

# Measuring Tsunami Preparedness in Coastal Washington, United States

D. JOHNSTON<sup>1</sup>\*, D. PATON<sup>2</sup>, G. L. CRAWFORD<sup>3</sup>,  
K. RONAN<sup>4</sup>, B. HOUGHTON<sup>5</sup> and P. BÜRGE<sup>4</sup>

<sup>1</sup>*Institute of Geological and Nuclear Science, 69 Gracefield Road, PO Box 30-368, Lower Hutt, New Zealand;* <sup>2</sup>*University of Tasmania, Launceston, TAS 7250, Australia;* <sup>3</sup>*Washington State Military Department, Emergency Management Division, M/S TA-20 Camp Murray, WA 98430-5211, USA;* <sup>4</sup>*Massey University, Palmerston North, New Zealand;* <sup>5</sup>*University of Hawaii at Manoa, 2500 Campus Road, Honolulu, HI 96822, USA*

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**Abstract.** A survey of over 300 residents' and visitors' (non-residents) perceptions of tsunami hazards was carried out along the west coast of Washington State during August and September 2001. The study quantified respondents' preparedness to deal with tsunami hazards. Despite success in disseminating hazard information, levels of preparedness were recorded at low to moderate levels. This finding is discussed in regard to the way in which people interpret hazard information and its implications for the process of adjustment adoption or preparedness. These data are also used to define strategies for enhancing preparedness. Strategies involve maintaining and enhancing hazard knowledge and risk perception, promoting the development of preparatory intentions, and facilitating the conversion of these intentions into sustained preparedness. A second phase of work began in February 2003, consisting of a series of focus groups which examined beliefs regarding preparedness and warnings, and a school survey. Preliminary findings of this work are presented.

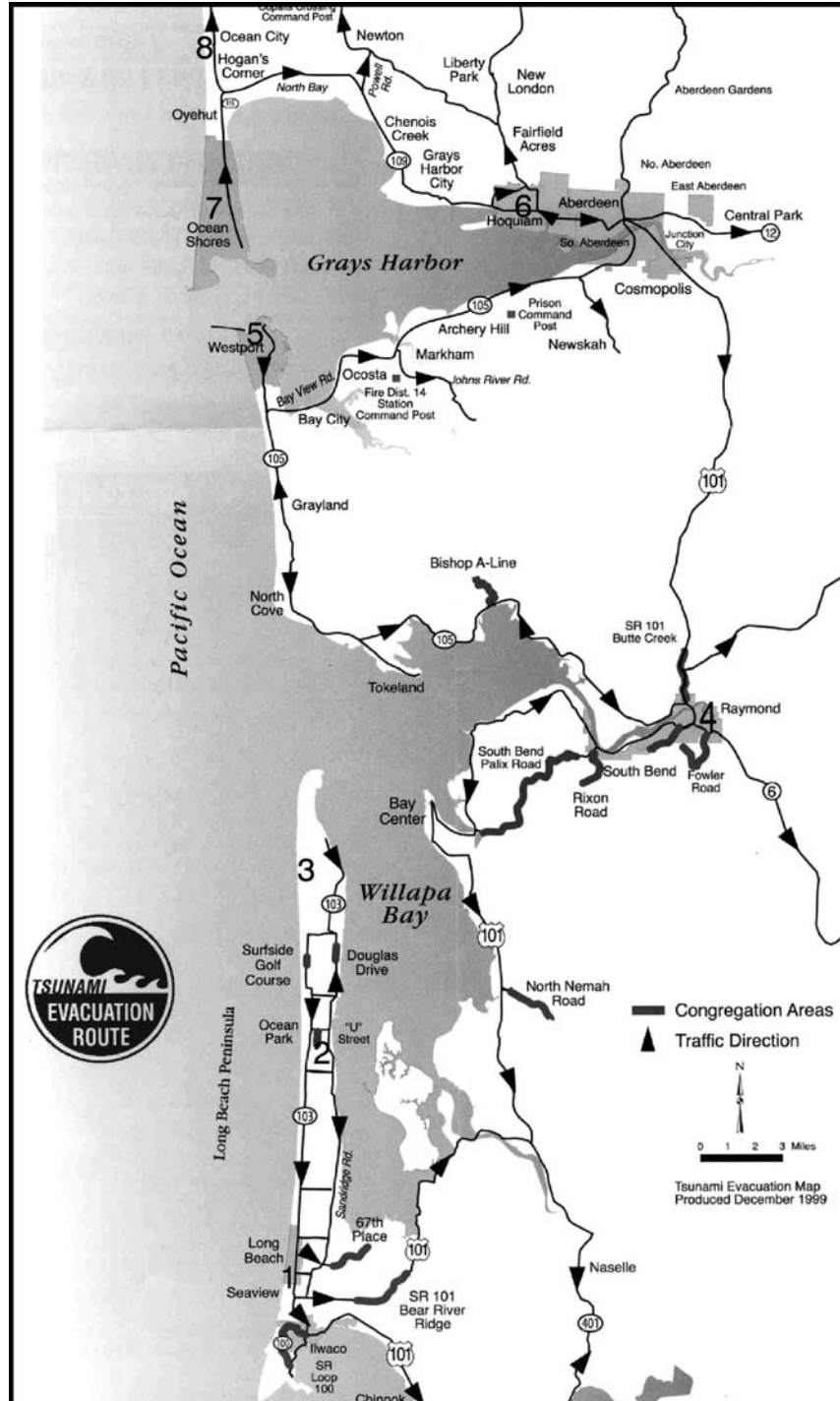
**Key words:** tsunami, public education, warnings, warning systems, preparedness, evacuation

## 1. Introduction

Considerable improvement in the understanding of tsunami risk in Washington has emerged from research over the past two decades (Wilson and Torum, 1972; Atwater, 1992; Atwater *et al.*, 1995; Walsh *et al.*, 2000). Since the mid-1990s the State of Washington, in association with the U.S. National Tsunami Mitigation Program, has undertaken a wide range of mitigation activities (Jonientz-Trisler and Mullin, 1999; Bernard, 2001). Consequently, information in several media (books, posters, pamphlets, school kits, mugs, and magnets) has been distributed to the communities surveyed here (Figure 1). Warning and evacuation signs have been erected in prominent positions, and maps and public displays illustrating the tsunami inundation zone

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\* Author for correspondence: Tel: +64-4-570 4538; E-mail: d.johnston@gns.cri.nz



for the southern Washington coast have been distributed to the community. Three studies have recently been undertaken to assess the influence of these activities on tsunami hazard preparedness.

## 2. Survey

A survey of over 300 residents' ( $n = 217$ ) and visitors' (non-residents,  $n = 83$ ) perceptions of tsunami hazards was carried out along the west coast of Washington State during August and September 2001 (Figure 1). Three different methods were used to collect information: delivering written questionnaires to individual residential houses, using postal (P.O. Box) delivery for questionnaires, and person-to-person interviews with tourists and residents. A total of 436 questionnaires were delivered directly to houses in the communities of Long Beach, Seaview, Ocean Park, Surfside Estates, Oysterville, and Ocean Shores between 26 August and 1 September 2001. A further 733 postal questionnaires were sent to random post office box numbers in the communities of Raymond, Hoquiam, Ocean Shores, and Westport in September 2001. Return rates varied from around 24% in Long Beach/Seaview to 9% in Raymond and provide a moderately representative sample of residents from the area being surveyed. It is also interesting to speculate on the implications of the differential rates of return from each area. Rates of return appear, with a few exceptions, to mirror proximity to the ocean, and thus the source of the tsunami hazard. For example, returns are relatively high from areas directly fronting the ocean: Long Beach (24%), Ocean Park (22%), Ocean Shores (20%), and Westport, (18%).

A total of 97 interviews were also conducted at several West Coast beaches including Long Beach, Seaview, Ocean City, Ocean Shores, and Westport between 28 August and 30 August 2001. People interviewed were mostly visitors (83) but a small number of residents (14) were also included in the sample.

The study was concerned with quantifying people's understanding of tsunami hazards on the Washington coast, their knowledge regarding the Washington State tsunami warning system, their preparedness to deal with tsunami activity, and providing information that could be used for baseline measurement. Data were collected using a questionnaire derived from a theoretically robust and empirically tested process model of preparedness (Paton, 2000, 2003; Paton *et al.*, 2001, 2003b). Details of the scales used and their sources are listed in Table I. A detailed report on the findings is



Figure 1. Survey locations: (1) Long Beach/Seaview, (2) Ocean Park, (3) Surfside/Oysterville, (4) Raymond, (5) Westport, (6) Hoquiam, (7) Ocean Shores, (8) Ocean City. Map also shows planned evacuation routes as presented in Grays Harbor and Pacific Counties' tsunami hazard brochure.

Table I. Scales used and their sources

Scale	Source
Precursor variables	
Risk perception	Johnston <i>et al.</i> (1999)
Critical awareness	Dalton <i>et al.</i> (2001)
Intention formation variables	
Outcome expectancy	Bennett and Murphy (1997)
Self-efficacy	Paton <i>et al.</i> (2001)
Intentions	
Intention/information search	Bennett and Murphy (1997)
Moderator variables	
Response efficacy	Lindell and Whitney (2000)
Perceived responsibility	Mulilis and Duval (1995)
Sense of community	Paton <i>et al.</i> (2001)
Timing	Paton <i>et al.</i> (2003b)
Outcome	
Adjustment adoption	Mulilis-Lippa Preparedness Scale Mulilis <i>et al.</i> (1990)

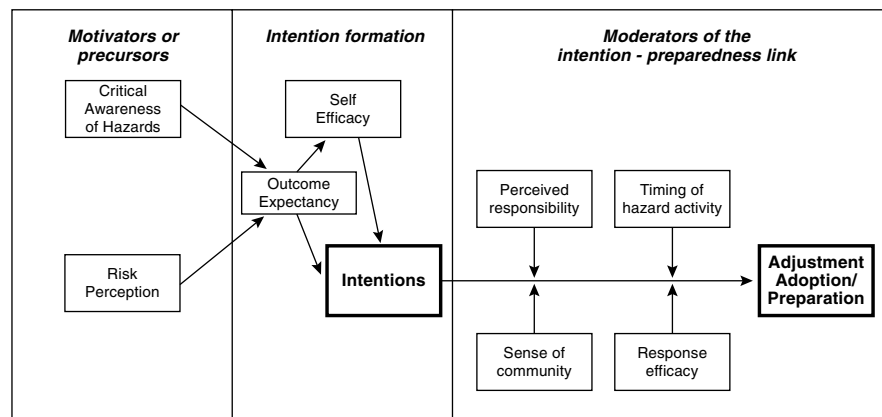
presented by Johnston *et al.* (2002) and key issues emerging from the study are discussed further by Paton *et al.* (2003a). The interviews with visitors consisted of eight brief questions that asked about the respondents' knowledge of tsunami hazards in the area and their awareness of the Washington State tsunami warning system.

Current initiatives appeared to be moderately to highly effective in raising public awareness of the hazard. For example, 62% of residents had seen the tsunami hazard zone maps and 76% of residents had heard or received information on tsunami hazards from a range of sources. In addition some 68% of residents reported that they had heard or observed other people preparing for tsunami hazards. However, visitors (non-residents) surveyed were significantly less aware of the tsunami hazard and the warning system. For example, only 19% of visitors had seen the tsunami hazard zone maps and 46% were unaware of the elements of the tsunami warning system. These observations suggest a need for additional research on tourist perceptions of, and responsiveness to, warnings and to investigate local attitudes to the provision of this information.

In addition to enhancing hazard knowledge, a second objective of public education programs is to facilitate preparedness to deal with hazard consequences. That is, the degree to which knowledge and awareness translate into preparedness behavior. An examination of the number of preparedness items adopted (Table II) suggests that receipt of the hazard and preparedness information did not translate into a corresponding level of preparedness. Of the 11 adjustments, the average number adopted per household was 2.66 and

*Table II.* Hazard preparedness indicators and the proportion of residents adopting each

Protect breakable household items	19%
Put strong latches on cabinet doors	7%
Add edges to shelves to keep things from sliding off	5%
Strap water heater	23%
Install flexible tubing to gas appliances	12%
Bolt house to foundation	31%
Pick an emergency contact person outside of the Northwest	28%
Buy additional insurance (e.g., home)	33%
Find out if you are in an area particularly vulnerable to a disaster	57%
Have home inspected for preparedness	3%
Talked to family members about what to do if a tsunami warning is heard	48%

*Figure 2.* The social-cognitive preparation model. Adapted from Paton *et al.* (2003b).

levels of adoption of each measure were low (Table II). Explanations for this discrepancy focus on the interpretive processes that influence how hazard information is rendered meaningful by its recipients. A tendency to overestimate perceived preparedness by extrapolating from the low levels of loss and damage associated with prior hazard experiences to a capability to deal with future events was supported by the data. A propensity to attribute the need for hazard information and preparedness to other members of their community rather than themselves was also evident (Paton *et al.*, 2003a). An explanation for low preparedness has previously been discussed using a process model of preparedness (Paton, 2003; Paton *et al.*, 2003b) that comprised three distinct, but related, stages (Figure 2). Acknowledging the distinction between these stages is important. They comprise different variables and require different intervention strategies to achieve change.

*Table III.* Means and standard deviations of preparedness process variables

Variable	Scale		
	Min.–Max.	Mean	SD
Risk perception	2–10	7.31	2.47
Critical awareness	2–10	5.09	2.09
Outcome expectancy	2–10	6.81	2.03
Self efficacy	4–20	10.93	2.37
Intention/information search	3–9	4.55	1.66
Responsibility	1–5	4.27	1.03
Response efficacy	5–25	12.36	4.49
Sense of community	9–45	27.73	4.02
Preparation	0–11	2.66	2.05

### 3. Motivating Factors

According to the model, preparedness is motivated by perception of hazard effects capable of posing a threat. In this sample, moderate to high levels of perceived threat (mean = 7.31) were attributed to tsunami hazards (Table III). The second motivating factors, critical awareness (thinking and discussing tsunami), presented at low to moderate levels (mean = 5.09, Table III). These data suggest that preparedness could be enhanced by increasing the perceived relevance of hazard effects for residents.

#### 3.1. FROM MOTIVATION TO PREPARATORY INTENTIONS

In the preparedness model (Figure 2), the relationship between precursors and intentions is mediated by outcome expectancy and self efficacy. Moderate levels of outcome expectancy (belief that hazard effects can be mitigated by individual efforts) were recorded (mean = 6.81, Table III) and these act to reduce preparedness. Low-moderate levels (mean = 10.93; Table III) of self-efficacy (judgment regarding their capabilities to mitigate hazard effects) will constrain preparedness. Low levels of these variables is consistent with the finding of low to moderate levels of preparedness intentions. Only 13% of the sample indicated a definite intention to actively prepare. These data are consistent with the low to moderate levels of preparation described above (Table II).

#### 3.2. MODERATING THE INTENTION-PREPARATION LINK

The model describes how preparedness can be moderated by several factors. Moderate to high levels of personal responsibility, resource availability (resource efficacy) and sense of community lessen the likelihood of their acting

to moderate preparedness. A final moderator is the time frame within which people anticipate the occurrence of the next tsunami (Paton, 2003). Those who anticipated this occurring within the next 12 months were likely to convert their intentions into actual preparedness. In the present sample, only 2% of the sample thought that a tsunami was likely within the next year. Consequently, this variable could significantly moderate the intention-preparedness link.

To facilitate motivation, public education and empowerment strategies are needed (Paton, 2000) that emphasize the salience of hazard issues for community members. Improved preparedness could also accrue from enhancing community members' beliefs in the feasibility of mitigating hazard effects through personal actions (e.g., counter beliefs that hazards have totally catastrophic effects) and enhancing beliefs in personal competency to implement these activities. Changing these factors requires a mix of public education, social policy, training, and empowerment strategies. The third stage, converting intentions into actual behavior, could be enhanced by focusing on encouraging acceptance of a "sooner rather than later" message. It is also important to understand the belief and attitudes that underpin the above responses. To examine this further a series of focus groups were contacted. The focus group discussions also explored members' perceptions of, and beliefs about, tsunami warnings.

#### **4. Focus Groups**

In February 2003 a series of six focus groups were run with the aim of exploring residents' experiences and perceptions of tsunami risk and preparedness. Understanding these attitudes is important and requires using qualitative research as a mode of inquiry. The groups were run in Ocean Shores (hotel managers and seniors), Pacific Beach (volunteer fire-fighters), Ocean Park (seniors), Long Beach (Kiwanis), and Aberdeen (Coastal Community Action Program members). Groups were selected to ensure that the views of a diverse and representative range of constituencies were canvassed. All focus groups were taped and were transcribed.

Initial analysis of the content identified a number of key issues. There was a high level of interest and support for participating in the focus groups. Most people expressed appreciation for the opportunity to "have their say" in an open forum. They were also happy for it to be recorded and pleased that "what was said" was going to be used in a constructive way. A wide range of topics were covered in the discussions, including risk perceptions, community awareness, issues relating to preparation, response, warnings and evacuation, and mitigation options (discussion included both comment on current initiatives and suggestions on possible options for the future).

In Ocean Shores many of the hotels had been proactive in promoting awareness and preparedness, including staff and customer awareness, staff training, and other mitigation measures. There was some discussion that this may not be the case in all communities with some remaining resistance from the business community in other parts of the state. A wide discussion was had on the potential effectiveness of warning systems. Some concerns regarding the level of community understanding of the warning system and its limitations were expressed. There seems to be some misunderstanding of the likely warning time that may be given. The issue of evacuation was explored in all groups. There is a clear understanding of the need to evacuate but many felt that the road networks would be unable to cope, especially during peak summer and holiday times. Many residents believed it would not be worth attempting to evacuate by car due to the perceived congestion following an evacuation order. It was commonly suggested that it may be better to move to local high points or as far inland as possible within the local area. Many suggestions for improving education among the population were made. School programs were seen as an important way of improving awareness in the community.

The unstructured data collected in the focus groups were systematically analyzed using various grounded theory analysis strategies and the qualitative data analysis programme ATLAS.ti. The researchers followed closely the procedures for open, axial, and selective coding (Strauss and Corbin, 1990; Browne and Sullivan, 1999; Chamberlain, 1999). Throughout the coding, they constantly drew comparisons among and between incidents, text segments, concepts, codes, and focus groups; asked questions of the data; wrote memos; formulated hypotheses; and created networks. These analysis strategies were used to develop a theory. This approach helped maintain balance between creativity, rigor, persistence, and theoretical sensitivity; assisted with grounding explanations in the data; and facilitated identifying links among concepts (Strauss and Corbin, 1990). The outcome was the best achievable fit between the data and their interpretation (Browne and Sullivan, 1999) and a “conceptually rich understanding and systematic integration of low-level descriptions into a coherent account” (Henwood and Pidgeon, 1992, p. 103).

The qualitative analysis of the focus group discussions yielded the following preliminary findings. Difficulties in regard to information distribution and the adequacy of its formatting reduced the capacity of residents to understand the nature of tsunami hazards, resulting in a substantial lack of information regarding tsunami preparation and warnings. The lack of the continuous availability data was identified as problematic, as was the perception that city councils and real estate agents are holding back information from new residents due to fear of negative impact on economic and business activity. Participants also felt that councils held back information for fear of criticism. Finally, the information that was disseminated was perceived as



being too general and in a format that residents had difficulties relating to. Information thus needs to be tailored more specifically to cater to the diverse needs and expectations of different groups within the community.

Inadequacies in regard to the content and frequency of dissemination of information reduced residents' knowledge regarding the nature and effects of tsunami, what they could do to prepare personally, and what their communities have in place for responding when a tsunami should occur. Inadequate knowledge, in combination with the highly complex nature of tsunami (i.e., the effect of tsunami depends on so many different factors and their interaction), contributes to the generation and maintenance of misconceptions and uncertainty among residents, increases the likelihood of residents either exaggerating or downplaying the risk and the consequences of tsunamis, and generated many questions in the focus groups. Participants reported that these issues contributed to many residents becoming apathetic. Inadequate knowledge, misconceptions, high uncertainty and/or apathy led, in several ways, to low levels of individual preparedness and high levels of refusals to evacuate. Although residents know about the many things they could do to prepare personally, they tend not to implement them. Furthermore, in the case of emergency kits, even if they had prepared them, many use their contents after a short while and do not renew them regularly.

The participants perceived that the current level of preparedness for natural hazards within their communities is poorer than it was in the 60s and 70s. In addition to the reasons outlined above, limited preparedness was also attributed to a combination of lack of money, the fear of negative effects on the economy, and perceiving the risk of a tsunami as relatively low.

Low levels of personal and community preparedness generated many concerns regarding warnings. In particular, participants were concerned about being able to get out in time for several reasons. First, they did not believe that the warnings would be early enough and/or loud enough or that there are sufficient sirens to cover the area effectively. The former relates to both the speed with which a warning can be issued, and the belief that a seismic event close inshore would reduce the effectiveness of a warning. Secondly, although noticed by many residents, evacuation signs are not known very well, were not specific enough, did not make sense to many residents, and were misleading. For example, some residents reported that following the signs could take you round in circles and that they did not direct one to safe areas. Further, residents were concerned that, with so many people following the signs simultaneously, the roads, and therefore the evacuation routes, will be blocked. Finally, many participants were highly concerned that there is often only one road out of town and that not all four lanes of this road will be available as exit routes due to accidents and people coming into the area (e.g., parents attempting to retrieve their children from

school, outside workers). These concerns are especially pronounced for residents living in flat areas and those residing furthest down the roads out of town. As a consequence of these beliefs many residents believe that they would not get out anyway and, therefore, would not self-evacuate when a tsunami occurs.

Overall, the analysis identified that the residents have to negotiate a highly complex decision-making process to figure out whether to respond, and how to respond, to a warning. However, a combination of their inadequate knowledge and the fact that the effect of tsunami depends on so many different factors, resulted in participants being highly unsure with regard to how to make these decisions, particularly within the short time frame available within which to make these decisions. Whether the participants respond and how they respond is influenced by several attitudes and beliefs that must be accommodated in public education programs if the effectiveness of the latter is to be enhanced.

If the effectiveness of the warning system is to be enhanced and evacuation and preparedness encouraged, it is important to acknowledge the reality of these beliefs. Consultation with the community (Paton, 2000) is required to reconcile these beliefs with the goals of the emergency management community and to promote sustained preparedness and readiness within communities vulnerable to tsunami hazards.

## 5. School Survey

In addition to the focus groups a series of six school surveys were also undertaken in February 2003. The school research builds on a number of studies undertaken over the past several years in Washington, Hawaii, and New Zealand to assess students' understanding and response to natural hazards (Johnston and Houghton, 1995; Johnston and Benton, 1998; Ronan and Johnston 2001, 2003; Gregg *et al.* 2004). Another primary purpose for undertaking such surveys is to establish and strengthen the link between school education programs and home-based preparedness (e.g., Ronan and Johnston, 2001). The questionnaire used in the current series of surveys is based on one developed for the 2000 Mount Rainier study (Johnston *et al.*, 2001; see also Ronan and Johnston, 2001). To date only a preliminary analysis of the survey has been undertaken. Students have a good awareness of the tsunami risk and perceive it to be a possible event within their lifetime. Most students report being involved in education programs and there is evidence that they have interacted with their parents on hazard issues. Some desirable levels of household preparedness appear to exist. Further analysis of these results will be undertaken over the coming year.

## 6. Conclusion

The overall conclusion of the three studies is that the hazard education program to date has been successful in terms of promoting awareness of and access to information about tsunami hazard among coastal Washington residents. Despite success in disseminating hazard information, levels of preparedness were recorded at low to moderate levels. The findings in these studies emphasized both the importance of accommodating pre-existing beliefs and interpretive processes, and the need for additional strategies to augment existing programs with initiatives that manage these beliefs and perceptions in ways that facilitate preparedness. The use of multiple methods – surveys, focus groups, and school surveys – is designed to enhance the validity of the findings. The data furnished by these analyses also provide baseline data against which subsequent intervention activities can be assessed.

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