacwhere" ["(home) maragaki motor cross"] "home" &
recode "standevacwhere" ["offshore"] "other" &
recode "standevacwhere" ["phone"] "stay" &
recode "1hrevac" ["mt. maumga","hill behind house (west)","brooklyn hill"] "hill" &
recode "1hrevac" ["mt. cook","mt.cook"] "mt cook" &
recode "1hrevac" ["up valley"] "inland" &
recode "1hrevac" ["open"] "?" &
recode "1hrevac" ["mt.victoria/ go inland","mt. victoria"] "mt victoria" &
recode "1hrevac" ["home high ground"] "home,high ground" &
recode "1hrevac" ["home (wainui o' marta)","home (tirohanga)","home (maragaki motor cross)","home
(hutt valley)"] "home" &
recode "1hrevac" ["kelburn university"] "leave,evac point" &
recode "1hrevac" ["hutt valley","kelburn","up to brooklyn"] "leave" &
recode "1hrevac" ["go uphill","go to higher ground","uphill","the nearest high building that
would allow me in or go home to tawa"] "high ground"  &
recode "1hrevac" ["evacpoint"] "evac point" &
recode "9hrevac" ["mt.victoria"] "mt victoria" &
recode "9hrevac" ["uphil","uphill","higher ground"] "high ground" &
recode "9hrevac" ["karori","kaori","fly"] "leave" &
recode "9hrevac" ["go to berkley rd","further inland"] "inland" &
recode "9hrevac" ["above blue line"] "blue" &
recode "9hrevac" ["home (naenae)","home (maragaki motor cross)","home (hutt valley)"] "home" &
recode "9hrevac" ["home (mt.cook)"] "home,mt cook" &
recode "9hrevac" ["home high ground"] "home,high ground" &
recode "9hrevac" ["botannical garden"] "hill" &
recode "9hrevac" ["central north island"] "leave,inland" &
recode "9hrevac" ["evact point"] "evac point" &
recodes ["9hrtravel","1hrtravel","mintravel","standtravel"] ["bicycle","bicyle"] "bike" &
recodes ["9hrtravel","1hrtravel","mintravel","standtravel"] ["run","walk"] "foot" &
recode "1hrtravel" ["motorbike"] "car" &
recode "standtravel" ["bike/foot"] "bike,foot" &
recodes ["standtravel","mintravel","1hrtravel","9hrtravel"] ["unsure"] "?" &
recode "standtravel" ["food"] "foot" &
recode "wheneq" ["anytime","at any time"] "?" &
```

```
recode "wheneq" ["within lifetime"] "lifetime" &
recode "wheneq" ["not lifetime ","not at all"] "not lifetime" &
recode "wheneq" ["10 years"] "10" &
recodeAge &
globalRecode [("unsure","?"),("mt.victoria","mt victoria")] &
map (>>= (\(R q r) -> if q/="suburb" then [R q r] else [R q r,R "isblue" (show $ isBlueLine r)]))
&
map (>>= (\(R q r) -> if q/="whathaz" then [R q r] else [R q r,R "tsuhaz" (show $ "tsunami"
`elem` split r)])) &
map (>>= (\(R q r) -> if q/="eqhaz" then [R q r] else [R q r,R "tsueq" (show $ "tsunami" `elem`
split r)]))

return b

mapResp q f = map (\(R q' r) -> if q==q' then R q' (f r) else R q' r)
recodeAge = map (mapResp "birth" $ codeAge) where
codeAge = codeAge' (f ages) where
codeAge' fs c = if all isDigit c && not (null c) then (show $ length $ takeWhile not $ map
($2013-(read c :: Int)) fs) else ""
ages = 0:16:[20,25..85]
f [i] = [(>i)]
f (i:j:is) = (\q -> q >= i && q < j) : f (j:is)

globalRecode codes x = map (map ff) x where
ff r = case lookup (response r) codes of;Nothing -> r;Just r' -> r {response = r'}
split = map strip . splitOn ","
where strip = let f = dropWhile (==' ') in reverse.f.reverse.f
unsplit = foldr (\xs b -> xs ++ (if null b then b else ',':b)) []
splitMap f = unsplit . map f . split
recode q fs f x = map (map rFun) x
where rFun (R q' r) = if q'==q then R q' (splitMap (\r' -> if r' `elem` fs then f else r') r)
else R q' r
recodes qs fs f x = foldr (.) id (map (\q -> recode q fs f) qs) x

whathaz = nub $ sfield "whathaz" mainn >>= split
feeleq = nub $ sfield "feeleq" mainn >>= split
eqhaz = nub $ sfield "eqhaz" mainn >>= split
whatwarn = nub $ sfield "whatwarn" mainn >>= split
standprior = nub $ sfield "standprior" mainn >>= split
standtravel = nub $ sfield "standtravel" mainn >>= split
minprior = nub $ sfield "minprior" mainn >>= split
mintravel = nub $ sfield "mintravel" mainn >>= split
hrprior = nub $ sfield "1hrprior" mainn >>= split
hrtravel = nub $ sfield "1hrtravel" mainn >>= split
hr9prior = nub $ sfield "9hrprior" mainn >>= split
hr9travel = nub $ sfield "9hrtravel" mainn >>= split
standevac = nub $ sfield "standevacwhere" mainn >>= split
minevac = nub $ sfield "minevacwhere" mainn >>= split
hrevac = nub $ sfield "1hrevac" mainn >>= split
hr9evac = nub $ sfield "9hrevac" mainn >>= split
standevacExpand (R q r) = if q=="standevacwhere" then [R ("standevacwhere_"++a) $ show $ any
(==a) $ split r | a <- standevac] else [R q r]
minevacExpand (R q r) = if q=="minevacwhere" then [R ("minevacwhere_"++a) $ show $ any (==a) $
split r | a <- minevac] else [R q r]
hrevacExpand (R q r) = if q=="1hrevac" then [R ("1hrevac_"++a) $ show $ any (==a) $ split r | a
<- hrevac] else [R q r]
hr9evacExpand (R q r) = if q=="9hrevac" then [R ("9hrevac_"++a) $ show $ any (==a) $ split r | a
<- hr9evac] else [R q r]
standtravelExpand (R q r) = if q=="standtravel" then [R ("standtravel_"++a) $ show $ any (==a) $
split r | a <- standtravel] else [R q r]
mintravelExpand (R q r) = if q=="mintravel" then [R ("mintravel_"++a) $ show $ any (==a) $ split
r | a <- mintravel] else [R q r]
hrtravelExpand (R q r) = if q=="1hrtravel" then [R ("1hrtravel_"++a) $ show $ any (==a) $ split r
| a <- hrtravel] else [R q r]
hr9travelExpand (R q r) = if q=="9hrtravel" then [R ("9hrtravel_"++a) $ show $ any (==a) $ split
r | a <- hr9travel] else [R q r]
whatHazExpand (R q r) = if q=="whathaz" then [R ("whathaz_"++a) $ show $ any (==a) $ split r | a
<- whathaz] else [R q r]
eqhazExpand (R q r) = if q=="eqhaz" then [R ("eqhaz_"++a) $ show $ any (==a) $ split r | a <-
eqhaz] else [R q r]
```

```
standpriorExpand (R q r) = if q=="standprior" then [R ("standprior_"++a) $ show $ any (==a) $
split r | a <- standprior] else [R q r]
minpriorExpand (R q r) = if q=="minprior" then [R ("minprior_"++a) $ show $ any (==a) $ split r |
a <- minprior] else [R q r]
hrpriorExpand (R q r) = if q=="1hrprior" then [R ("1hrprior_"++a) $ show $ any (==a) $ split r |
a <- hrprior] else [R q r]
hr9priorExpand (R q r) = if q=="9hrprior" then [R ("9hrprior_"++a) $ show $ any (==a) $ split r |
a <- hr9prior] else [R q r]
feelExpand (R q r) = if q=="feeleq" then [R ("feeleq_"++a) $ show $ any (==a) $ split r | a <-
feeleq] else [R q r]
whatWarnExpand (R q r) = if q=="whatwarn" then [R ("whatwarn_"++a) $ show $ any (==a) $ split r |
a <- whatwarn] else [R q r]
mainn = unsafePerformIO mainnn
replace (R q' r) rs = map (\(R x y) -> if x==q' then R q' r else R x y) rs
warnExpand a = a' ++ foldr replace defwho whowarn ++ foldr replace deflong howlong where
warnings = concat [split r | R q r <- a,q=="whatwarn"]
whowarn = [R ("whowarn_"++w) r | w <- warnings | r <- split $ head [rr | R qq rr <-
a,qq=="whowarn"]]
howlong = [R ("howlong_"++w) r | w <- warnings | r <- split $ head [rr | R qq rr <-
a,qq=="howlong"]]
defwho = [R ("whowarn_"++q) "_" | q <- whatwarn]
deflong = [R ("howlong_"++q) "_" | q <- whatwarn]
a' = filter (\(R q r) -> q `notElem` ["whatwarn","whowarn","howlong"]) (a >>= whatWarnExpand)
ggg = head mainn
fff = map (\x -> sort $ warnExpand x >>= feelExpand >>= whatHazExpand >>= hrpriorExpand >>=
hr9priorExpand >>= standpriorExpand >>= minpriorExpand >>= standtravelExpand >>= mintravelExpand
>>= hrtravelExpand >>= hr9travelExpand >>= eqhazExpand >>= standevacExpand >>= minevacExpand >>=
hrevacExpand >>= hr9evacExpand) mainn
ffff = map (\x -> sort $ warnExpand x >>= feelExpand >>= whatHazExpand >>= hrpriorExpand >>=
hr9priorExpand >>= standpriorExpand >>= minpriorExpand >>= standtravelExpand >>= mintravelExpand
>>= hrtravelExpand >>= hr9travelExpand >>= eqhazExpand >>= standevacExpand >>= minevacExpand >>=
hrevacExpand >>= hr9evacExpand) fixed
unResponse xs = r1:rs where
r1 = map question $ head xs
rs = map (map response) xs
unCSV xs = unlines cs where
cs = map (unsplit . map (\x -> "\""++x++"\"")) $ unResponse xs
writeCSV f xs = writeFile f (unCSV xs)
mainf = writeCSV "derp.csv" fff
mainf2 = writeCSV "derp2.csv" mainn

table f x y = array ((0,0),(b1,b2)) [((i,j),f (x!i) (y!j)) | i <- [0..b1], j <- [0..b2]]
where ((_,b1),(_,b2)) = (bounds x,bounds y)
l2a x = listArray (0,length x -1) x
a2l x = map snd $ assocs x
indexOf xs x = indexOf' 0 x xs where
indexOf' n x [] = -1
indexOf' n x (y:xs) = if x==y then n else indexOf' (n+1) x xs
indicies xs = map (indexOf xs) xs -- inverse is: (lbls!!)
lbls = map question (head fixed)
vals = map (flip sfield fixed) lbls
mapTo xs x = case lookupWith setEq x xs of;Just v -> v;Nothing -> error (show x ++ show xs)
setEq = ((==) `on` (S.fromList . split))
lookupWith _ _ [] = Nothing
lookupWith f x ((y,v):xs) = if f x y then Just v else lookupWith f x xs
mapFrom xs x = mapTo [(y,x) | (x,y) <- xs] x
mapping q = [(i,x) | x <- sort $ nubBy setEq q | i <- [0..]]
valmap = map mapping vals :: [[(Int,String)]]
codedvals = zipWith (\a b -> map (mapFrom a) b) valmap vals
avg xs = fromIntegral (sum xs) / genericLength xs
covar x y = avg $ zipWith (*) x y
correl x y = covar x y / (sqrt $ covar x x * covar y y)
correlMat x = let ix = [0..length x -1] in [[(lbls!!i,lbls!!j,correl (x!!i) (x!!j)) | i <- ix] |
j <- ix]
main = mapM_ print $ reverse $ nubBy (\(a,b,c) (x,y,z) -> symEq (a,b) (x,y)) $ sortBy (compare
`on` (\(a,b,c) -> abs c)) $ filter ((\(a,b,c) -> a/=b && (not $ isNaN c))) $ concat $ correlMat
codedvals
--writeCorrels f = main >>= (writeFile f . unlines . map show)
symEq (x,y) (a,b) = (x,y)==(a,b)||(y,x)==(a,b)
aZipWith f x y = accum f x $ filter (inRange (bounds x) . fst) $ assocs y
```

```
--NOTE TO SELF. CREATE CAUSALITY GRAPH

isHarbor x = elem x ["cbd","petone"]
isBlueLine x = elem x ["owhiro","island"]

spitData l xs = (print $ "###"++l++"###") >> pretty' xs where
pretty' xs = putStrLn (unwords $ map snd xs) >> putStrLn (unwords $ map (show. fst) xs)
scluster l xs = spitData l $ fcluster l xs
--sclusterSplit l ps xs =
mmm m = mapM_ (\(x,f) -> spitData x (f x m))
[("wheneq",fcluster),
("birth",fcluster),
("eqhaz",fclusterSplit),
("whathaz",fclusterSplit),
("feeleq",fclusterSplit),
("standprior",fclusterSplit),
("minprior",fclusterSplit),
("standtravel",fclusterSplit),
("mintravel",fclusterSplit),
("1hrtravel",fclusterSplit),
("9hrtravel",fclusterSplit),
("standevacwhere",fclusterSplit),
("1hrevac",fclusterSplit),
("9hrevac",fclusterSplit),
("income",fcluster),
("tsuhaz",fcluster),
("tsueq",fcluster),
("standevac",(\a b -> fclusterSplit a (selectAll [("suburb",isBlueLine)] b))),
("standevac",(\a b -> fclusterSplit a (selectAll [("suburb",not . isBlueLine)] b))),
("whatwarn",fclusterSplit)]
fixed = selectAll [] mainn

clusterAlarmTime = sortBy (compare `on` (\(a,b) -> if all isDigit b then read b else 0)) $
fcluster "howlong_alarm" ffff


incomegraph q x = mapM_ (\i -> putStrLn "" >> (fclusterM_ q $ selectAll [("income",(==show i))]
x)) [1..15]
agegraph q x = mapM_ (\i -> putStrLn "" >> (fclusterM_ q $ selectAll [("birth",(==show i))] x))
[1..15]
```

Appendix D: Coding guide

The coding guide was based off of interview version 2, which can be seen in appendix A

1. **What two natural disasters do you believe are most likely to affect your current location?**
   EQ
   tsunami
   tidal wave
   fire
   storm (rain, cyclone, hurricane, typhoon, wind…)
   tornado
   landslide
   flood (Regardless of source)
   volcano
   disease
   other (asteroid, solar flare, alien attack, ocean level rising, drought…)

2. **What life-threatening hazards and dangers do you associate with an earthquake?**
   tsunami
   tidal wave
   debris (glass, metal, electrocution (Fallen power lines…): This category refers to any harmful interaction with debris or smaller items, includes falling objects)
   fire
   collapse (building collapse, buildings damage, structure collapse, squashed, crushed…): This category refers to hazards caused by collapse or damaged buildings
   sanitation (sewage issues, disease…: this category refers to hazards caused by damage to waste management/treatment)
   food (food issues): This category refers to shortages or issues with food
   water
   roadway (road/highway/automobile issues): This category refers to damages to roads or vehicles that are causing the participant harm
   Faulting (cracks/holes/openings in ground): This category refers to any changes in the earth that could cause physical harm)
   explosion
   gas leak
   Flood
   landslide
   essential (loss of electricity, gas, heat, essential items, general isolation): This category refers to loss or inability to gain access essentials
   hysteria (panic, trampling…): This category refers to any harm caused to people by people responding in harmful/ inappropriate ways.
   other (communication loss, water displacement, things moving…): This category refers to non-life-threatening inconveniences or occurrences from an EQ as well as unclear or inappropriate responses)

3. What would warn you of an incoming tsunami?

a. EQ (tremors, ground shaking/rumbling)
alarm (sirens, horns, bells, warning systems…)
sea (tide receding, horizon changes, water changes, strange ocean noises): This category refers to any warning discovered by observing the sea
animal (abnormal animal behavior, animal warnings): This category refers to any warning discovered by observing animals/pets/etc.
human (people warning others, people screaming, people panicking, people running): This category refers to warnings delivered by local word of mouth
phone (txts, alert txts, calls, alert calls): This category refers to any warning received on a mobile or home phone
internet (Facebook, twitter, news websites): This category refers to any warning discovered on the internet
media (unspecified mass communication, unspecified news stations)
radio TV (any station: news, weather, etc.)
weather (Stormy weather)
other (this category refers to any warning that is inappropriate, unclear, or unique)

b. CD ("civil Defence" or "Public Defence")
GNS
WREMO
council (city council)
govt: This category refers to government affiliated organization (except CD, GNS, WREMO, and city council), state institutions, and scientists in related fields
PTWC (Pacific tsunami warning center)
public: This category refers to unorganized responders issuing independent warnings
subscription (geonet, twitter, etc): This refers to any non-governmental organization that issues a warning based on subscription
geonet (non-subscription viewings)
fire (fire brigade)
police
news: This category refers to organizations who job is it to transmit news. can be TV, radio, internet…
station (radio stations, TV stations)
social media (twitter, facebook, google+)
other (this category refers to anything that is inappropriate, unclear, or especially unique)

c. immediately

not long (not long, not very long, short amount of time, “pretty quick”, “very soon”): This category refers to any expression given for a short amount of time that we cannot interpret

depends: This category refers to a response that states that the time depends on characteristics of EQ’s or tsunami, or a response that depends on the arrival of an EQ/tsunami

1-5 [minutes] (also includes any variation of “a few minutes” or “a couple of minutes” or “minutes”)

5 10 [minutes]

10-30 [minutes]

30 [minutes] – 1 [hour]

1 [hour]-3 [hours] (also includes any variation of “a few hours” or “a couple of hours” or “hours” or “several hours”)

3 [hours] - 9 [hours]

more than 9 [hours]

inform (wait to be told what to do, or depends on what news says)

INSTRUCTION ON CODING TIMES

[for ranges of time that span more than 1 hour, use the minimum. Otherwise, take the average of the range]

[if depends and we forced the range, then use lowest range]

[For phrases such as “several hours” “several minutes” “minutes” “hours”, use top of range]

[if depends, but only given a higher range, just put “depends”]

4. Describe properties of an earthquake that you believe could cause a tsunami severe enough to need to evacuate.

strong (big movements, large, intense…)

long: This category refers to responses that imply length but do not specify an exact time, 30 seconds, a few minutes, 2 minutes)

richter (any response referencing a measurement of the Richter scale or magnitude)

unsure (any response that is unsure or “don’t know” or “any size” or “hard to tell”)

immeasurable (any response reported that is immeasurable to the respondent other than plate movement)

Offshore (Out at sea. Also can imply that they can’t feel the EQ)

directional (specific directional shaking)

loud

plate (any response referring to tectonic plates)

stand (a response that implies that it is difficult to stand in)

minute (a response that specifically mentions lasting more than 1 minute)

object (a response that is based on objects moving or falling, does not include the earth)

building (a response that refers to structure collapse, or structure movement)

earth (a response based on observing changes in the earth: rolling)

other (this category refers to anything that is inappropriate, unclear, or especially unique)

cannot determine (All sizes of EQ’s can cause tsunami)

5. If you were to evacuate, where would you evacuate to?

stay (wouldn't evacuate)
open: (any evacuation towards "open" areas including: streets, parks, fields)
waterfront (any evacuation towards water)
high ground (any evacuation to guessed higher ground)
hill (any evacuation to named hill such as botanic garden)
mt victoria
mt cook
inland (any evacuation away from water or north into island)
home (any evacuation home, but it is on low ground or the elevation of their home is unclear)
building (any evacuation attempt to seek refuge in a building)
evac point (schools, civil defence centers)
objects (any attempt to evacuate in or under a table, chair, doorway, car or other objects.)
unsure (no indication of evacuation site, but ensures evacuation)
follow (will evacuate where told to)
leave (any evacuation out of current suburb to another named area)
blue (above blue line)

5b. **What would you do before evacuating?**

nothing
phone (any call or text made to friends, family, neighbors, or colleagues)
valuable (retrieving items of value including important papers, cash, credit cards, electronics, "stuff", personal belongings…)
essential (retrieving essential items including clothing, medication, first aid, things…)
kit (emergency kit)
food
water
assist (attempt to warn people, gather people, help people, or check on people around interviewer)
secure (attempt to turn off utilities or secure home or business)
gather (attempt to meet, or retrieve family, friends, neighbors, or colleagues)
check - would fall under assist (checking on distant people without knowing by what means)
pet (attempt to recover pets)
tuned (wait for more information regarding disaster or evacuation)
follow (following others or ask people for advice)
investigate (investigate further into possible threats, through internet and such means)
unsure
wait (would wait to proceed)
other (assessing situation, get down on the ground, buy train tickets for family)

5bi. **How long would it take?**

no time (immediately)
1 [second] – 1 [minute]
1 – 5 [minutes] (also pertains to "a few minutes" and "a couple of minutes")

5 – 10 [minutes]
10 – 30 [minutes]
30 [minutes] – 1 [hour]
1 [hour] – 3 [hours]
3 [hours] – 9 [hours]
more than 9 [hours]
quickly as possible (also pertains to "as long as needed")
not long (also pertains to "minutes" "very little time")
while (responses involving "a while" or "a long time", "Decent amount of time")
depends
unsure
other

INSTRUCTIONS FOR CODING TIME
[Take the maximum amount of time if range is given. This way, we know up to the most time it would take to evacuate]

5c. **How would you travel?**
foot
bicycle
car
public (including buses and trains)
taxis
fly (airplanes)
unsure (also includes responses that state it "depends" on certain aspects of the situation)

9a. **Have you received tsunami info?**
yes
no

9b. **What did you learn?**
evacuation (proper zones, routes, and behavior)
preparation (emergency kits and proper supplies)
natural (how to identify tsunami through natural warnings)
official (what official warnings exist)
drop (earthquake drop, cover, hold)
shakeout (participated in shakeout program)
vague: Refers to a response that is too unclear to categorize
tsunami
fire (fire drill training)
EQ (earthquake training)

9c. **Where did you learn it?**
mail (pamphlets in mail)

news (learned about information from news sources including newspaper, radio, or television)
work (conducted drills at workplace)
CD (received info from civil defence or partook in a civil defence meeting, talk, or drill)
school (conducted drills in a school)
govt (received info from government related ads or sources)
evacuation (took part in an actual tsunami evacuation; experience)
online (learned from online sources)
Te Papa (Any MUSEUM)
Exp (experience)
community (interaction with community: word of mouth, etc.)

10a. **Do you know what the blue line is?**
no
yes
guess (Guessed correctly)

10b. **Where did you learn about it?**
mail
wom (word of mouth)
newspaper
session (informational session at work, school, etc.)
internet
media (television or radio broadcasts, “on the news”)
saw (Saw the line itself and figured it out)
GNS
unsure
sign
other

11. **When do you expect the next tsunami to strike?**
1 (1 year)
10 (10 years)
Lifetime (anytime)
not lifetime
unsure

12. **Where would a tsunami originate from?**
Pacific (ocean)(southeast Asian region)
cook strait (south of wellington)
nz south island
ring of fire
nz coastal area
tasman (Sea)

fault (New Zealand)
south pole
subduction zone
south america
north America
wellington (wellington land)
alaska
harbor (wellington harbor)
japan
plate (plate boundary)
trench
volcano (undersea volcano)
Petone Fault
Basin
indonesia
mariana trench
Unsure (south of wellington)

demographic

Profession?
managers and administrators
professionals
associate professionals
technicians and trades workers
community & personal service workers
clerical and administrative workers
sales workers
machinery operators and drivers
laborers and related workers

How severely would a tsunami affect your livelihood?
severely
not severely
good (I would benefit from a tsunami)

Age?
15 – 19 years
20 – 24 years
25 – 29 years
30 – 34 years
35 – 39 years

40 – 44 years
45 – 49 years
50 – 54 years
55 – 59 years
60 – 64 years
65 – 69 years
70 – 74 years
75 – 79 years
80 – 84 years
85 years +

Gender?
male
female

Education?
1. school
2. trade
3. qualification
4. undergraduate
5. postgraduate

Are you a resident or visitor?
resident
visitor

How long have you lived here?
0 – 1 years
1 – 2 years
2 – 3 years
3 – 4 years
4 – 5 years
5 – 10 years
10+ years

Where are you visiting from?
will be analyzed separately

How often do you visit?
1.more often
2.monthly
3.Annually
4.less often
5.First visit

Where do you live?
will be analyzed separately or…
inland - low-lying area (in a tsunami threating area/ below the blue line)
coastal area (above the blue line/ safe zone)
coastal area (in a low-lying area)
(use zone evacuation map)

Household income?
1. <20,000
2. 20,001-30,000
3. 30,001-50,000
4. 50,001-70,000
5. 70,001-100,000
6. 100,000+

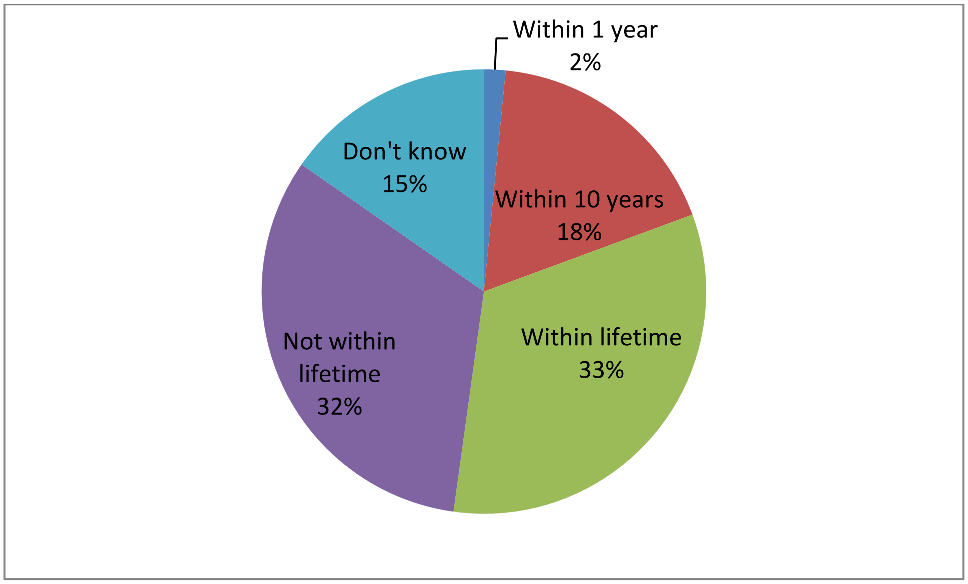
When listing two items for a single item in a list that is order specific, group those two items in parentheses and separate each item in the parentheses by a comma, no spaces.
GNS or CD = (GNS,CD)

Appendix E: Strongly correlated response themes

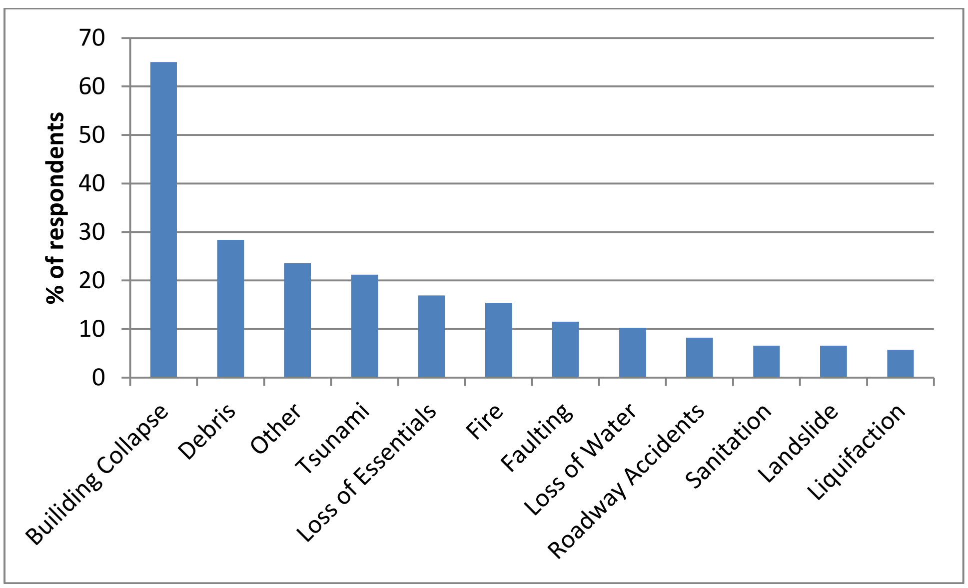
This table shows a selection of statistically significant correlations between themes in our data side-by-side

Evacuation behavior for >1min EQ	Evacuation behavior for EQ too strong to stand
Travel method for 1hr tsunami warning	Travel method for earthquake evacuation
Has tsunami training	Evacuation location
Has tsunami training	Knows of the blue-line
Has tsunami training	Evacuation transportation method
How soon a tsunami is expected	Evacuation behavior for earthquakes
Travel method for 1hr tsunami warning	Travel method for 9hr tsunami warning
Income	Evacuation behavior
Knowledge of the blue-line	How soon a tsunami is expected
Age	Evacuation behavior
Kowledge of the blue-line	How severely a tsunami would affect
Evacuation location	Evacuation transportation method
Income	How soon a tsunami is expected
Has tsunami training	What hazards are most expected
Has tsunami training	How soon after a warning a tsunami is expected
What hazards are most expected	How soon a tsunami is expected
Age	Has tsunami training

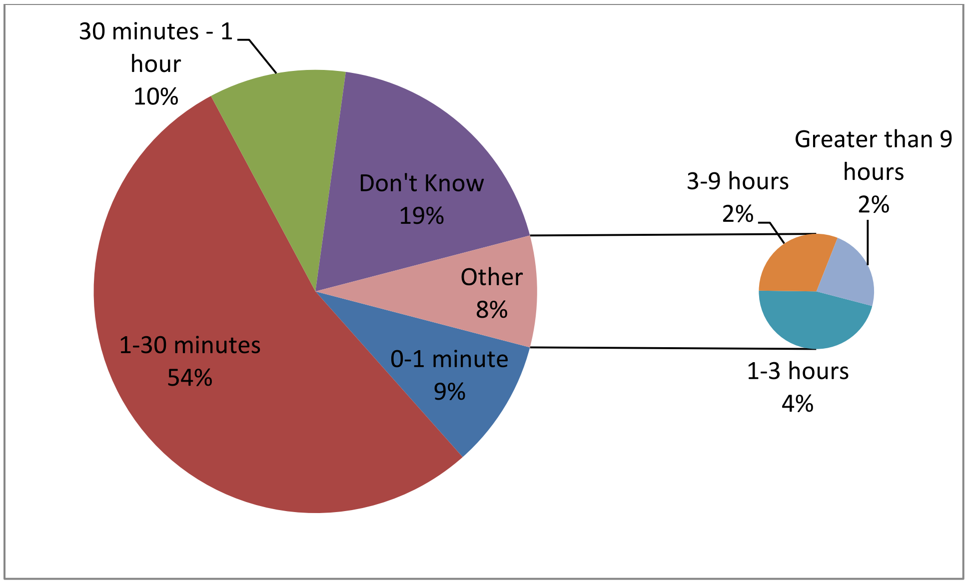
Appendix F: Additional figures



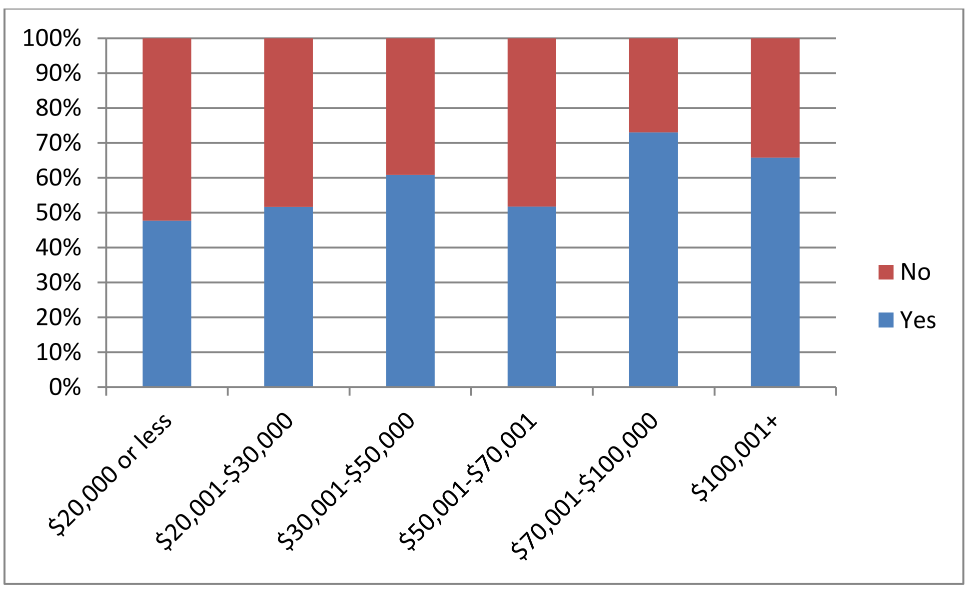
"When would you expect the next damaging tsunami to affect the GWR?"



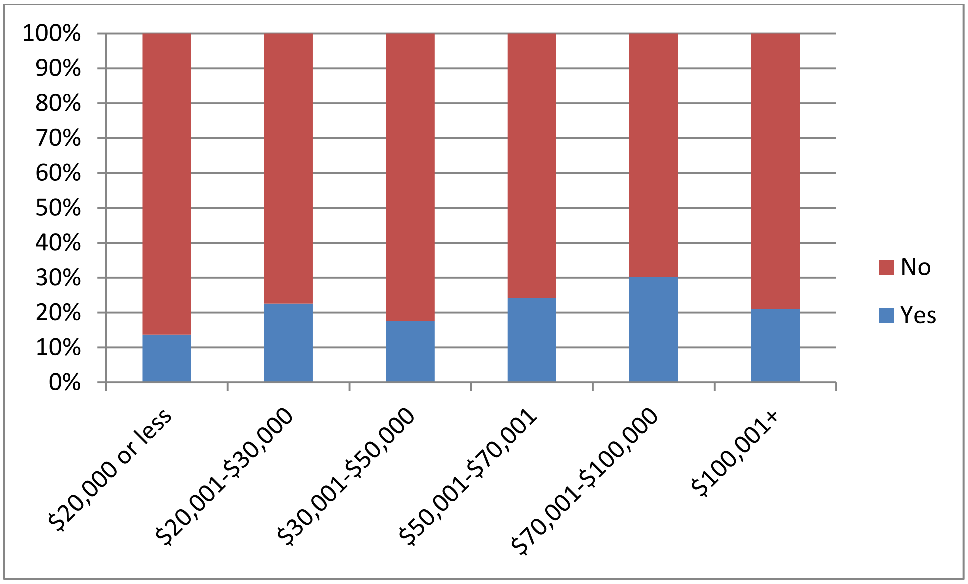
Hazards associated with earthquakes



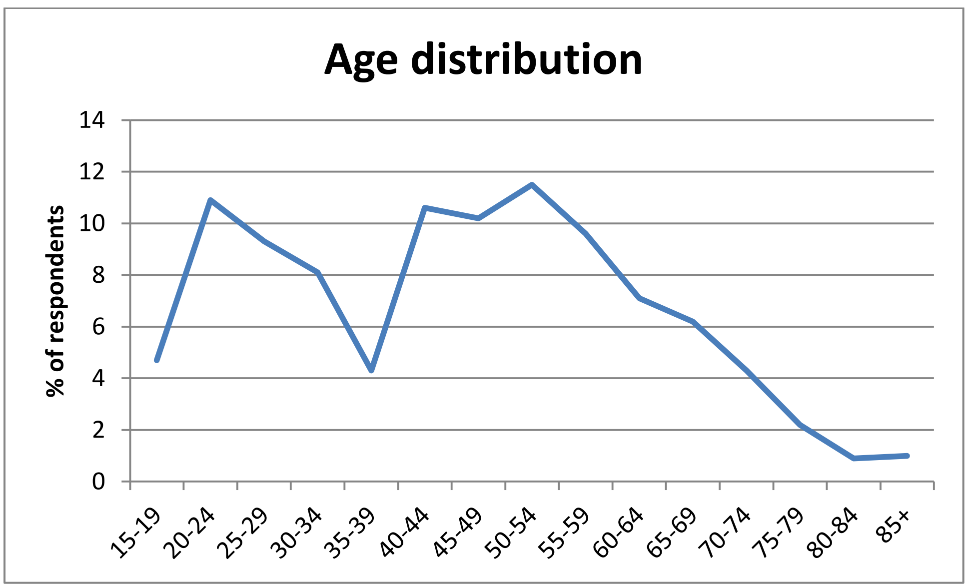
Expected tsunami time after alarm



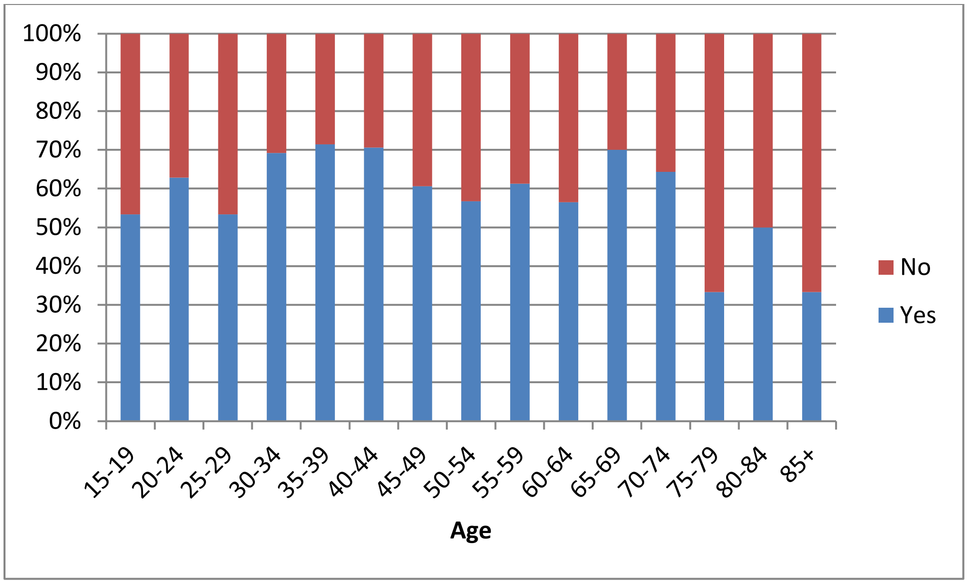
Have general concern of tsunami



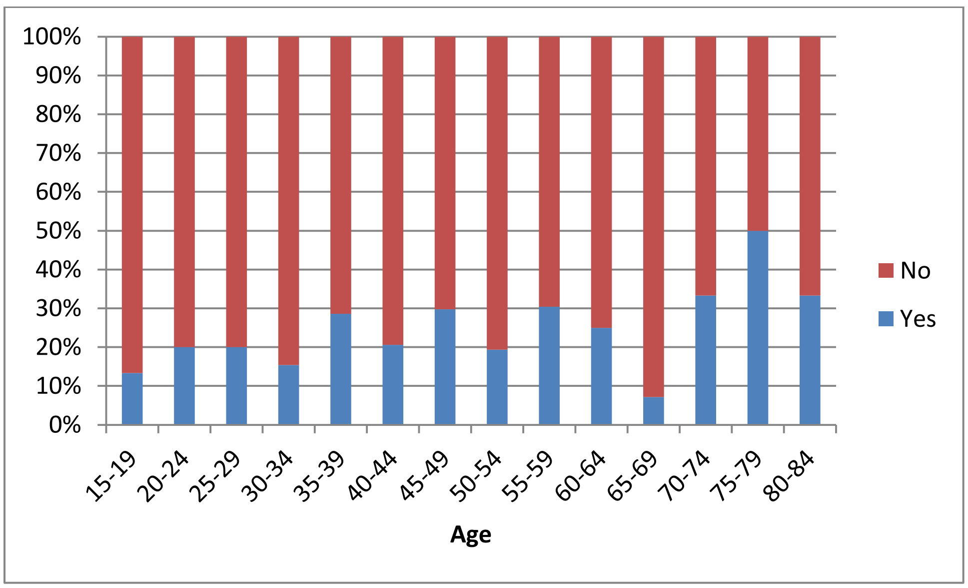
Associate tsunami with earthquake



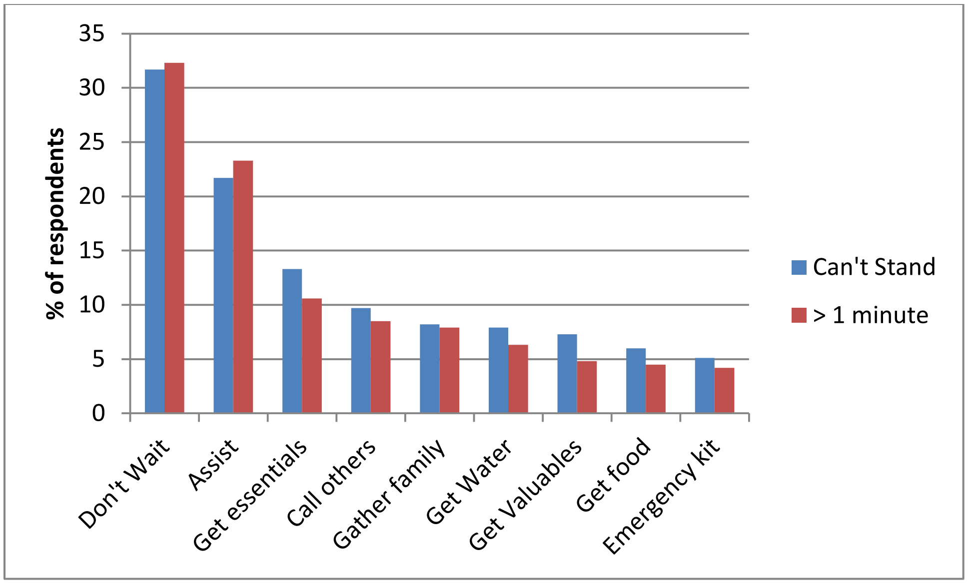
Age distribution of interview samples



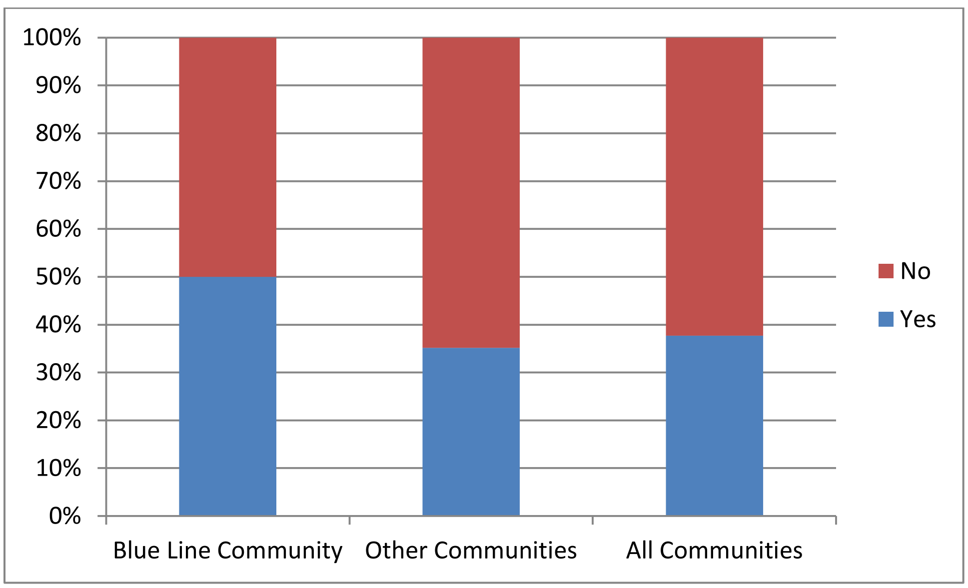
Consider tsunami a general threat, distributed by age



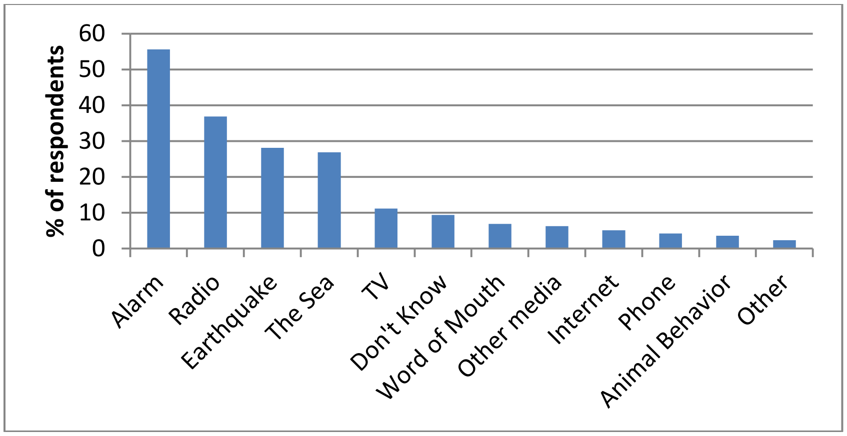
Associate tsunami with earthquakes



Pre-evacuation behavior in earthquake



Evacuation from an earthquake too strong to stand in



Expected tsunami warning sources

Signs by Lyall Bay beach depicting public hierarchy of public announcements

Appendix G: Mail-in survey

Natural Disaster Survey

Thank you for taking the time to complete this 5 minute survey
The findings from this study will be used to help local communities better prepare for future natural disasters
None of your responses will be identified with you. Demographic information is used solely for comparison with the census
If you have any questions please contact Graham Leonard or Julia Becker at GNS Science: 04 570 1444 or g.leonard@gns.cri.nz

GNS SCIENCE
TE PŪ AO

Demographic

1. **What category most closely describes your profession?**
   ☐ Manager or administrator ☐ Professional
   ☐ Associate professional ☐ Technician or trades worker
   ☐ Community & personal service worker
   ☐ Clerical and administrative worker ☐ Laborer or related
2. **In what year were you born?** 19 __
3. **What is your gender?** ☐ Male ☐ Female
4. **What is the highest level of education you have completed?**
   ☐ School ☐ Trade ☐ Qualification
   ☐ Undergraduate (e.g. Bachelor)
   ☐ Postgraduate (e.g. Masters,PhD)

4b. **How long have you lived in your current suburb?** ____________________

4c. **Where do you live?** [address or at least nearest intersection]

____

____

5. **What is your household income category?**
   ☐ Less than $20,000 ☐ $20,001-$30,000 ☐ $30,001-$50,000
   ☐ $50,001-$70,000 ☐ $70,001-$100,000 ☐ Over $100,000

Main

6. **What two natural disasters do you believe are most likely to affect your current location?**
   ☐ Earthquake ☐ Fire ☐ Flood ☐ Storm ☐ Tsunami ☐ Other
7. **Rank these hazards accociated with earthquake (1=Most Severe, 7=Least Severe)**

_____ Building collapse or falling debris

_____ Roadway accidents

_____ Liquefaction

_____ Tsunami

_____ Being cut off from essentials (Water, Food, Electricity, Isolation etc.)

_____ Gas or Power accidents (Fire, Explosion, Electricution, Chemical Spill)

_____ Other (Optional, Please Describe) ____________________________

8a. What would be your first warning of potential tsunami? (Check One)
□ Alarm sound □ Media (Radio, Television, Internet, etc)
□ Visible changes in the sea □ Earthquake □ Other

8c. How long would you expect the tsunami after that warning? (Check One)
□ One minute or less □ 2-30 minutes □ 30 minutes - 1 hour
□1-3 hours □ 3-9 hours □ More than 9 hours

9. What qualities of an earthquake do you believe could cause a tsunami severe enough to evacuate? (Check all that apply)
□ Lasts longer than a minute □ Might not feel at all
□ Strong enough to collapse buildings
□ Too strong to stand during □ Other (Please Describe)

____

Here we present three scenarios and ask your responses for each one
After an earthquake that you fear could cause a tsunami...

10a. Where would you evacuate to from here? [nearest intersection/city]

____

10b. What would you do before evacuating? (Check all that apply)

□ Nothing

□ Assist others in evacuation

□ Get life essentials (Food, Water, Medicine, etc.)

□ Valuables (Jewlery, Money, etc.)

□ Call family or friends

□ Gather family

□ Seek further information (From radio, TV, other people, etc)

□ Other (Please Describe) ______________________________

10b i. About how long would all of this take?
□ One minute or less □ 1-10 minutes □10-30 minutes
□ 30 minutes - 1 hour □ 1-3 hours □ Longer than 3 hours

10c. How would you travel to your intended destination?
□ Car □ Foot □ Public transport □ Flight
□ Bicycle or similar (Skateboard, etc.)

If there were an official warning of a tsuanami in 1 hour...

11a. Where would you evacuate to from here? [nearest intersection/city]

____

11b. What would you do before evacuating? (Check all that apply)

□ Nothing

□ Assist others in evacuation

□ Get life essentials (Food, Water, Medicine, etc.)

□ Valuables (Jewlery, Money, etc.)

□ Call family or friends

□ Gather family

□ Seek further information (From radio, TV, other people, etc)

□ Other (Please Describe) ______________________________

11b i. About how long would all of this take?
□ One minute or less □ 1-10 minutes □10-30 minutes
□ 30 minutes - 1 hour □ 1-3 hours □ Longer than 3 hours

11c. How would you travel to your intended destination?
□ Car □ Foot □ Public transport □ Flight
□ Bicycle or similar (Skateboard, etc.)

If there were an official warning of a tsuanami in 9 hour...

12a. Where would you evacuate to from here? [nearest intersection/city]

____

12b. What would you do before evacuating? (Check all that apply)

- □ Nothing
- □ Assist others in evacuation
- □ Get life essentials (Food, Water, Medicine, etc.)
- □ Valuables (Jewlery, Money, etc.) ____________
- □ Call family or friends ____________
- □ Gather family ____________
- □ Seek further information (From radio, TV, other people, etc)
- □ Other (Please Describe) ______________________________

12b i. About how long would all of this take?
□ One minute or less □ 1-10 minutes □10-30 minutes
□ 30 minutes - 1 hour □ 1-3 hours □ Longer than 3 hours

12c. How would you travel to your intended destination?
□ Car □ Foot □ Public transport □ Flight
□ Bicycle or similar (Skateboard, etc.)

13. What is your primary source of tsunami information (Check One)
□ Work □ School □ Internet □ Radio/Television
□Word of Mouth

14. How severely would you expect a tsunami to affect your livelihood?
□ Not at all □ Little □ Severely