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ABSTRACT

Washington State Emergency Management Division provides warning for a range of hazards, including tsunami and Mount Rainier eruptions and lahars via All-Hazard Alert Broadcast (AHAB) Sirens. It can be difficult to gauge the effectiveness of a warning system for infrequent but high consequence hazards. In line with best practice these systems are regularly tested for technical reliability with community involvement. Effective warning systems for infrequent events require regular (e.g. annual) exercising to evaluate how reliable and effective the system actually is and to aid in planning and education. This report reviews and develops procedures for warning system testing and evaluation, especially of the human response.

We provide general recommendations for the following: designing a warning system with the community for effective evacuation response; conducting a community-led evaluation; conducting a community-lead evacuation exercise; 'keeping it simple'; evaluation criteria for observers and participants; community-based post exercise work-up.

Draft procedures and templates were tested in two exercises. The draft observer template was trialled in a state-wide tsunami siren test on September 15th 2010, and a draft community survey was also trialled following that test. The draft participant template was then trialled on September 17th 2010 during a tsunami evacuation exercise at Shoalwater Bay Community. From trialling those draft templates, aspects of some questions and methods were improved and a final set of templates is provided.

KEYWORDS

Exercise, evacuation, evaluation, drill, test, tsunami, volcanic eruption, lahar, warning, siren, Washington State, emergency management, community planning.

1.0 OVERVIEW

Washington State Emergency Management Division provides warning for a range of hazards, including tsunami and eruptions and lahars from Mount Rainier via All-Hazard Alert Broadcast (AHAB) Sirens. It can be difficult to gauge the effectiveness of a warning system for infrequent but high consequence hazards. In line with best practice these systems are regularly tested for technical reliability with community involvement. Effective warning systems for infrequent events require regular (e.g. annual) exercising to evaluate how reliable and effective the system actually is and to aid in planning and education. This report reviews and develops procedures for warning system testing and evaluation, especially of the human response.

This project has included the following tasks:

- 1) A review of methods for collecting quantitative effectiveness data during warning system tests (Section 2.0).
- 2) Development of a draft set of guidelines for the collection and analysis of such data.
- 3) Participation in warning system exercises (Sections 3.0 and 4.0), to evaluate and improve these guidelines.
- 4) Provision of a final set of guidelines and templates (Section 2.1 to 2.6 and 5.0).



Figure 1 An AHAB siren tower in the lahar hazard zone near Orting



Figure 2 A volcano evacuation route marker near Orting

2.0 EXERCISE EVALUATION

International literature on the quantitative evaluation of any kind of exercise or drill is surprisingly sparse. The benefit of exercises is widely accepted (e.g. Sorensen 2000), and evaluation of those exercises is commonly recommended (e.g. MCDEM 2008; MCDEM 2009), however, publication of frameworks for evaluation or the results of quantitative evaluation is rare. The exercise evaluation research that has previously been published is discussed in a specific hospital evacuation context (e.g. Thomas *et al.* 2005), in relation to static warnings such as on consumer packaging (e.g. Emilia *et al.* 2007), or in a less quantitative way as part of debriefing meetings and notes (e.g. Spahn *et al.* 2010).

The goal of public warning systems is to effectively move people out of harm's way. For warning systems to be effective five groups of components must work seamlessly together (Figure 3). The goal of evaluation is (a) to quantitatively evaluate how well each component is working and feed the results back into improvements, as well as (b) provide education and participation opportunities.

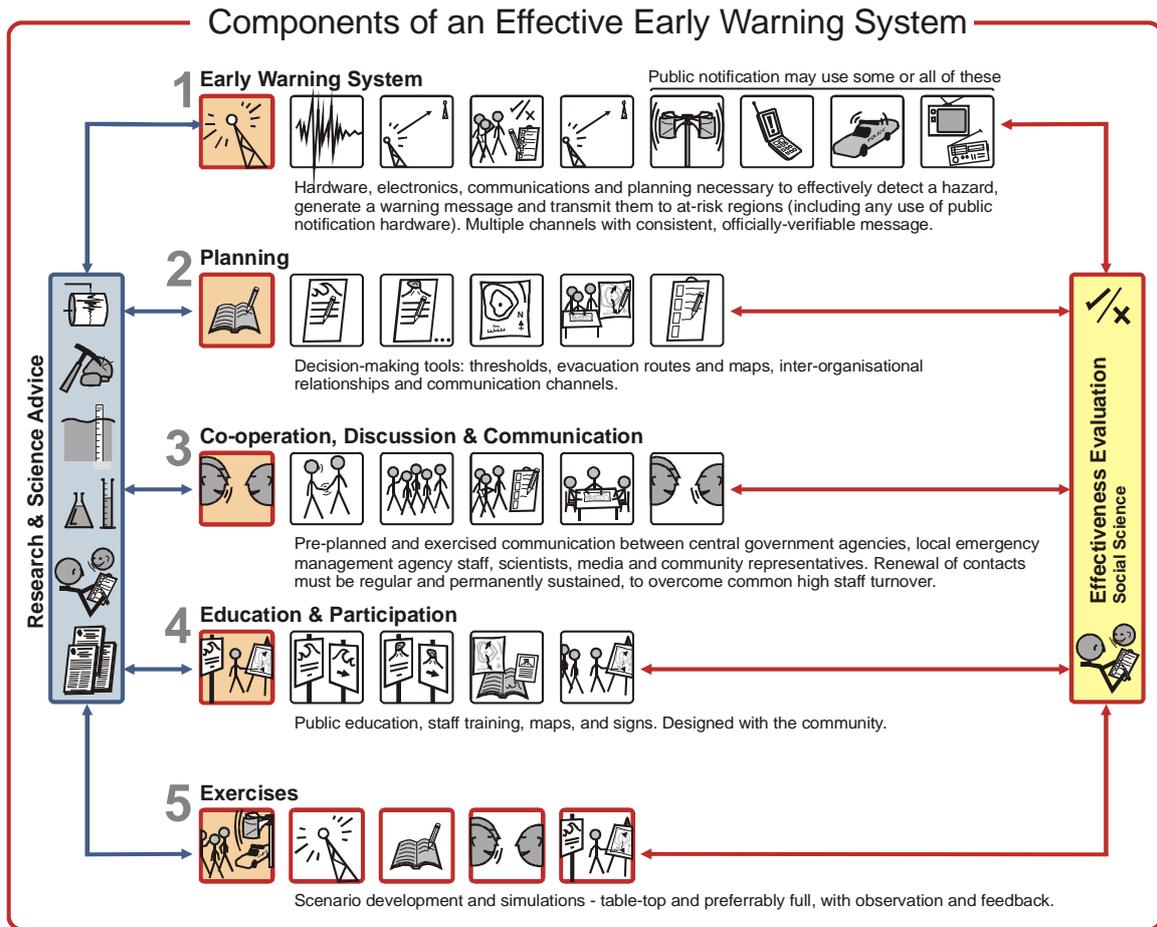


Figure 3 Observed components of more effective warning systems as presented by Leonard et al. (2008).

The evaluation framework summarised here has been developed by the research team in four contexts (eruption lahar exercises, New Zealand; tsunami exercise, Indonesia; tsunami exercises, New Zealand; tsunami exercises conducted as part of this project in Washington State) and with input from the above literature.

Templates developed for Washington State are given in Section 5.0.



Figure 4 Evacuees gather on a purpose built tsunami evacuation structure during an exercise in 2008 in Banda Aceh, Indonesia. Lessons from the evaluation of that 2008 exercise are one of the sources for the recommendations given in this report.

2.1 Designing a warning system for effective evacuation response

A warning system will be most effective if it is planned, used and evaluated in cooperation with the community that will be responding to it. The following steps provide one way of engaging a community in the warning system and response development. Further discussion of the community based planning can be found in Mitchell et al. (2010). If any steps are already in place, skip these and revise after your first exercise:

- Convene a local planning group of community representatives and agencies with a community role (ideal to use existing structures)
- Decide if the plan and warning system will cover just one, or preferably multiple locally-important hazards.
- Customise evacuation maps as a team exercise (these need to be agreed with and supported by emergency managers)
- Map out, as a team, a draft placement of all sign types (these need to be agreed with and supported by emergency managers)
- Draft a plan to cover evacuation, warning response, all-clear and welfare. Include clear roles and responsibilities.
- Check that sign locations and evacuation routes make sense on-the-ground
- Plan for wider community education and feedback
- Revise evacuation maps and sign placement map
- Obtain and place signs (with supporting education to wider community)
- Annually: Conduct exercise of evacuation plans, maps and signs
- Annually: Evaluate these exercises (method as per this report)
- Regularly: Survey awareness of the hazard, warning system, and response actions (every few years, or even annually)
- Review evacuation map and sign placement on a regular agreed schedule.

2.2 Community-based evaluation

The framework and forms in this report are designed to be able to be used by community participants, emergency managers, and social scientists alike.

Exercise evaluation internationally has typically been conducted by emergency management personnel or social scientists, and as a result of limited resources is only applied in a minority of exercises. For exercises involving the community, structured community based evaluation has the potential to lead to (a) simple quantitative evaluation of all exercises (b) improvements to existing arrangements from the results of those evaluations and (c) added ownership and understanding of the warning system and response by the community.



Figure 5 Volunteer fire personnel form part of the community warning and exercise planning group in Whananaki, New Zealand. The experience of developing community response plans in Whananaki and other New Zealand communities has fed into this report.

2.3 Planning and conducting an evacuation exercise

The following checklist provides one way a community can run and evaluate its own exercise. Completing this list should be as much the responsibility of the community group as possible:

- Set up evacuation exercise planning group of community members and nominate a leader. A representative of emergency managers should join initial meeting(s)
- Obtain agreement of local authorities, emergency management, and wider community (or a subset of) to exercise
- Map out observer locations on map of siren locations, evacuation routes, and signage
- Obtain sufficient observers and agree on observation locations. Observers can be anyone willing to and capable of following this guideline
- Set a date and time

- Ensure emergency managers give notification of the exercise to all relevant agencies such as emergency services, schools, community leaders and media
- Consider which community groups should be actively encouraged to participate – for example, schools and emergency responders (including volunteers) are excellent to have involved
- Decide on whether or not the evacuation exercise will be advertised (if it is advertised, prepare for the media a clear statement of the objective(s), and give plenty of notice)
- Choose a method of communication to be used between the leader and observers
- Organise relevant welfare facilities at the assembly points
- Decide on when the exercise will be finished and on how evacuees and all participants will be notified
- Organise triggering of warning system with emergency managers
- Arrange a meeting of observers and representative(s) of exercising participants before the evacuation drill, to clarify procedure and timetable
- Familiarise all evacuees with evaluation forms so they know what type of observations are expected
- Distribute forms and arrange for collection of forms at the end of the exercise

On the day:

- Ensure that observers are in position before the sirens are activated, and that the start time/trigger and sequence of events is clear
- Trigger siren
- Evacuate / observe actions
- Fill out forms - during evacuation (observers) and during or immediately after evacuation (participants)
- Observers meet at a designated place to return completed forms

On the day or soon after:

- Tabulate and chart results – this can be done in a spreadsheet or with a pen and paper.
- Meet to discuss results with the local planning group for the community plan from Section 2.1
- Agree improvements to arrangements and who will action each
- Set a date for the next exercise

2.4 Keep it simple and decide on scope

Make meetings as short as is needed to discuss the agenda points. The level of evaluation should be decided ahead of time in discussion between the emergency managers and the community planning group, based on both groups intended goals. **At the very least the audibility of the warning system in a range of places, the time taken to reach safety, and any issues with the warning, route or plan should be analysed in each exercise.** Aim to give this task to someone who finds such a job interesting. If no-one is happy to draw up a table of the results, looking through the observer and participant forms at the meeting is better than nothing. **It's important to make the community effort sustainable from year to year**, so planning and evaluation should be as fun, short and simple as possible and aim to make the exercise day fun for all.

2.5 Evaluation criteria

This section presents the basic evaluation criteria that should be considered for forms used during evaluations. These are applied in the templates in Section 5.0 and have been derived from examples in New Zealand, in Indonesia and from the trials conducted in Washington State in 2010.

2.5.1 General survey content for observers and participants

- Audibility of the warning system (using a scale such as 1-5 and/or descriptors such as quiet, loud, muffled, clear, etc.), for both:
 1. Message
 2. Tone
- Start time, stop time of notification
- Start time, stop time of evacuation (stop time against specific completion criteria)
- Actions of public
- Action of official
- Weather conditions (temperature range; sunny, partly cloudy; cloudy; rain, drizzle, dry, etc.)
- Location(s) of warning system (e.g. siren tower location, or NOAA weather radio, etc.)
- Materials carried by evacuees
- Comments

2.5.2 Survey content for people observing an evacuation exercise

- Document numbers of exercise participants observed in the area visible to the observer, groupings of those people (i.e. are they moving in groups or individually)?
- Location(s) observed from/at – be specific so this can be mapped
- Proportions of people conducting specific actions, when (specific time during the drill)

2.5.3 Survey content for exercise participants (evacuees)

- Start Location – be specific so this can be mapped
- Time taken to get to a specific place (use start and finish time if you like)
- What that destination was – be specific so this can be mapped
- Items taken (e.g. clothes, pets)
- Comments on ability to use route, and in various conditions (weather, light, etc.)
- Comments on ability to use destination
- Time from initiation of alarm to departure evacuating
- Suggested welfare needs at the destination
- Number of evacuees travelling together

2.6 Post-exercise analysis and debrief

Forms should be collected in one place at the conclusion of the exercise and checked to make sure the name of the observer/participant and any other specifics such as date or location are complete on the form. Data then needs to be tabulated, most easily in a spreadsheet (such as Microsoft Excel). The title of the questions should be across the top as column headings (referred to as 'variables') and the unique codes from each form should be down the left side as row identifiers (each form equals one row and in social science is referred to as one 'case').

In the simplest analysis the results can then be discussed from a simple summary table at a debriefing meeting, including consideration of needs for improvement. The range of audibility scores and times taken to complete exercise tasks are commonly important variables to be reviewed.

Beyond skimming over the table, simple statistics can be generated such as means and ranges for audibility or time taken and the number of people observed taking specific actions, etc. Any variables that are located in space can be plotted on a map (see Appendix 3, for example – mean audibility values colour coded by 'zone' on a map of expected siren coverage).

Sections 2 and 3 give examples of the type of information that can come from a post-exercise analysis of survey forms. Work out which aspects you are most interested in and make sure you check those every time – e.g. warning audibility, what people did, how fast they did it, and what could be improved.

3.0 WASHINGTON STATE SIREN TEST EXERCISE

A state-wide test of the tsunami siren system was conducted on 15 September, 2010. The research team used this event to trial observer and participant questionnaires. The test was advertised in print and on broadcast media, and on road-side billboards in the days leading up to the test. Four observers were positioned in Ocean Shores, Ocean City and Pacific Beach during the test, and they completed observer forms (App 1 Figure 16). Over the following six hours they conducted a post-test public questionnaire (App 1 Figure 17) in the following Grays Harbor locations: Aberdeen, Greyland, Ocean City, Ocean Shores, Pacific Beach and Westport (Table 1). The results are summarised here.

Table 1 Number of questionnaire responses in study locations

Location	Number of responses
Aberdeen	39
Greyland	2
Ocean City	6
Ocean Shores	41
Pacific Beach	18
Westport	22
Total	128

Section 3.1 presents the results from the four observers. Section 3.2 onwards presents the results of the public questionnaire survey. A few charts showing results of the study are included in the sections, but most charts depicting results are contained in Appendix 1, but are discussed in the following sections. The public questionnaire survey was conducted by the four observers in each town, by asking the questions of members of the public, or by letting them fill it out themselves. Participants were selected by going door to door, and asking any pedestrians encountered between doors regardless of who they were (i.e. saturation sampling, of a specific area of several city blocks for communities larger than several city blocks – Aberdeen, Ocean Shores, Pacific Beach and Westport).

3.1 Test observations

- The test was conducted at approximately 10:18am and lasted for about 1 minute.
- The range of possible scores for audibility was between 0 (inaudible) to 5 (loud and clear)
- Two observers were located in Ocean Shores. Outside of McDonalds at the corner of “Point Brown Ave NE” and “West Chance A La Mer NW” the siren and message were both loud and clear (score 5 and 5, Figure 20(c)) with about 8 people present in the wider area. There was no public response. On the sandy road that provides access west of the beach from “West Chance A La Mer NW” the siren and message were also both loud and clear (score 5 and 5), with ten people present on the beach and two more walking back to their cars. There was no public response.

- In Ocean City at the corner of Pacific Blvd and 2nd Ave the siren and message were both moderate to loud and clear (score 4 and 4, Figure 20(b)). One person was present at the test start, a total of five different people were present throughout the test, and two remained present at the end. One person came out of a building to hear the siren better.
- In Pacific Beach at the corner of Main St and 2nd St S the siren and message were both loud and clear (score 5 and 5; Figure 20(a)), but the message was ‘somewhat muffled’. There was no public response observed (‘no heads turned’), with three people present at the both the start of the test and at the end of the test. A few cars drove through Main St during the test.



Figure 6 Tsunami siren test roadside information ahead to the September 15th exercise

3.2 Results of the Public Survey: Where were you when the siren sounded?

- Respondents interpreted this question in a variety of ways, especially as a type of place, a specific named place or conducting a specific activity. Thirty two percent gave a specific address or place that could be located on a map (Figure 18).
- Nine people specifically stated ‘inside’, but many others inferred this, so inside/outside wasn’t charted because of ambiguity.
- The most common response was at work or in a store / business premises, which is not surprising given the time of day on a weekday.
- The common pair of responses (20 responses, Figure 18b) was giving an address that could be mapped and stating that they were at work / store / business premises.



Figure 7 An AHAB siren tower in coastal Washington, tested during the exercise.

3.3 Results of the Public Survey: Audibility

- Substantially more people could not hear the siren or message in Aberdeen than in other locations, followed by Ocean Shores (Figure 19). However, this may be explained by more people in Aberdeen having been inside a building at the time of the test.
- Audibility of the message was not much lower than that of the siren, other than in Westport (Figure 18a vs 19b).
- It is important to stress that BOTH the siren and message should be separately answered, even if the number given is the same.
- Audibility when mapped out for those responses that could be geo-coded via an address or place-name (Figure 20) was good in Pacific Beach and Ocean City, and in northern 'downtown' Ocean Shores. However farther south down the Ocean Shores spit, and in outlying suburbs of Aberdeen some people reported low or no siren/message audibility. Audibility in Westport was also mixed.

3.4 Results of the Public Survey: What did you do when you heard the warning? Why?

- Most respondents reported that they knew what to do when they heard the warning (Figure 8).

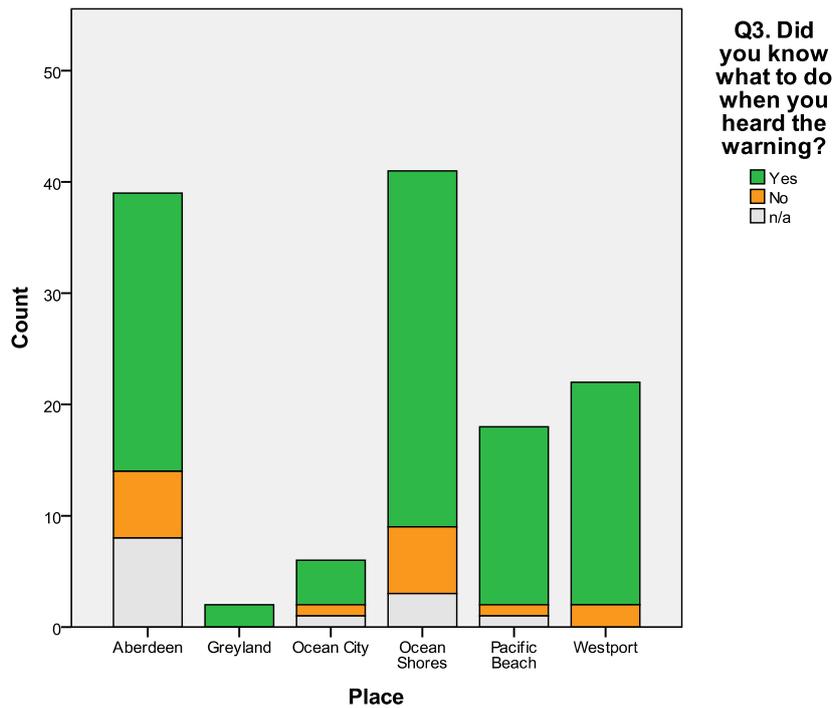


Figure 8 Results from the question “Did you know what to do when you heard the warning?”

- Most respondents either: listened to the test, did nothing and/or knew it was a test (Figure 21). Three respondents specifically stated they did nothing and said they knew it was a test (Figure 21b). A range of other actions were reported, each by 4 or less people. Two people reported that they either got to high ground and/or evacuated.
- The most common response to the follow up question ‘Why?’ was because they knew it was a test/drill (Figure 21c). However, more people simply did not say why, and many other responses overlapped in meaning with the ‘what did you do?’ question.



Figure 9 A tsunami evacuation route marker in coastal Washington

3.5 Results of the Public Survey: What did you think the warning meant?

- The most common responses were test / practice, followed by tsunami, with six respondents mentioning both categories (Figure 22). The purpose and nature of the exercise appears to have been well known.

3.6 Results of the Public Survey: Did you know about the test? How had you heard / read about it?

- A large majority of people (73%) reported having heard about the test ahead of time (Figure 10).
- The most commonly reported source was [roadside] signs, followed by radio, road and/or newspaper. Fifteen people mentioned both signs and roads (Figure 23).
- Eight respondents simply stated 'yes' indicating they had misread the question as 'had you heard / read about it?'.

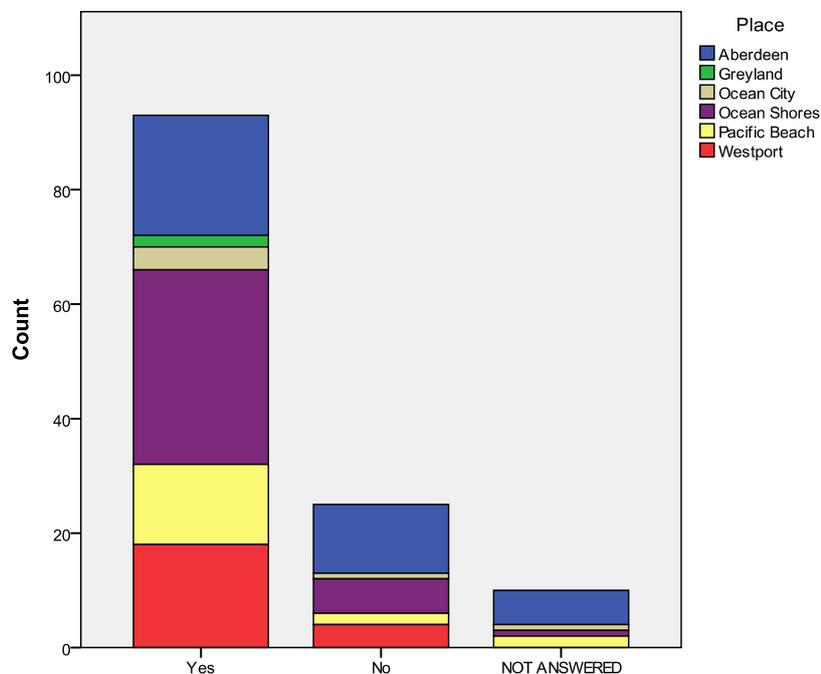


Figure 10 Response to "Did you know about this warning system test ahead of time?"

3.7 Results of the Public Survey: Describe natural hazard information you have seen for this community; where did you see it?

- "Tsunami followed by earthquake" were the most common topics mentioned, and six people mentioned both tsunami and earthquake (Figure 24).
- Some topic/content answers are in the form of 'where did you see it?' and signs followed by flyers / pamphlets / handouts were the most common. Ten people specifically wrote 'none' or 'unknown'.
- When asked "where did you see it?" nearly half (63) did not answer (Figure 25). Of those who did answer, "roads and signs" were most common (often mentioned together as road signs), followed by a few mentioning a specific geographic place (town name, 'lived by beach' etc.) or hotel/motel and store/library. One motel response stated: "Disaster response guide book for hotels and motels on Washington Coast"

3.8 Results of the Public Survey: What extra information would you need to help you know where to go in a warning?

The following individual responses were given:

- A warning pattern
- At campground - an evacuation route map
- By TV
- Could have been louder if people were asleep might not have heard
- Current strategy seems sufficient
- Expected time to arrival of "the wave"
- Flyer
- Get a radio
- Have posted next to both doors in my house
- How do I get out of town with dog triffil [sic]
- How to run faster
- Know the routes out of area
- Know what to do
- Where warning sirens are located
- Mail - pamphlet
- Make sure all are aware I was not aware
- More paper info in post office boxes
- More volume on instruction message
- None I knew where to go and have a map
- None it was informative
- Not sure (hazard radio did not go off)
- Preparation for food/supplies and transportation to a safe location
- Route to take
- The siren going off
- Turn on radio for instructions/hazard radio did not go off
- TV, TV, TV
- Verbal plan of what to do from the message
- Was pamphlet in tsunami warning in 60's
- Well informed
- What direction to go!
- What radio station to tune into
- When wave is expected
- Where in O/S would you go
- Where to get a helicopter
- Where to go
- Where to go
- Where to go - what food to buy
- Where to go and how soon
- Where to go to be safe
- Which direction to go and car pool

3.9 Results of the Public Survey: Demographics

The vast majority of people surveyed were local to the Grays Harbor area (Figure 31), with some moving from one Grays Harbor town to another over the course of that day (Figure 26, coloured by place surveyed). Sixty percent reported that they were a resident. Sixty one

percent of those who identified as residents stated that they had been resident for more than 10 years (Figure 27). The duration of the time that visitors stayed was relatively short, from 1 to 11+ days (Figure 28). A significant proportion of respondents were retired and almost all spoke English as a first language (Figure 32). The gender of respondents was relatively evenly split male/female (Figure 29) and the ages reported are skewed towards older people (aged 50 years or older) (Figure 30), consistent with a high percentage of persons reporting that they were 'retired' when asked about their occupation.

3.10 Summary of results by place

Overall

- There was high awareness of the test (large majority) with the roadside signs as the most common source, along with local paper and radio.
- The warning was heard by several on radio and seen on TV by a few.
- High awareness of tsunami hazard, from drills primarily, then flyers, then 'common knowledge', several simply equated the coast with tsunami 'of course'.
- High correlation of drills to awareness highlights the effectiveness of these as education
- Several people reported that they needed to know where to go.

Pacific Beach

- Very loud with the message understandable but a little crackly and muffled.
- High awareness of the test.

Ocean City

- Moderate to loud, most aware of the test.

Ocean Shores

- In the downtown area loud and clear, including on the beach, moderate audibility in some buildings, others loud. Patchy and low audibility in some places further south.
- A couple didn't hear it (e.g. Makah Ave, ½ way down peninsula)
- Some couldn't hear or understand the message.

Aberdeen

- High traffic in and out.
- Generally moderate to high audibility siren, low to moderate for message – many couldn't understand it due to volume/clarity. Some couldn't hear, including downtown but especially in outlying suburbs.
- Some itinerant population, some with English as second language, and a few didn't know about the tsunami risk.
- Most people inside their shops didn't hear it.
- One person didn't hear in Hoquiam, one low to moderate audibility in Cosmopolis

Westport

- Moderate to high audibility for both siren and message throughout town.
- Many fisherman don't hear the drills because they are out during the day
- Many tourists came in for the afternoon, some weren't aware of tsunami hazard. Most didn't notice road-side signs.

3.11 Evaluation of questionnaire and method

- Generally respondents provided clear and expected answers to the question “What did you think the warning meant?” This suggests that this question is phrased well and is useful.
- The strong responses to “How had you heard / read about it?” could be used to create a multi-choice set.
- The audibility and location questions were generally answered well, while some action and information questions can be improved as follows.
 - Future questionnaires should always ask whether the respondent was indoors or outdoors during the test. Be specific if you want to map the place name (address or nearest intersection) and make this a separate question. Ask the name of the town in yet another separate question.
- In response to “What did you do?” two questions were actually answered – What were you doing?, and What did you do in response? One or both of these should be asked specifically and separately.
- “What were you doing?” and “why?” could be asked as one question, or strong responses could be used to create a multi-choice set.
- The hazard information topic and source questions resulted in a particularly low rate of response and should be removed. If a specific hazard information source or topic is of interest questions could be designed for this.
- It is important to stress that BOTH the siren and message should be separately answered, even if the number given is the same.

4.0 SHOALWATER BAY EVACUATION EXERCISE

On the 17th September 2010 the Shoalwater Bay Indian community conducted a planned and publicised tsunami evacuation exercise in conjunction with Washington State Emergency Management Division and attended by a representative of the NOAA 'Tsunami Ready Communities' initiative. The exercise was used as an opportunity to evaluate indicator questions related to evacuation. The warning systems for evacuation was not tested.



Figure 11 Evacuation exercise participants at Shoalwater Bay.



Figure 12 Assembly area signage near the welfare trailer.



Figure 13 Welfare trailer and the first evacuation exercise participants to reach the assembly area.

4.1 Participant form results

Twenty five participants completed evaluation forms (Figure 33) and the results are given here. It was an open-ended self-completion questionnaire administered at a debriefing meeting, with lunch (i.e. an incentive to participate) provided, within an hour of the exercise.

- Evacuees reported departing from the Medical Centre, Tribal Centre, WBE Building and Court Building. One person reported leaving from the Casino parking lot.
- Respondents were asked to ignore the siren start and stop times and audibility questions, because the siren system was not activated.
- Travel times ranged from 5 to 35 minutes. The most common reported travel time was 20 minutes. Departure times ranged from 10:30am to 10:50am
- Destination was referred to as Eagle Hill mostly, and also 'trailer uphill' and 'water tower'.
- Most respondents simply reported that 'yes' the terrain was easy (four reported "No"), with the following other comments: "Hill a bit steep, trail good"; "flat with a moderate hill"; "Fairly"; "No, steep, muddy"; "Not bad but not easy"; "Flat – uphill"; "I ran up the hills. It was hard but, very [easily] done at a walking pace"
- The weather was reported variably as sprinkling / light rain / rain by 11 people, overcast /cloudy by 9 people, misty / fog by 2 people, and mild / fine / good by 4 people.
- Raincoats / jackets / sweater were the most commonly reported item carried by respondents while evacuating (7 people), with the full list of responses as follows (individual responses are separated by semicolons): Blackberry phones; Cell; CERT team members ID's; Coat, umbrella; Coats; I [had] cellphone, coat, ID, something to drink, I also has a bunch of grapes I snacked on, on way back; Jackets; NOAA radio, raincoat; Not asked to bring anything; Nothing; Nothing/drill; Paper pad, pen, water; Rain coats – umbrellas; Selves only?; Sweaters, hats; Themselves; Vest - Emergency van – gator; Water; Water, raincoat.
- Jeans, sweatshirts and coats / jackets (7 people each) were the most commonly reported specific clothing worn. This is notable because of the poor warmth properties of cotton once wet.

- Only three of the people reporting coats / jackets were the same people wearing jeans and/or sweatshirts.
- Four respondents reported that the map was either easy, very [easy], or “OK, small scale” to read. Twelve did not answer this question and 5 indicated that they had not seen a map of which 3 indicated they knew the route so a map was not necessary.
- Thirteen people reported that the signs were easy / OK / good. Three indicated they did not see signs.
- Sixteen respondents reported that they would be able to use the route in all weather conditions. Three further people reported “yes hope so” / probably / “I would think I would”. The following single responses were also given: Hard to say; Maybe, everything but snow ice; Most; No - too muddy and could slip; Road could have a slide but except for watching for falling trees if we were having a gale; Yes, just with flashlight.
- Thirteen people reported they would be able to use the route in the dark, a further 5 said yes if they had a light / flashlight, and two more simply required “sufficient lighting” / “some ambient light”. Four reported no as follows: No (2 people); No - too muddy and could slip; Would be very hard.
- When asked “What would you like to have at your safe location if staying there?” 8 people reported shelter of some kind; 12 reported water; 7 reported food; 5 reported chairs / somewhere to sit; 5 referred to supplies / emergency management equipment in general (3 stating these were already in place); 4 reported blankets / heating; two suggested communications / radio; two suggested beds or bunkhouse; and one each stated “map/sign with more info on emergency shelter and provisions”, bathroom facility, and electricity.
- The following table shows how people conceptualised the groups they were travelling in, from one (i.e. themselves only) to “about 60” indicating they were part of one large group:

How many people in total were you travelling with?	Number of people giving this response
1	1
1 - 3	1
Self & periodically 2 others	1
2	1
3	4
4	1
2 close, 80 total	1
25	1
>15	1
30	2
40?	1
50 to 60 in small groups of 2 to 6	1
About 60	1
Everyone	1
Numerous different, at rate of walking speed	1
Started out with all and at end ended up by self at end of route	1
[no response to question]	5

- When asked for “Any suggestions for improving the evacuation?” 13 respondents either did not answer (10) or said no (3). The following responses were given:
 - Better way to show beginning of drill
 - Blind [likely means not aware exercise was about to happen], closer location

- Crossing the highway was tricky
 - Everyone on same page
 - Incident captain should be at the closest location to where we are going
 - Involve kids
 - Just to be prepared for anything!
 - Quads
 - Signs saying where we are going to meet at the top of hill
 - Walk in direction of traffic, water
 - We really didn't know where to go exactly. Maybe post signs?
- Overall, the careful consideration and sensible responses given to questions indicate a high level of interest and buy-in by those who responded (nearly half of the evacuees). The relatively high response rate also indicates interest in positive outcomes from the exercise.



Figure 14 Post-exercise debriefing. Participant evaluation forms were collected back here.



Figure 15 The debrief meeting concluded with a ceremony for the Shoalwater Bay Community to receive their Tsunami Ready Community certificate and signage.

4.2 Evaluation of questionnaire and method

The questionnaire worked well and the results were easy to analyse. The departure location questions could be more specific, and a range of questions could use scales instead of open-ended responses. However, as long as a small number of questionnaires are used, open-ended responses allow more detail to be brought through to improvements without taking too long to analyse. 10-20 questionnaires would be fine, as long as this is enough to spatially cover the area being warned and evacuated. **A small sample size is acceptable for the most important variables of audibility, speed and route/plan effectiveness and can be observed by one or two people at each location. Rather than sampling many people, the goal is to cover a range of locations and evacuation routes. In contrast, perception question answers have been shown to vary much more in the population, so the more people who answer these questions the better.** The questions asking about time should be more clearly worded to use specific numeric units.

5.0 RECOMMENDATIONS AND FORM TEMPLATES

A primary goal of this work was to develop procedures and templates for evaluation of exercises. General recommendations for procedures for developing effective warning systems with the community, and evaluation of them are given in Sections 2.1 to 2.6. Draft templates were tested (Sections 3.0 and 4.0) and revised, and the updated templates for observer and participant evaluation of exercises, for locating observers, and for surveying the public after a test, are given below. After a suitable period of application the recommendations of this report and its templates should be updated.

The key templates developed are as follows:

Warning Drill Evaluation Form: PARTICIPANT				Date:	
Name:			Age:		Gender: M / F
Siren Audibility (Circle one)			Message Audibility (Circle one)		
0 not audible	1 barely	2 moderate	3	4	5 loud & clear
NOTES (variability, clarity, wind etc.):			NOTES (variability, clarity, wind etc.):		
Where did you evacuate from exactly? give street address					
Siren start time		am/pm		Siren stop time	
				am/pm	
Exact time of departure evacuating			am/pm		
Time you reached safe location			am/pm		
Which safe location did you go to? Name or description					
Was the terrain easy? Please describe					
What was the weather like? (light, wind, visibility, rain)					
Could you use the route in all weather conditions?					
What items did you and others around you take?					
Describe the clothing you and others around you wore					
How easy was the evacuation map to read?					
How easy were the signs to follow?					
Would you be able to use this route in the dark?					
What would you want at your safe location if staying there?					
Any suggestions for improving the evacuation:					
How many people in total were you travelling with?					

Warning Drill Evaluation Form: OBSERVER		Date:
OBSERVER'S Name:		Age:
Location NAME:		Gender:
Weather conditions (light, wind, visibility, rain):		
Siren Audibility (Circle one)		Message Audibility (Circle one)
<p>0 1 2 3 4 5 not barely moderate loud audible & clear</p> <p>NOTES (variability, clarity, wind etc.):</p>		<p>0 1 2 3 4 5 not barely moderate loud audible & clear</p> <p>NOTES (variability, clarity, wind etc.):</p>
Public response		
Number of people in area at start:		
Total number of people through area:		(include any that passed through)
Total number of people at exercise end:		
<p>GIVE AS MANY DETAILS OF PUBLIC RESPONSE AS YOU CAN (i.e. people not evacuating, going wrong way, understanding of message, delays, problems, recommendations etc.): GIVE TIMES:</p>		
Officials' response		
<p>GIVE AS MANY DETAILS OF OFFICIALS' RESPONSE AS YOU CAN (note type of staff, actions, communications they made with public and each-other): GIVE TIMES:</p>		

OBSERVER LOCATOR SHEET

[PASTE or DRAW MAP here (show observer locations by name/number preferably)]

Rank	Location Name	Risk	Grid Reference	Location Detail
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Place the locations that are of more importance higher up the ranking – if you have limited observers prioritise them into the highest ranked locations

Washington State
Siren Test Survey

(please answer all questions according to your own perceptions only, there are no wrong answers)

Where were you **exactly** when the siren sounded? Please give street address and town (this lets us work out how widely the siren can be heard): _____

Q1 When the siren sounded were you: ₁ Indoors ₂ Outdoors ₃ In car

Q2 What were you doing when you heard the warning?: _____

Q3 **How well could you hear** each of the following? (please tick one per line):

Warning	0 Not at all	1 Barely	2	3 Moderate	4	5 Loud & clear
Siren	<input type="checkbox"/> ₀	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅
Message	<input type="checkbox"/> ₀	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄	<input type="checkbox"/> ₅

Q4 **Did you know what to do** when you heard the warning?: ₁ Yes ₂ No

Q5 **What actions did you take** when you heard the warning, and **why**?: _____

Q6 What did you think **the warning meant**?: _____

Q7 **In a real warning** what actions would you take?: _____

Q8 Did you **know about this warning** system test ahead of time?: ₁ Yes ₂ No

Q9 **Where** had you heard/read about it?: _____

Q10 **What extra information** would you need to help you know what to do in a real warning?

Q11 Are you a **resident of or visitor** to this community?: ₁ Resident ₂ Visitor

Q12 **Residents:** How long have you lived in this community (even with gaps)? (only **one**)

₁ First year ₂ 2-10 years ₃ 11-20 years ₄ 21+ years

Q13 **Visitors:** How many **days** do you expect to visit this community this year? (only **one**)

₁ None ₂ 1 day ₃ 2-5 days ₄ 6-10 days ₅ 11+

Q14 Where do you **normally live**: City: _____ State: _____

Q15 Are you: ₁ **Male** or ₂ **Female** In what **year** were you **born**?: _____

Occupation: _____ **First language:** _____

Please return this form to: Earthquake/Tsunami/Volcano Program Manager, Washington
Emergency Management Division,
Building 20, Camp Murray, WA 98430-5112

Thank you! **Your answers will help improve the warning system**

Note: A return address and thank-you along the lines of the above should be printed as a footer to all forms:

6.0 ACKNOWLEDGEMENTS

The authors would like to acknowledge the support and assistance of George Crawford, Dave Nelson, John Schelling, and Brynne Walker at Washington State Emergency Management Division.

7.0 REFERENCES

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00/22

OCEAN CITY ; LL ENTERED

00 01

Washington State Siren Survey

Date: _____

(Please give your own perceptions only; there are no wrong answers)

Q1 Where were you when the siren sounded?: in condo

Q2 How well could you hear each of the following (from 0-5)? (please tick one per line):

	0	1	2	3	4	5
	Not at all	Barely		Moderate		Loud & clear
Siren	<input type="checkbox"/> 0	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input checked="" type="checkbox"/> 3	<input type="checkbox"/> 4	<input type="checkbox"/> 5
Message	<input type="checkbox"/> 0	<input type="checkbox"/> 1	<input type="checkbox"/> 2	<input type="checkbox"/> 3	<input checked="" type="checkbox"/> 4	<input type="checkbox"/> 5

Q3 Did you know what to do when you heard the warning?: 1 Yes 2 No

Q4 What did you do when you heard the warning?: talked about it new it was at test.

Q5 Why? _____

Q6 What did you think the warning meant?: tsunami warning unfort the hills follow signs

Q7 Did you know about this warning system test ahead of time?: 1 Yes 2 No (go to Q9)

Q8 How had you heard/read about it?: saw the signs

Q9 Please describe natural hazard information you have seen for this community:

Topic/content?: not to get alarmed it will be at test

Where did you see it?: driving into town on reader boards + in stores well advertised

Q10 What extra information would you need to help you know what to do in a warning?
could have been louder if people were asleep. might not have heard

Q11 Are you a resident of or visitor to this community?: 1 Resident 2 Visitor

Q12 Residents: How long have you lived in this community (even with gaps)? (only one)
1 First year 2 2-10 years 3 11-20 years 4 21+ years

Q13 Visitors: How many days do you expect to visit this community this year? (only one)
1 None 2 1 day 3 2-5 days 4 6-10 days 5 11+ days 8 weeks

Q14 All: Where do you normally live: Town/City: Du pont State: WA

Are you: 1 Male or 2 Female In what year were you born?: 1947

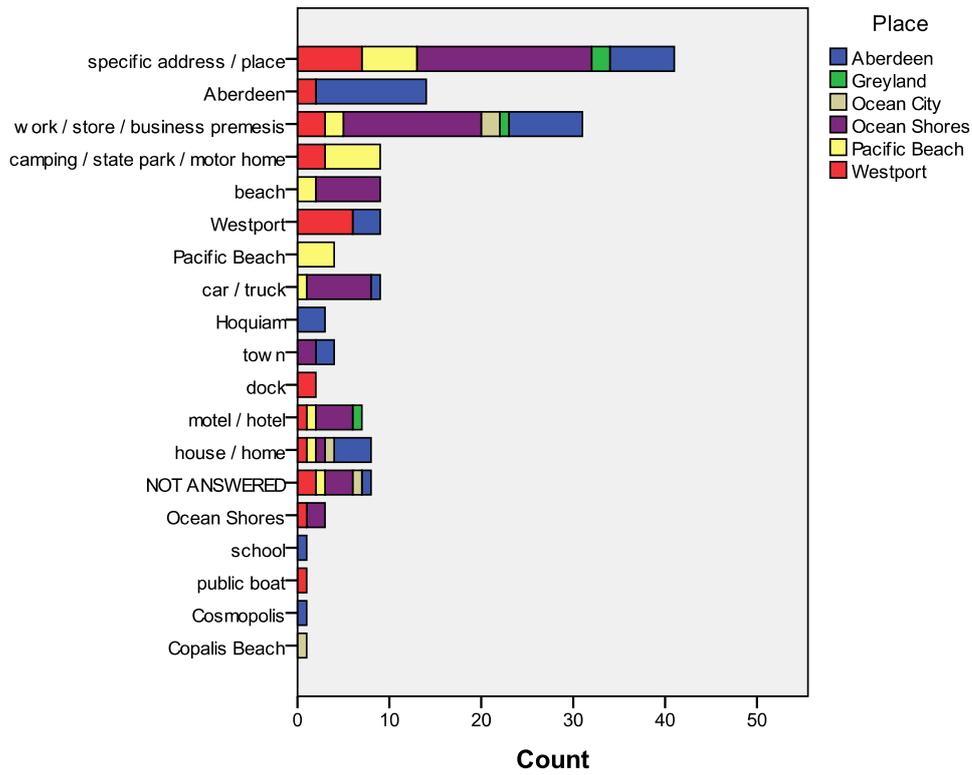
Occupation: retired (semi) First language: english

Please return this form to: Earthquake/Tsunami/Volcano Program Manager,
Phone: 253-512-7067 Washington Emergency Management Division,
Building 20, Camp Murray, WA 98430-5112

Thank you! Your answers will help improve the warning system

Figure 17 Sample participant survey. The remaining figures in this Appendix present the aggregate results of this survey.

(a)



(b)

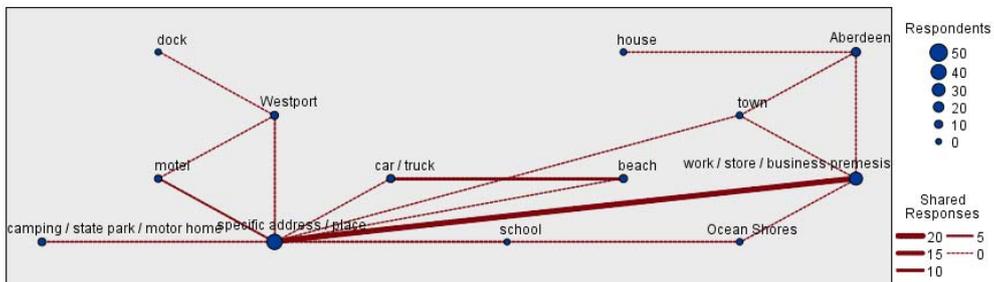
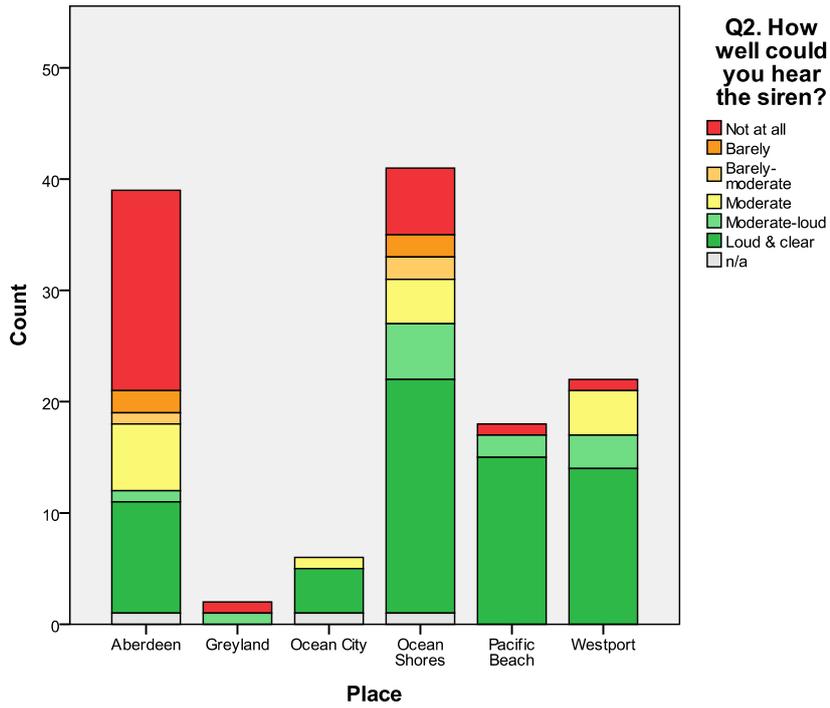


Figure 18 (a) Results from open-ended question “Where were you when the siren sounded?”. Categorized themes from trained, automated text analysis; each respondent may have mentioned one or more than one category. (b) shared response web showing the number of respondents (symbolised by line weight) who mentioned two specific categories.

(a)



(b)

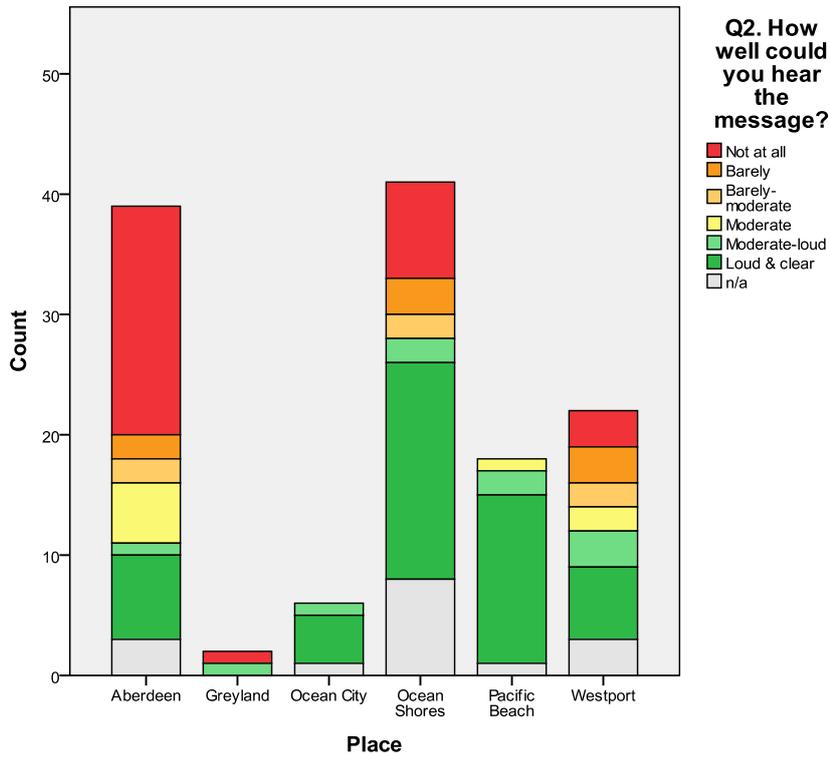
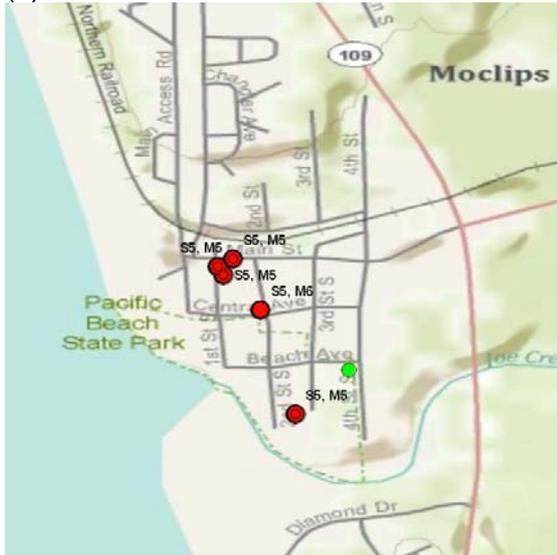
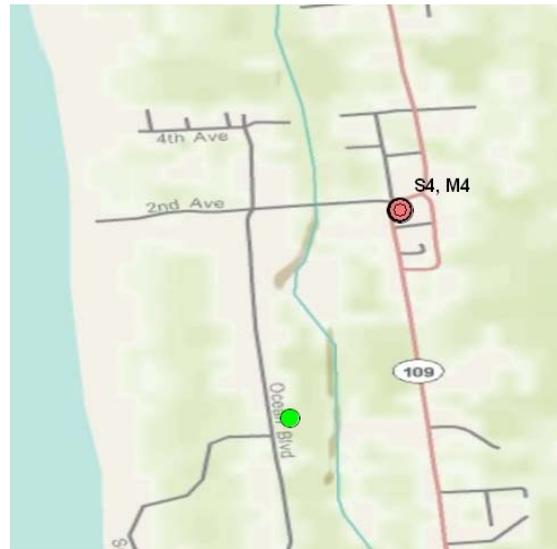


Figure 19 Results from the question “How well could you hear (a) the siren and (b) the message?”, prompted using the scale shown at right. n/a = NOT ANSWERED

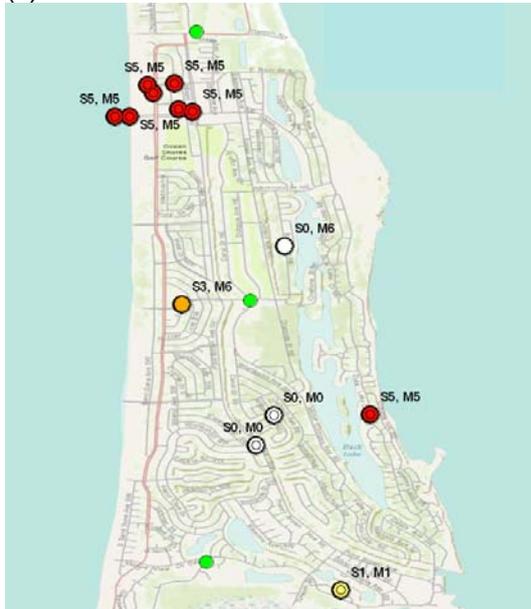
(a) – Pacific Beach



(b) – Ocean City



(c) – Ocean Shores



(d) – Aberdeen

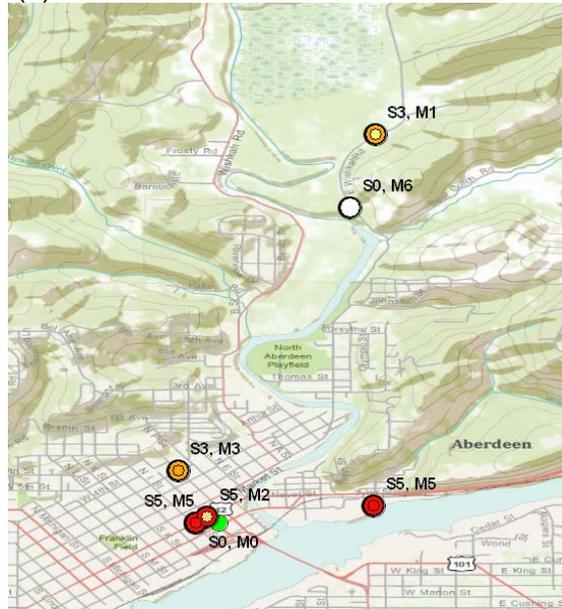


Figure 20 (see next page for caption)

(e) – Westport

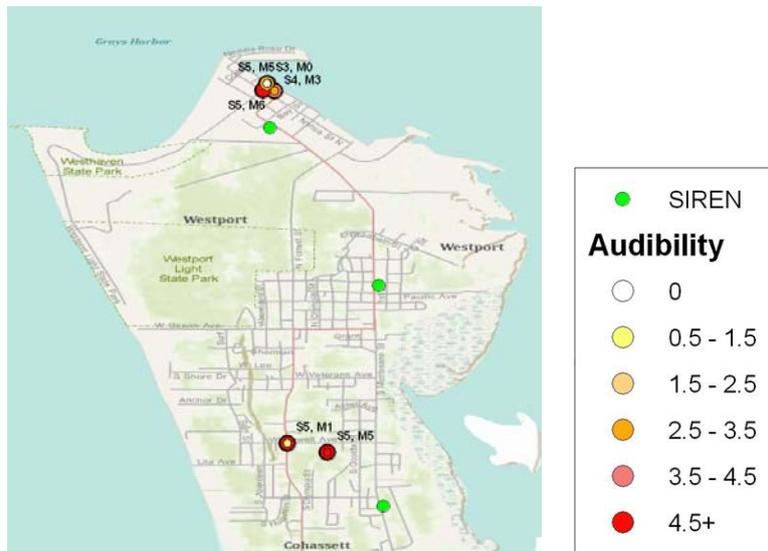


Figure 20 (a) – (e) Audibility maps. S = Siren, M = message. The outer circle is colour coded for siren audibility and the inner circle for message audibility. An audibility of '6' = No audibility given by respondent.

(a)

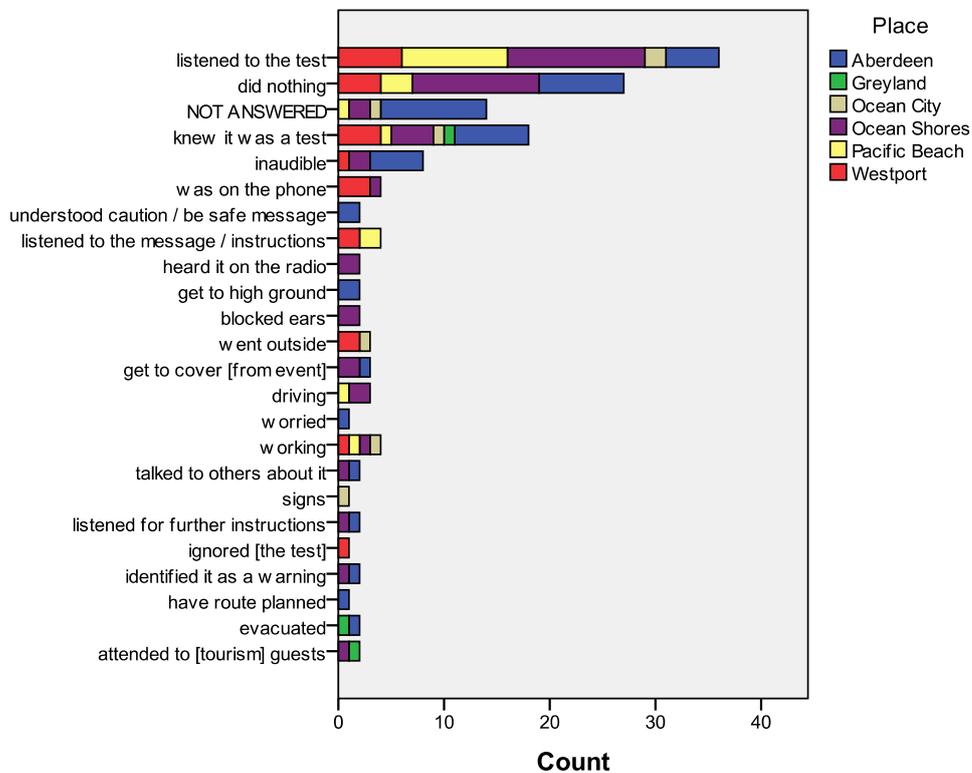
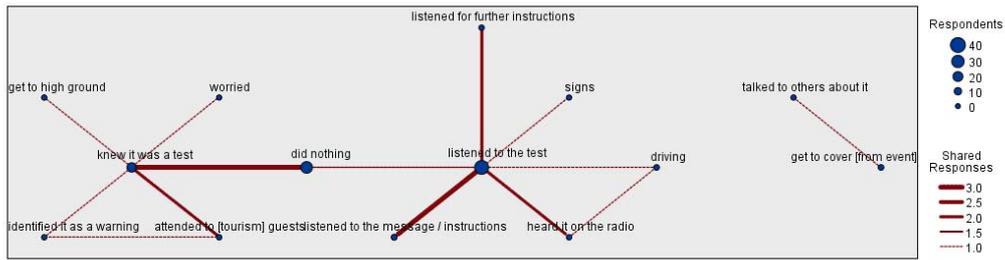


Figure 21 (see next page for caption)

(b)



(c)

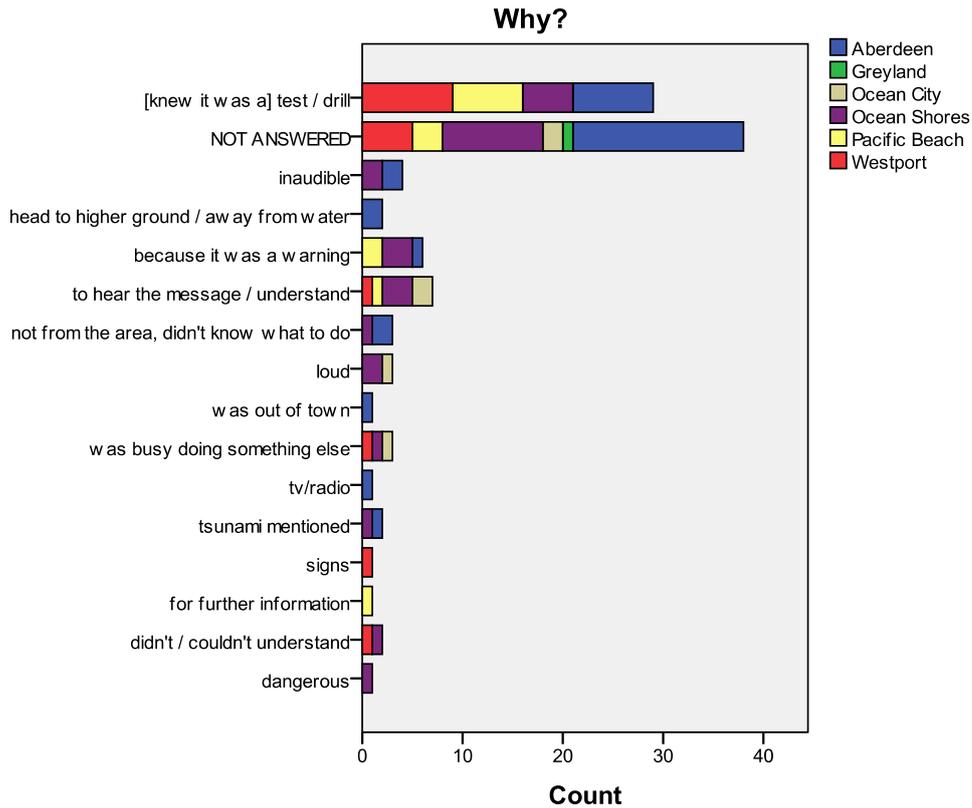
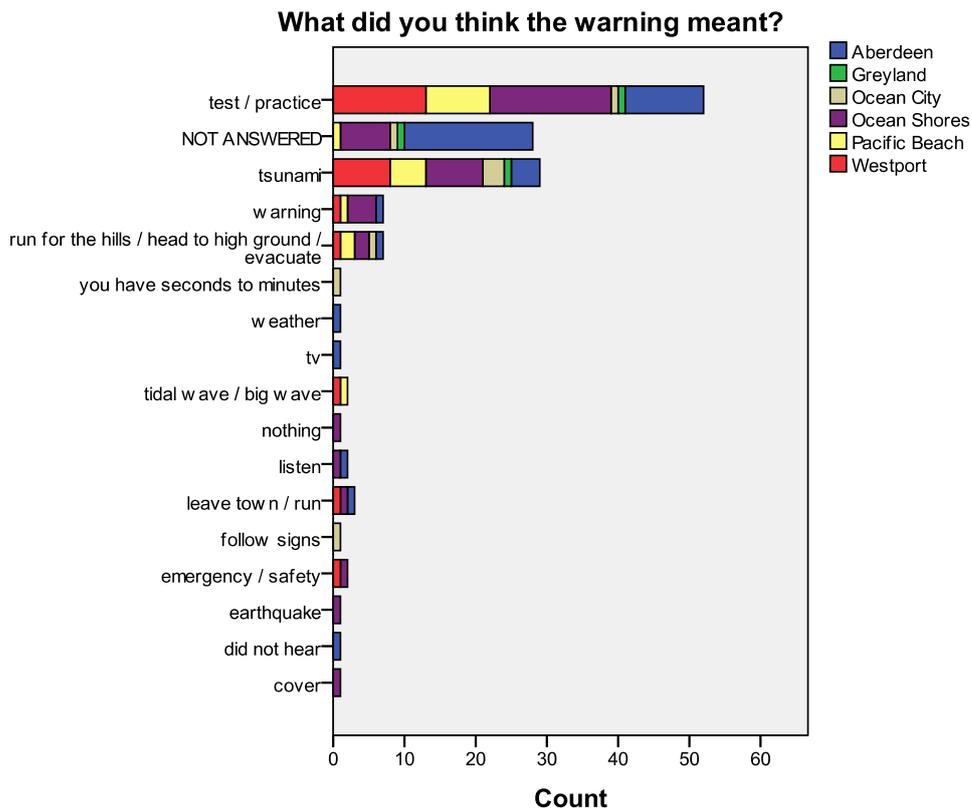


Figure 21 (a) Results from the open-ended question “What did you do?” categorised into themes from trained, automated text analysis; each respondent may have mentioned one or more than one category. (b) shared response web showing the number of respondents (symbolised by line weight) who mentioned two specific categories. (c) Results to the follow-up question “Why?”

(a)



(b)

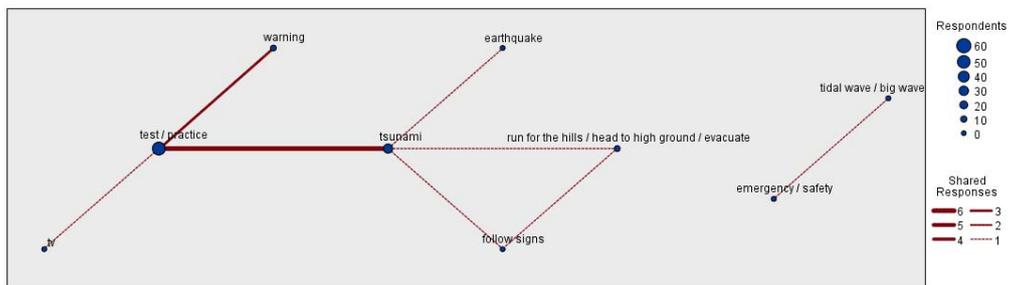
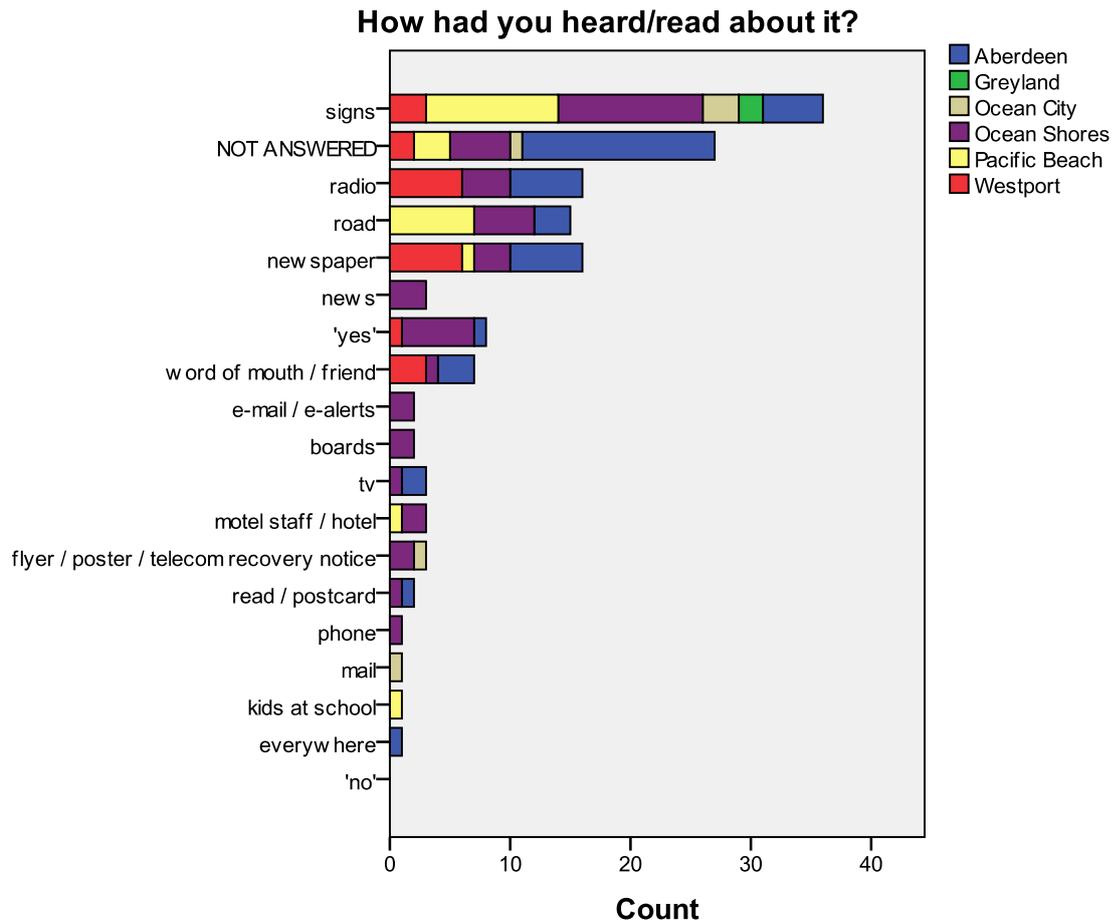


Figure 22 (a) responses to the question “What did you think the warning meant?” categorised into themes from trained, automated text analysis; each respondent may have mentioned one or more than one category. (b) shared response web showing the number of respondents (symbolised by line weight) who mentioned two specific categories.

(a)



(b)

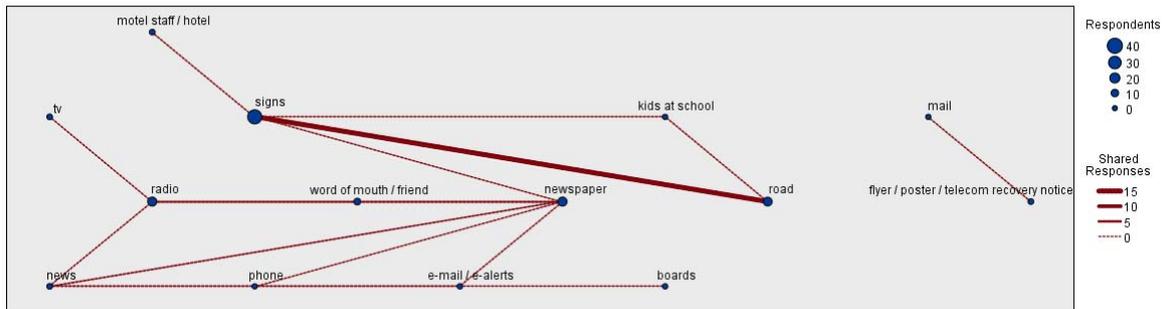
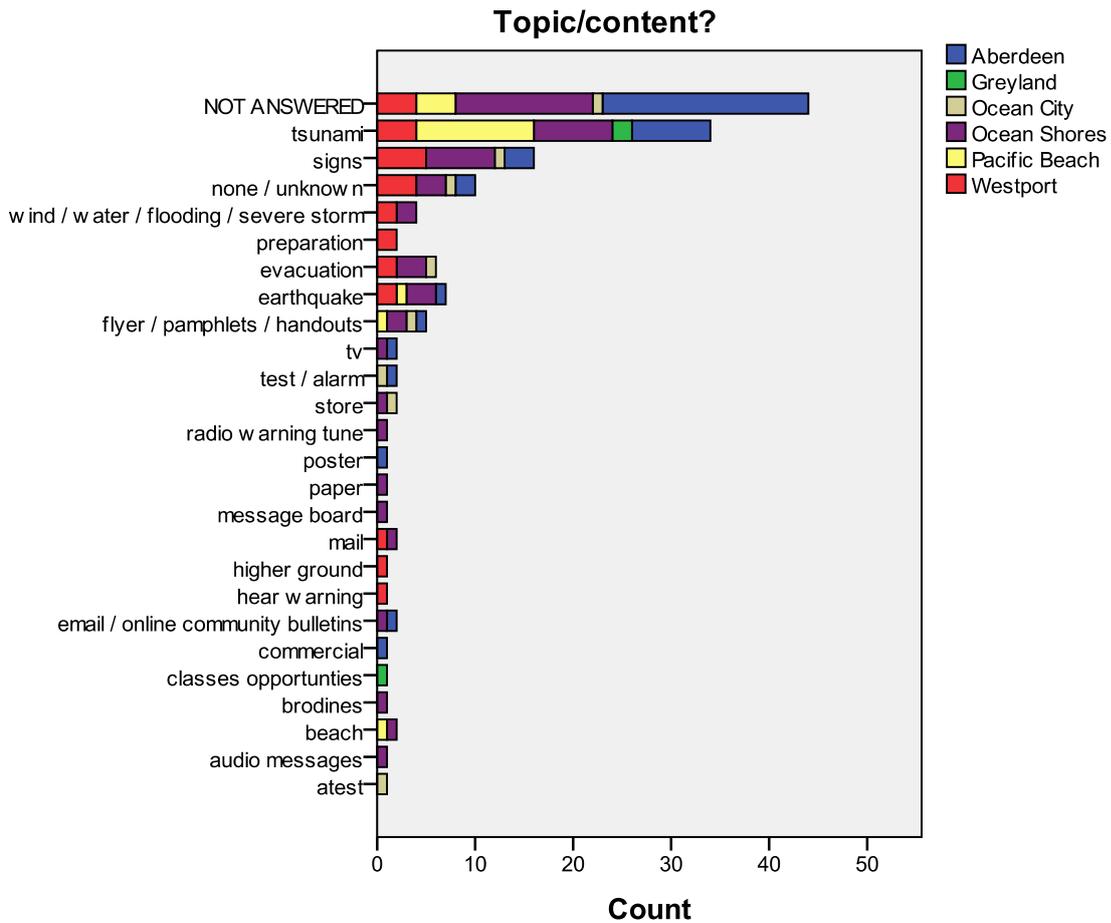


Figure 23 (a) Responses to “How had you heard / read about it?” categorised into themes from trained, automated text analysis; each respondent may have mentioned one or more than one category. (b) shared response web showing the number of respondents (symbolised by line weight) who mentioned two specific categories.

(a)



(b)

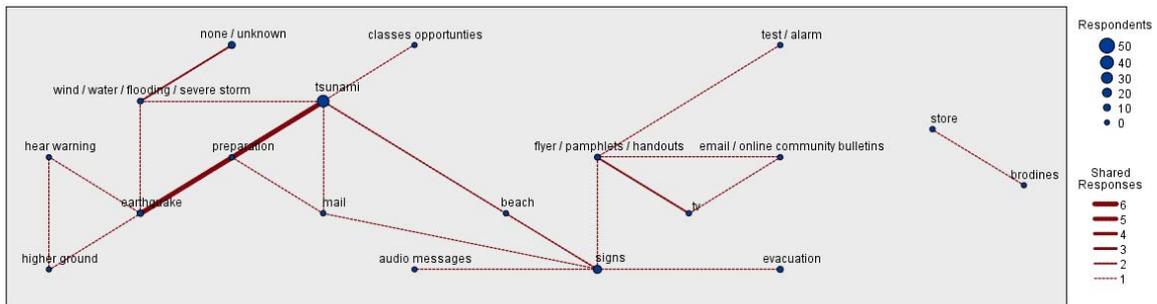
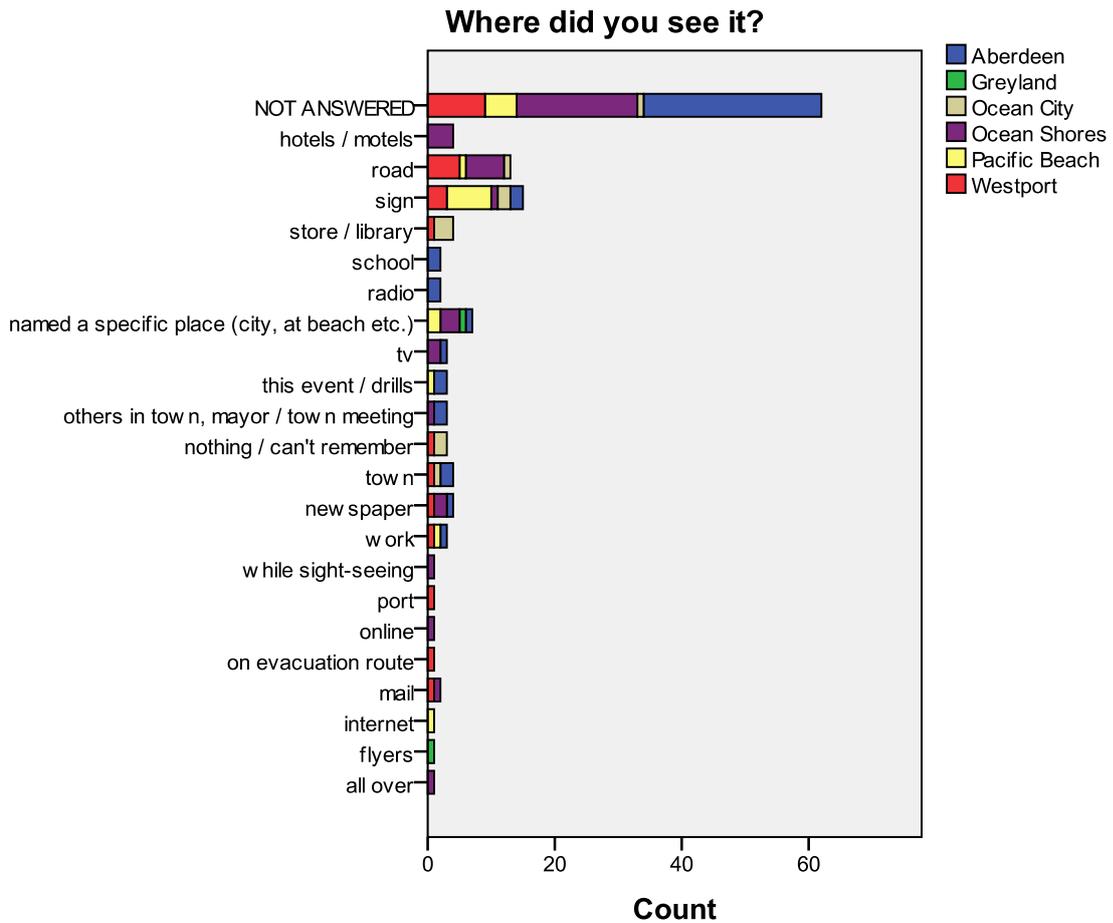


Figure 24 (a) responses to “Please describe natural hazards information you have seen for this community” categorised into themes from trained, automated text analysis; each respondent may have mentioned one or more than one category. (b) shared response web showing the number of respondents (symbolised by line weight) who mentioned two specific categories.

(a)



(b)

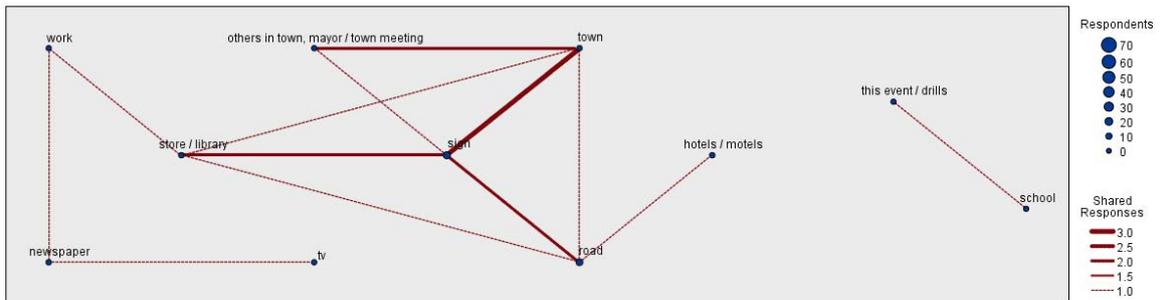


Figure 25 (a) “where did you see it?” categorised into themes from trained, automated text analysis; each respondent may have mentioned one or more than one category. (b) shared response web for (a).

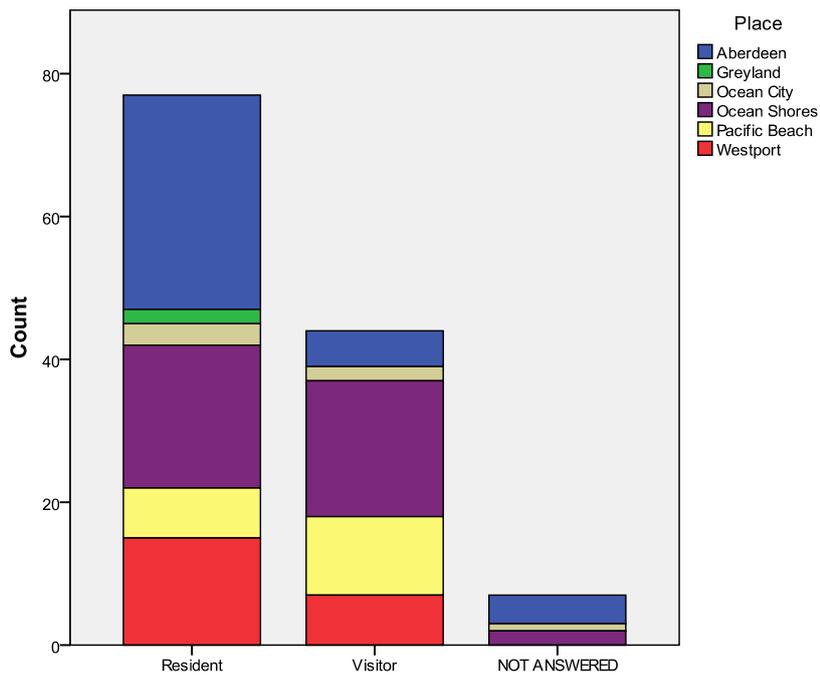


Figure 26 Response to "Are you a resident of or visitor to this community?"

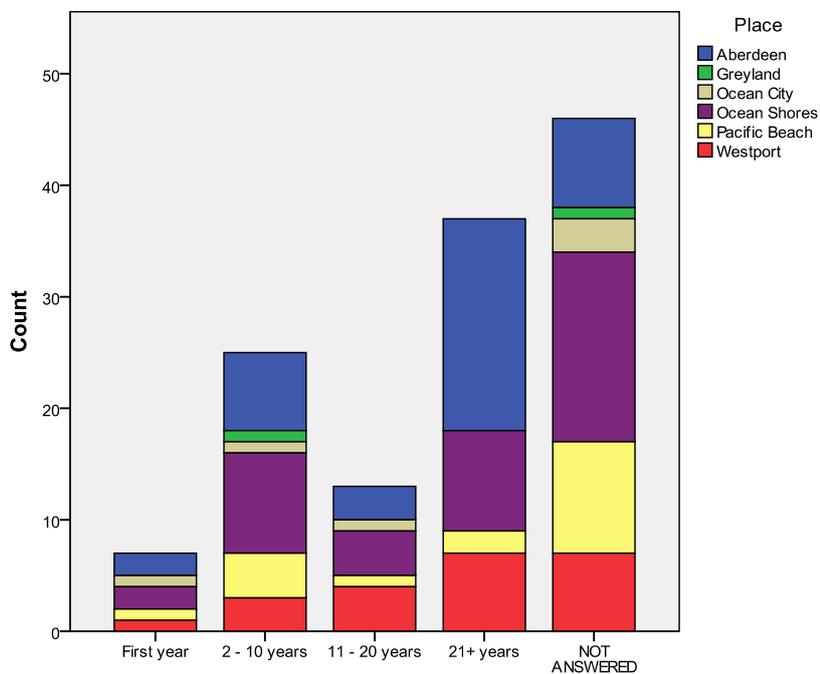


Figure 27 Response to "Residents: How long have you lived in this community (even with gaps)?"

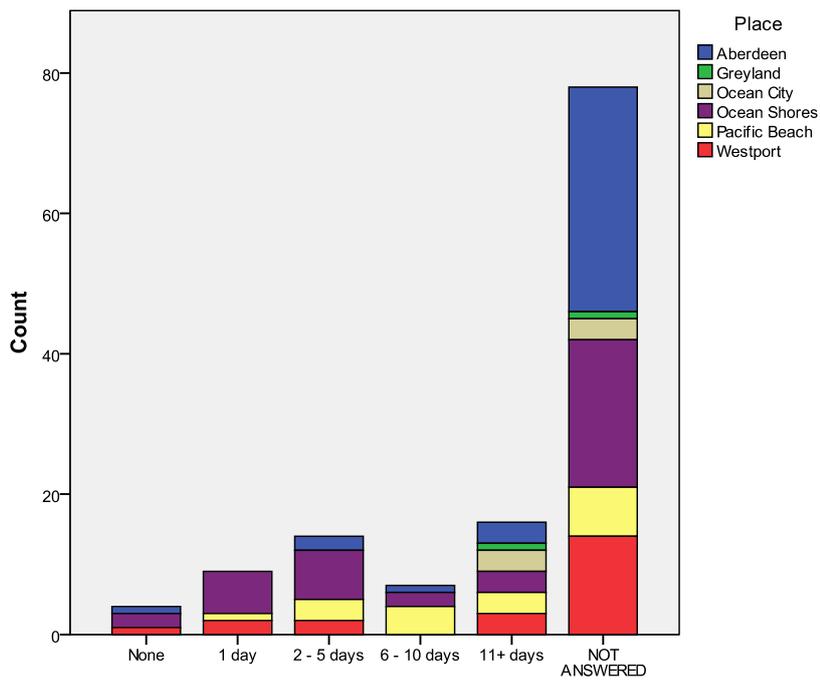


Figure 28 Response to “Visitors: How many days do you expect to visit this community this year?”

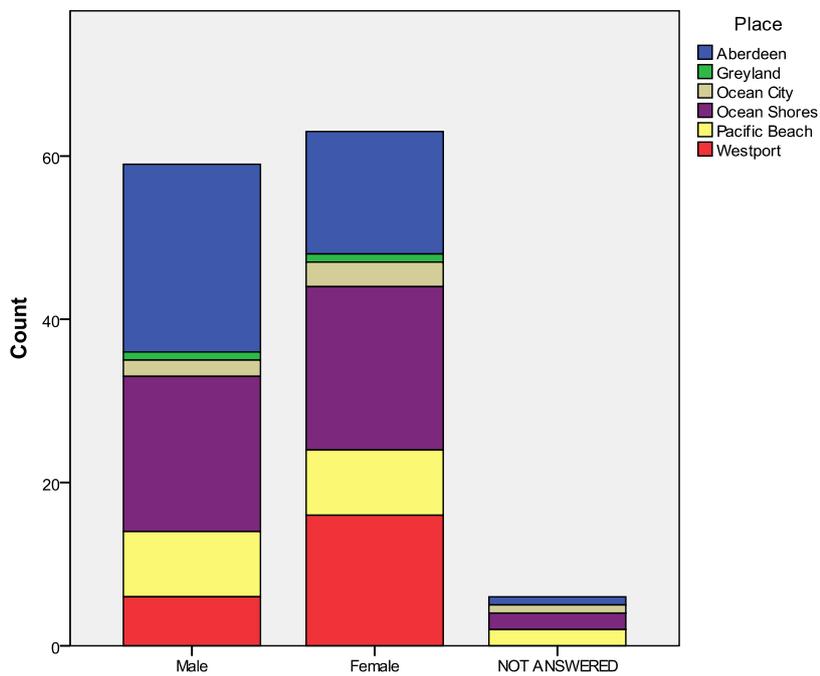


Figure 29 Gender response

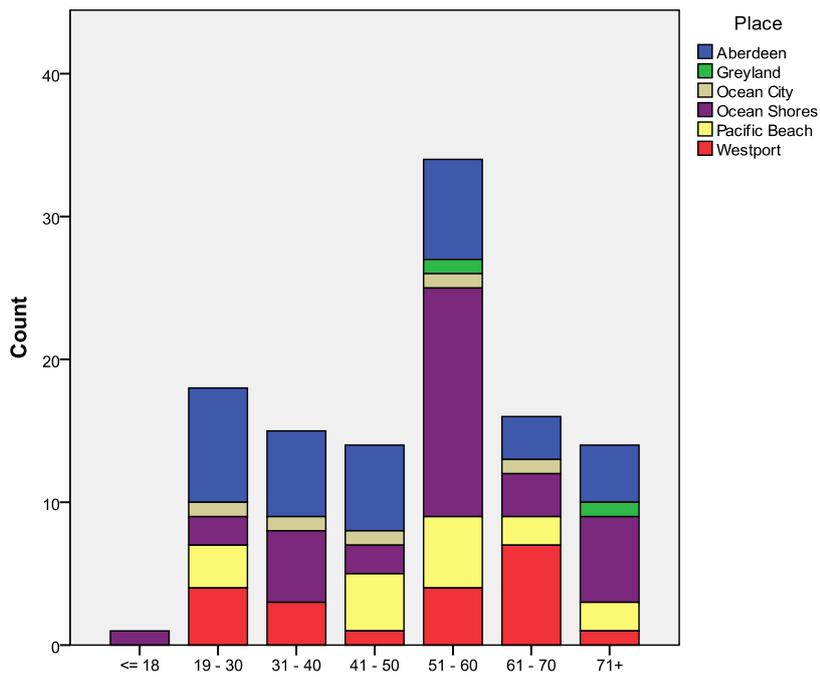
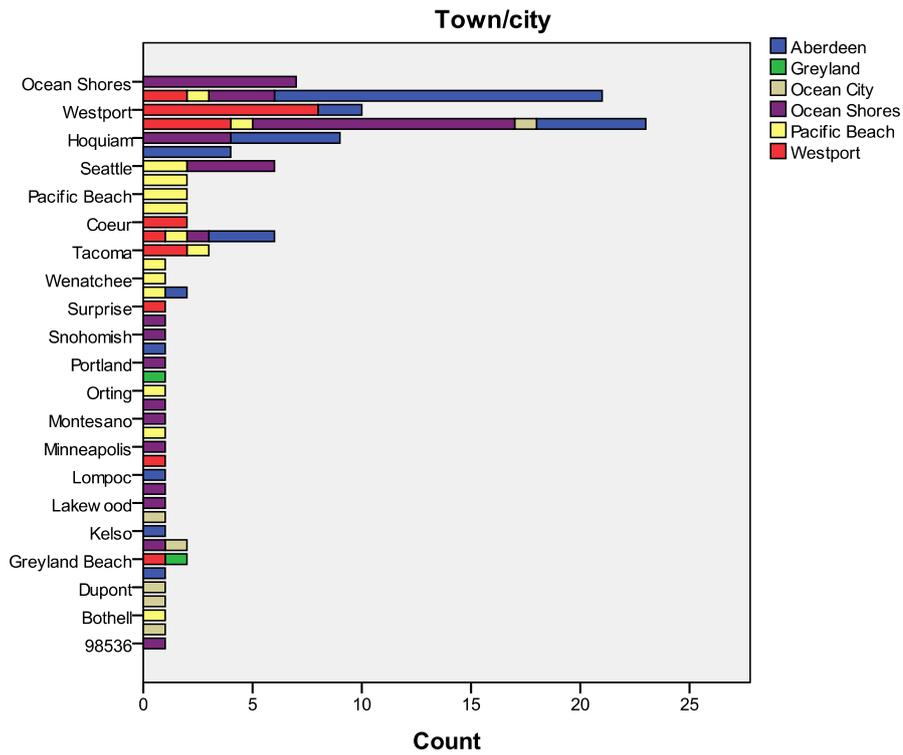


Figure 30 Age or respondent derived from asking “In what year were you born?” and subtracting this from 2010. Accurate to +/- one year.

(a)



(b)

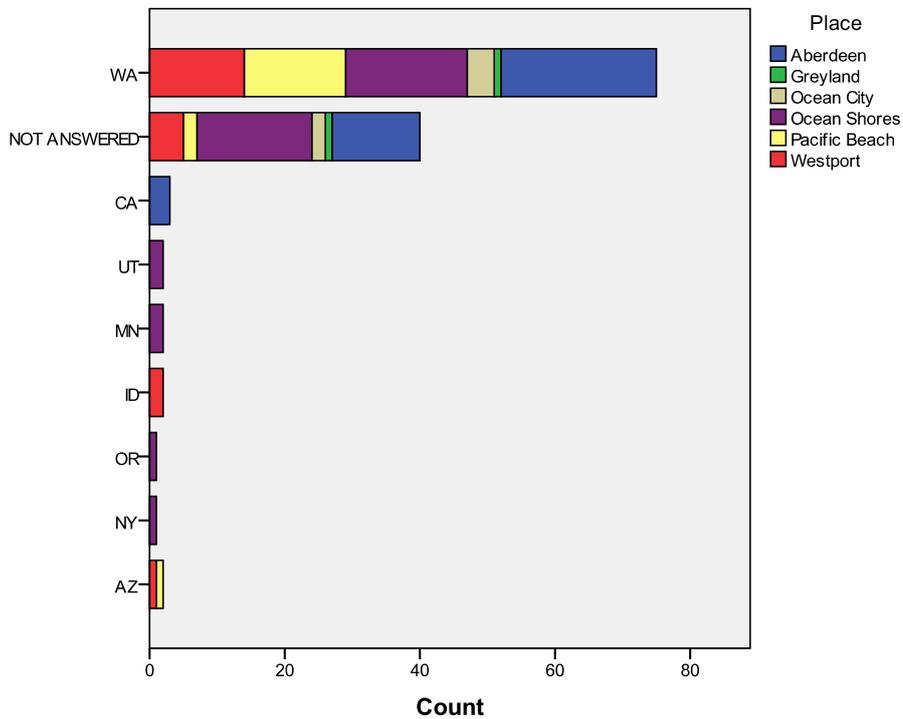
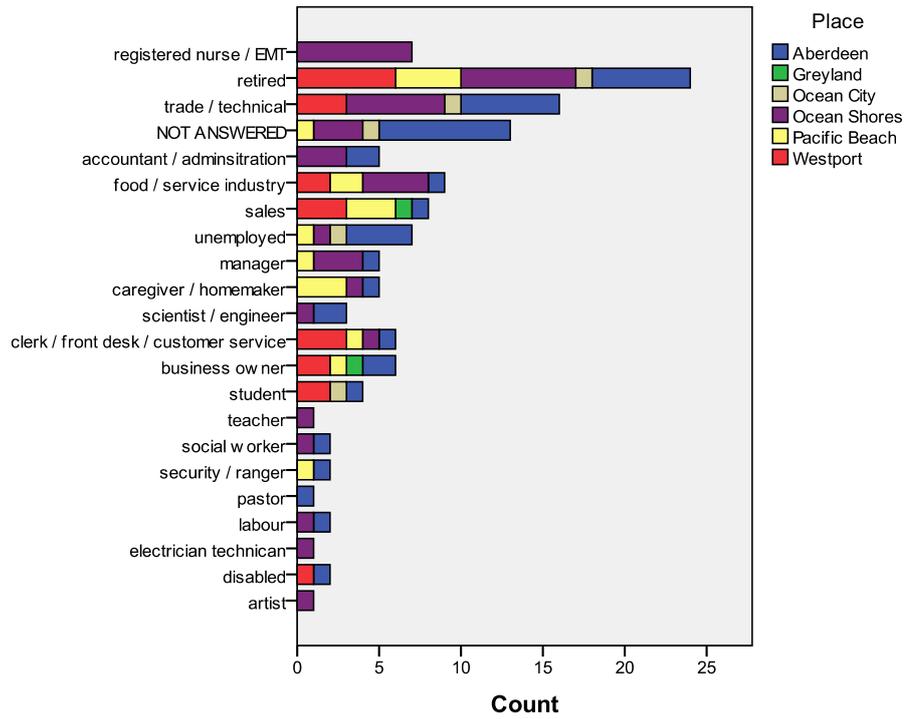


Figure 31 Where do you normally live? – (a) town / city and (b) state

(a)



(b)

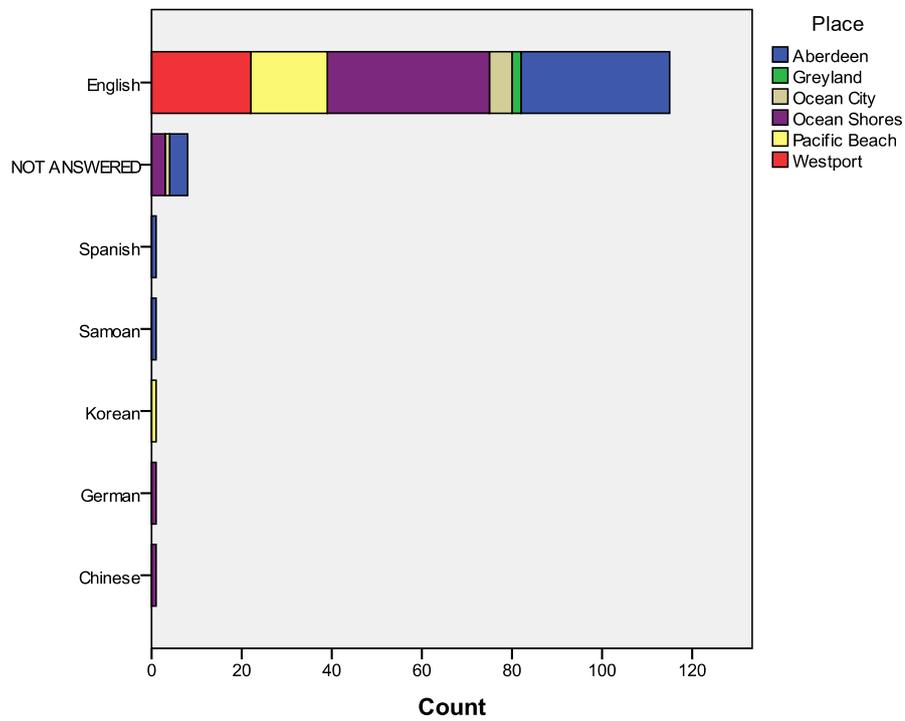


Figure 32 (a) what is your occupation and (b) what is your first language?

APPENDIX 2 TSUNAMI EVACUATION DRILL PARTICIPANT FORM

APPENDIX 1 TSUNAMI EVACUATION DRILL FORMS

ENTERED

00001

Warning Drill Evaluation Form: PARTICIPANT		Date: 9/17/10.
Name: G. Leonard.	Age: 32	Gender: M / F

Siren Audibility (Circle one)	Message Audibility (Circle one)
0 1 2 3 4 5 not barely moderate loud audible & clear	0 1 2 3 4 5 not barely moderate loud audible & clear
NOTES (variability, clarity, wind etc.):	NOTES (variability, clarity, wind etc.):

Where did you evacuate from exactly?	Medical centre.
Siren start AND stop times	X
Exact time of departure evacuating	10:35.
Time you reached safe location	10:59
Which safe location did you go to?	(A)? - Trailer up hill.
Was the terrain easy?	, ok, Hill a bit steep, trail good.
What was the weather like? (light, wind, visibility, rain)	ok, slight fog & humidity.
What items did people take with them?	sweaters, hats.
Clothing people wore	jeans, t-shirts & sweaters.
How easy was the evacuation map to read?	ok, small scale.
How easy were the signs to follow?	good, plenty, one at bot of hill didn't say tsunami
Would you be able to use the route in all weather conditions?	Yes, just. with flashlight
Would you be able to use this route in the dark?	Yes "
What would you like to have at your safe location if staying there?	food, shelter, water, chairs. communications
Any suggestions for improving the evacuation:	Blind, closer location,
How many people in total were you travelling with?	2 close, 80 total.

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Figure 33 Sample participant form used for the Shoalwater Bay Community evacuation exercise evaluation

APPENDIX 3 EXAMPLES

No.	Locations	RISK	Ski Run(s)
1	Top of Turnpipe	HIGH	17 Dreamer, 18 Turn Pipe, 19 Three Pin Ridge, 20 Twin Rocks (West), 59 Wizards
2	Far West T drive	HIGH	16 Venom, 15 Milk Run, 16 Turner's Gully, 59 Wizards, 60 Black Magic
3	Waterfall T drive	HIGH	29 Turtle Run, 36 K Road, 37 Valley Exit, 38 The Terraces, 39 Nose Dive
4	Top of the gut	HIGH	26 The Gut
5	Haensli Face	HIGH	27 The Gut, 29 Turtle Run, 63 Haensli Face
6	Top Water fall T	HIGH	30 Turtle Run, 36 K Road, 37 Valley Exit, 38 The Terraces, 39 Nose Dive
7	on waterfall face	HIGH	3 Hutt Flat Beginner, 40 41 Staircase, 42 Honeymoon valley, 49 Waterfalls
8	Old pinnacle platter area	HIGH	3 Pinnacles Platters Beginners, 47 Broken Leg (lower), 48 Couloirs
9	Express Q drive	HIGH	2 Hutt Flat Beginner, 40 41 Staircase, 42 Honeymoon valley, 49 Waterfalls
10	Valley T drive	LOW	32 Valley Highway, 33 Bilbo's, 34 Gollum, 35 Pinnacle Valley, 43 Pinnacle Traverse
11	Knoll café outside	SAFE	
12	TOB Café,	SAFE	1 Happy Valley Beginner Area
13	West Ridge drive	LOW	10 Downhill easy, 11 Goomie bowl, 12 T1, 13 Riviera Paradise
14	Knoll T drive	LOW	27 Knoll Face, 28 Cut Back, 30 Shirt Front, 31 Valley Traverse
15	Top of Valley T	LOW	33 Valley Highway, 33 Bilbo's, 34 Gollum, 35 Pinnacle Valley, 43 Pinnacle Traverse
16	Top of Knoll Ridge T	LOW	28 Knoll Face, 28 Cut Back, 30 Shirt Front, 31 Valley Traverse
17	Top West ridge Quad	SAFE	6 Christies, 5 Rockgarden
18	West Café inside	SAFE	
19	Hut Flat café inside	SAFE	5 Christies, 5 Rockgarden
20	Knoll café inside	SAFE	
21	Rock garden face	SAFE	4 Christies, 5 Rockgarden
22	Happy Valley	SAFE	2 Happy Valley Beginner Area
23	Broken Leg	LOW	44 Front Stage, 45 Back Stage, 46 Grand Gully, 47 Broken Leg Gully
24	?TOB outside	SAFE	3 Happy Valley Beginner Area
25	?Yankee area	SAFE	6 Tennant's Valley, 7 Tennant's Ridge, 8 Home Run (East), 50 High Traverse, 51 McKenzie's Mistake, 52 The Chimney, 53 54 Yankee Face, 55 Steve's Bowl
26	?Traverse/delta trail	LOW	21, Twin Rocks (East), 22 S Bends, 23 Cornice Bowl, 24 Delta Trail, 25 Traverse of Fear, 61, Stebbings, 62 Screamer
27	?Amphitheatre	LOW	8 Home Run (West), 9 Murphie's Schuss, 58 Amphitheatre

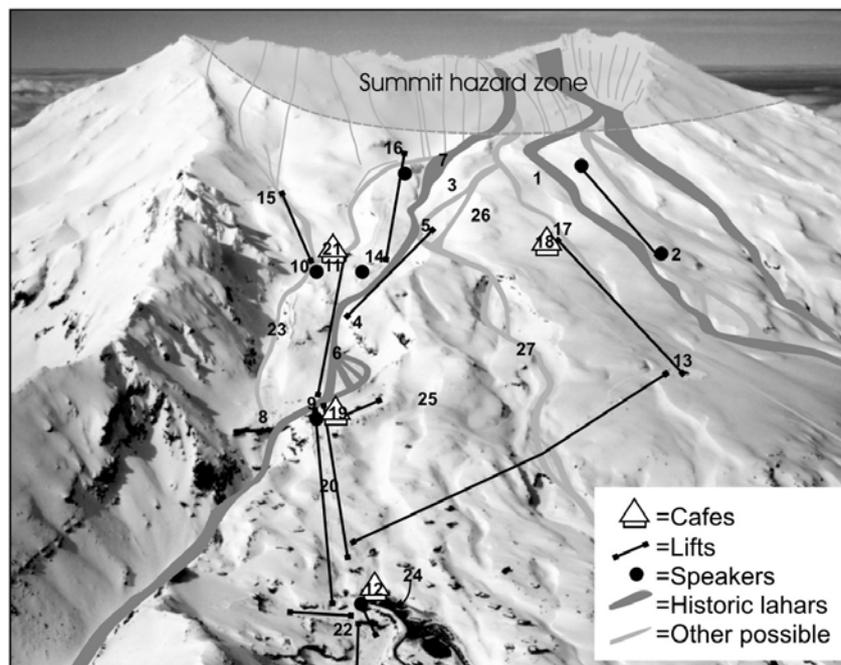


Figure 34 Observer location map example (Whakapapa ski area, Ruapehu, NZ; 2009)

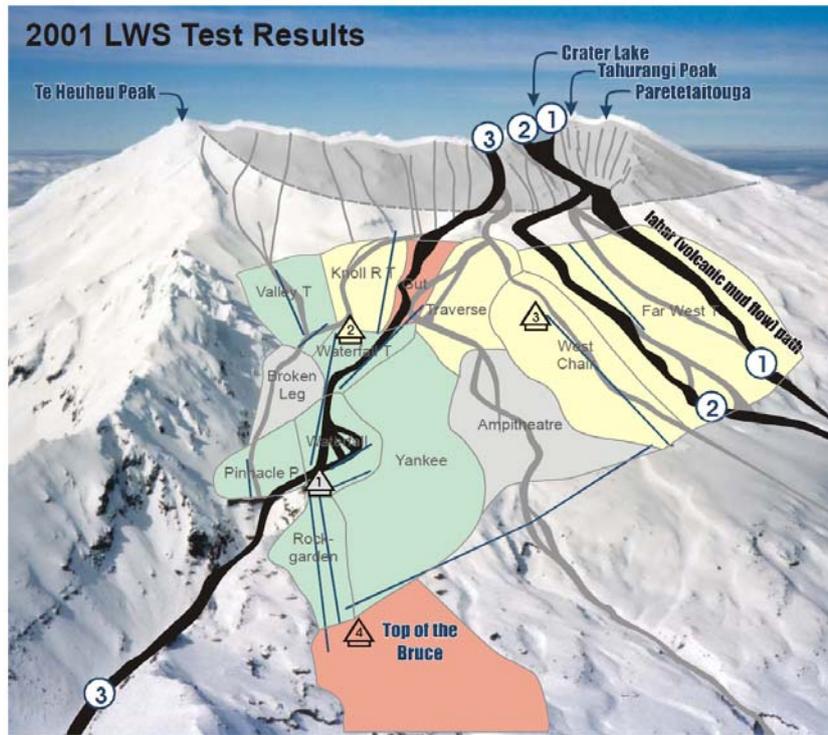


Figure 35 Colour coded audability map (eruption lahar; Ruapehu, New Zealand, 2001)



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