Exploring Perceptions of Disaster Risk and Earthquake Hazard on Southern Vancouver Island, British Columbia, Canada

by

Brittany Jennifer Schina
B.A., University of Victoria, 2013

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ABSTRACT

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Southern Vancouver Island, situated on Canada's West Coast, is exposed to many natural and human-made threats due to its physical geography and demography. Perceptions of these disaster risks and of seismic hazard, in particular, were surveyed through locally-administered questionnaires conducted with 105 members of the general public and 13 emergency managers living and working on southern Vancouver Island, specifically in the Cowichan Valley Regional District (CVRD) and the Capital Regional District (CRD).

Perhaps the greatest risk to the region, and that, which is perceived by both the general public and practitioners as the greatest risk, is low frequency, high consequence earthquake events. The region is exposed to earthquakes from many sources, but has not experienced a damaging quake in several decades, begging questions as to whether residents consider earthquake a prominent threat and whether they have an accurate appreciation for the earthquake hazard (likelihood) in the region.

While researchers have scientifically quantified the earthquake hazard in the region for over 50 years, only in the past 10 years has this hazard information been presented in a format that is comprehensible by the general public. In order for individuals and communities to make informed decisions, this information must ultimately reach the public and be interpretable and actionable. This research describes and analyzes disaster risk and seismic hazard perception on Southern Vancouver Island, and identifies whether there are gaps in communication between the

scientists who create the knowledge, the emergency managers who disseminate the information, and the general public who ultimately needs to act on the information to increase their resilience.

Results reveal that earthquakes are perceived as the highest disaster risk among both the general public and emergency managers on southern Vancouver Island, and that a large majority of participants know that their community is at risk from an earthquake. In addition, while emergency managers consider mostly natural threats to be significant risks, the general public more commonly identify human-made intentional threats as significant risks. The study also found that gender and location influence how individuals prefer to receive hazard information. In addition, household income and time spent living on Vancouver Island are key variables for how likely members of the general public are to be prepared.

Findings suggest that while both emergency managers and the general public overestimate the earthquake hazard on southern Vancouver Island, on average emergency managers perceive the earthquake hazard to be greater than the general public does. Interestingly, general public respondents in the CVRD perceive seismic hazard to be higher than respondents in the CRD, while the calculated hazard is actually higher in the CRD. In addition, emergency managers underestimate residents' perceptions of earthquake hazard. In other words, they feel that the public underestimates the hazard when actually both emergency managers and the general public overestimate it. These misperceptions have implications for future seismic hazard and disaster risk communication.

Prior to this study, disaster risk perception has not been explored in detail in this region, and while limitations to this research are outlined, the study provides a useful descriptive analysis and baseline information for emergency managers and academic researchers to build upon. The findings of this research have specific relevance for emergency managers to inform their public education and outreach efforts around preparation, response and resilience to disasters on southern Vancouver Island.

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ACKNOWLEDGEMENTS

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DEDICATION

I would like to dedicate this thesis to the people of British Columbia, and the rest of the world, who have suffered through the consequences of disasters, and came together in the face of extreme adversity to help neighbours and strangers. It is the resilience of individuals and communities that makes the field of disaster management so inspiring.

CO-AUTHORSHIP STATEMENT

This thesis is the combination of two scientific manuscripts for which I am the lead author. In collaboration with my co-supervisors, Dr. Denise Cloutier and Dr. Mark Seemann, I developed the project structure, with an objective to determine a baseline of earthquake hazard perceptions, perception of disaster risk and the relationship between perception of the general public and emergency managers. This was identified as a key research area necessary to broaden the scientific knowledge of disaster risk perceptions and earthquake hazard perceptions on southern Vancouver Island. For both manuscripts, I led all research, data collection, data analysis interpretation of the results and manuscript writing. Dr. Denise Cloutier and Dr. Mark Seemann provided guidance throughout all aspects of the thesis project from developing research questions, methodology, development of the survey tools, human research ethics, data collection and interpretation, thesis writing and manuscript co-authorship.

1.0 INTRODUCTION

Vancouver Island, situated on the southwestern coast of Canada, is exposed to many natural and human-made hazards such as climate change, severe weather, flood, drought, hazardous material spills, disease outbreaks and power outages (Emergency Management BC, 2016; Natural Resources Canada, 2016b; Stevens & Hanschka, 2014; Zhang & Hebda, 2005). The degree to which people on Vancouver Island may be vulnerable to certain threats depends on how and where they live (Etkin, Haque, Bellisario, & Burton, 2004). For example, those who live on the coast of the island may be exposed to threats such as tsunami or adverse effects of climate change, while others inland may not be, and those in more rural, inland areas may be vulnerable to environmental threats such as compromised water supplies that those in urban areas may not necessarily face. Although threats vary by geographic location, population density, infrastructure and the built environment and more, emergency management professionals and scientists agree that a large earthquake event is likely not only Vancouver Island's greatest potential natural disaster, but Canada's as well (Clague, 2002; Etkin et al., 2004).

The unique makeup of southern Vancouver Island, specifically the Capital Regional District (CRD) and Cowichan Valley Regional District (CVRD) (Figure 2.1), result in a broad range of threats and varied vulnerabilities. Threats range from potential catastrophic natural threats such as landslides, flooding, and tsunamis on the West Coast, to the potential for intentional human-made threats such as terrorism due to the proximity of Capital city infrastructure and the Canadian Forces Base, as well as potential for unintentional human-made hazards that come with any settled place such as motor vehicle accidents, infrastructure failures and structural fires (Office of the Auditor General of British Columbia, 2014; Shreve et al., 2014). In addition, regional demographics indicate several population segments who have increased vulnerability such as: older populations, transient, non-permanent residents due to the concentration of universities and colleges in the sampled areas and homeless peoples due to the

relatively mild climate in an urban centre (BC Stats, 2012b, 2012c; City of Victoria, 2012). These populations may be more vulnerable to disasters due to their inability to either respond or recover independently. For example, older adults may have trouble physically protecting themselves in an emergency or evacuating a building, whereas transient or homeless people may not have a safe place to shelter or supplies to support themselves, therefore they will have to take advantage of shelter and aid from external resources, placing a potential strain on the community. These are just some of the unique structural and social vulnerabilities the region faces. When examining economic vulnerability, both the CRD and CVRD have a larger proportion of lower income households and older people than the provincial average (BC Stats, 2012b, 2012c).

In addition to the array of threats that southern Vancouver Island faces, the earthquake potential in the region is considered the most significant threat as it is one that would lead to a plethora of cascading secondary threats ranging from tsunami to fires to floods (Emergency Management BC, 2016; Natural Resources Canada, 2013; Office of the Auditor General of British Columbia, 2014; Renteria, 2014). For this reason, emergency managers on southern Vancouver Island focus much of their planning, preparedness and public outreach efforts on informing local residents about earthquakes, under the assumption that if you are prepared for an earthquake, you are prepared for anything (Emergency Management BC, 2016; Renteria, 2014).

In Canada, the southern Pacific Coast is the most seismically active region of the country, with over 1000 earthquakes recorded in the region each year (Natural Resources Canada, 2013). These are generated by tectonic interactions between the Pacific, North America and Juan de Fuca plates (Clague, 2002). The Juan de Fuca oceanic plate, located west off the coast of Vancouver Island and extending from the northernmost point of Vancouver Island to northern California, is moving eastward towards North America at the speed of 2-5 centimetres per year, and subducting beneath the continental plate, creating what is called the Cascadia Subduction Zone (Figure 1.1) (Clague, 2002; Natural Resources Canada, 2013). In this region, there have

been over 100 earthquake events registering a magnitude of 5.0 or greater in the past 70 years (Natural Resources Canada, 2013). However, most recorded earthquakes are not felt, as they are typically located in unpopulated areas such as off the coast, and occur at depths that would not be felt on the surface (Natural Resources Canada, 2013). In addition, a regional earthquake has not caused significant damage in more than 50 years (Natural Resources Canada, 2013).

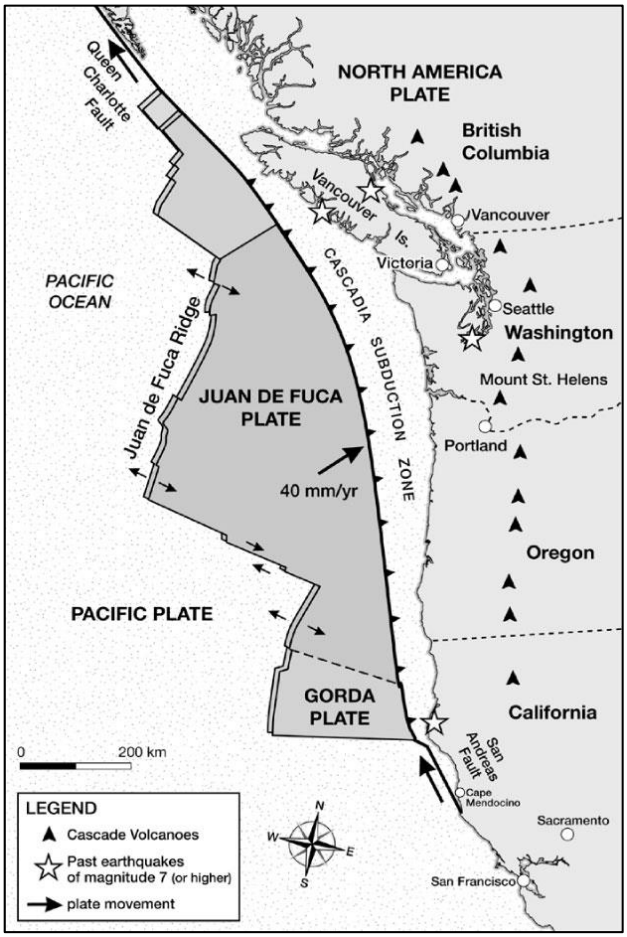

Figure 1.1 Cascadia Subduction Zone (Thompson, 2011)

The West Coast of Canada has a unique predisposition to earthquakes, as it is exposed to various types of tectonic plate movements (Natural Resources Canada, 2013; Seemann, Onur, & Cloutier-Fisher, 2011). These movements include sliding past each other, converging with each other or diverging from each other (Natural Resources Canada, 2013; Seemann et al., 2011). Vancouver Island is vulnerable to three categories of earthquakes. Subduction interface

earthquakes, also called “megathrust” earthquakes, typically have a magnitude greater than 8.0 and typically cause ground shaking for longer than two or three minutes, resulting in significant damage and threats to public safety (Natural Resources Canada, 2013; Rogers, 1988; Seemann et al., 2011). Two other categories of earthquakes known to occur in this region are crustal and sub-crustal earthquakes (Clague, 2002; Hyndman & Rogers, 2010; Natural Resources Canada, 2013; Seemann et al., 2011). On the south coast, crustal earthquakes occur within the North America plate and sub-crustal earthquakes occur within the subducting Juan de Fuca plate, beneath central Vancouver Island (Clague, 2002; Hyndman & Rogers, 2010). All recorded earthquakes on and near Vancouver Island have been crustal and sub-crustal earthquakes (Hyndman & Rogers, 2010). The last Cascadia Subduction Zone event known to have occurred off the West Coast was on January 26, 1700, therefore the impact that modern North American infrastructure would experience from this type of event has been only been estimated (Clague, 2002; Hyndman & Rogers, 2010). While no Cascadia subduction event has been observed, based on geologic evidence (Clague, 2002), it recurs episodically and is expected to be catastrophic. This event has not been experienced in over 300 years, and responders and emergency managers are unsure of their capacity to respond to an event of this magnitude (Renteria, 2014). Looking to other regions of the world as a proxy to begin to grasp the potential impacts of this type of subduction interface event and the rebuilding and recovery demands that would follow, it is likely that costs would exceed $75 billion in southwest BC (Cascadia Region Earthquake Workgroup, 2013; Clague, 2002; Hyndman & Rogers, 2010; Insurance Bureau of Canada, 2013; Renteria, 2014). Due to the magnitude associated with subduction interface events, they typically trigger larger and more numerous aftershocks than smaller crustal and sub-crustal earthquake events (Seemann, Onur, & Cassidy, 2008). These are typically widespread and can occur over hundreds of kilometres, affecting a much broader region than the more localised crustal and sub-crustal events (Natural Resources Canada, 2016a; United States Geological Survey, 2016).

The need to effectively communicate the implications (specifically, the likelihood and consequences) of megathrust earthquakes is significant as they are less frequent than sub-crustal or crustal earthquakes, but their consequences can be greater due to the wider region affected and the triggering of such cascading threats as landslides and tsunami (Rogers, 1988; Seemann et al., 2008; Seemann et al., 2011), which increases the probability of structural damage, personal injury and economic losses.

Recent quantitative research of seismic hazard on Vancouver Island, BC, has provided a foundation in conveying scientific estimations to the general public (Seemann et al., 2011). For example, by translating highly technical scientific estimations expressed as peak ground accelerations [PGA, the largest increase in velocity recorded during an earthquake (United States Geological Survey, 2016)] or spectral accelerations [SA - the approximate acceleration that is experienced by a building, as predicted by a model (United States Geological Survey, 2016)] into simplified seismic ground-shaking probabilities, Seemann et al. (2011) offer new seismic probabilities and argue they can provide meaningful information for community decision-makers and the broader public regarding the likelihood of damaging earthquakes occurring. Presumably, the general public can better comprehend simplified percentage probabilities than they can understand PGAs and SAs. However, the best way to effectively communicate seismic hazard estimates remains unclear, as limited research has been conducted to understand the most effective ways to frame and distribute information on earthquake hazard, consequence and risk to the general public (Mileti & Fitzpatrick, 1992; Nigg, 1982). This is a fundamental gap in earthquake risk communication and it is one that this research aims to address.

While studies of earthquake perceptions are limited, particularly in North America, the majority have been conducted in communities that have recently suffered a large earthquake, which tell us that recent or direct experience with an earthquake event increases perception (Kung & Chen, 2012; McClure, Johnston, Henrich, Milfont, & Becker, 2014; Nakayachi, Yokoyama, &

Oki, 2014). On Vancouver Island the only study that quantified perceptions of earthquake risk on Vancouver Island was conducted over 30 years ago, when Jackson (1981) looked at Victoria, BC as one of several North American, coastal study sites exploring whether participants identified earthquake as a disadvantage to living in their structure and location. Jackson (1981) found that only 1.7% of all respondents even mentioned earthquakes. This highlights either a lack of perception of earthquake risk, or a degree of apathy to the threat when this research took place more than 30 years ago.

This thesis aims to address the identified research gaps: Perceptions of disaster risk and earthquake hazard among members of the general public and emergency managers living on southern Vancouver Island and recommended ways to inform the public of hazard and risk based on their perceptions.

1.1 Exploring Disaster Risk

There is potential for disasters of some scale to happen wherever we live. However, potential risk from threats, whether frequent or infrequent, high or low severity is not always well understood by the general public. In some research, disaster risk is defined as the potential product of hazard (or likelihood) and consequences (R= H x C), and is explained by diverse forms of potential losses such as loss of lives, health status, livelihoods, and assets and services (Bosher, 2008; The United Nations Office for Disaster Risk Reduction, 2009). Researchers have noted that while advancements in technology and development have increased our knowledge regarding disaster risk and have informed prevention, protection and mitigation efforts enabling us to live with risk, an over-reliance on technology has also increased the potential for the negative consequences that result from natural hazards (Mileti, 1999). For example, technological mitigation efforts such as levees can prevent short-term damage from flooding, but eventually have exponential consequences when hazard events exceed the capacity of the mitigation to contain the level of destruction, causing greater capital losses and threats to community safety

(Beck, 1992; Burton, Kates, & White, 1968; Mileti, 1999). Other explorations of the term risk in relation to hazard and disaster studies discuss risk as a "combination of the factors that determine the potential for people to be exposed to particular types of natural hazard" (Wisner, Blaikie, Cannon, & Davis, 2003, p. 7). These terms and others necessary for the comprehension of this thesis are further explained in the subsequent section.

For clarity, this section defines key words commonly used throughout this thesis. It is important to note that terms referenced in this section have various definitions, many of which are debated in the literature (Drabek & Evans, 2007). However, for the purposes of this thesis, the following definitions are adopted for analysis.

Recognizing the variation inherent in these definitions, this thesis presents **risk** as the *product of a hazard occurring and the consequences that will follow*, **hazard** as the *likelihood of a damaging event occurring in a given location within a given timeframe*, **consequences** as *the outcomes, whether negative or positive, material, economic, social, environmental or otherwise*, and a **disaster** as the *negative overall outcome of risk* (Cutter et al., 2008; Gierlach, Belsher, & Beutler, 2010; Seemann, 2012; Wisner et al., 2003) (Figure 1.2). The relationship between these terms lends itself to the equation: Risk (R) = Hazard (H) x Consequence (C) (Cutter et al., 2008; Gierlach et al., 2010; Seemann, 2012; Wisner et al., 2003), which is used as a framework for analysis in this thesis. These terms are further explained in the remainder of this section.

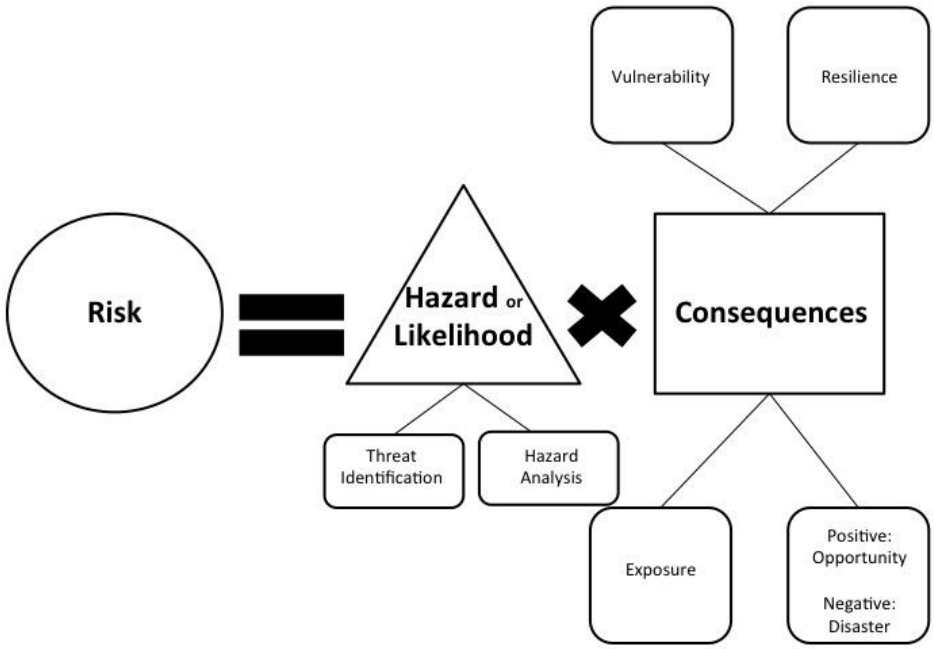

Figure 1.2 Visual explanation of the relationship between risk, likelihood and consequences
Adapted from: Cutter et al., 2008; Gierlach et al., 2010; Seemann, 2012; Wisner et al., 2003

1.1.1 Risk. Risk is the product of a threat's hazard and the consequences that will follow, whether environmental, material, economic, social or otherwise (Figure 1.2) (Gierlach et al., 2010; Seemann, 2012). Risk implies a certain amount of surprise in its outcomes: we can predict what an outcome may be, but, as a product of probability, there is a certain level of uncertainty. With uncertainty, may come surprise. Risk can have either a positive or negative projected outcome. Expectations of risk formulated by the general public are created based on their previous experience, perceptions and knowledge, and are generally taken based on opportunities presented for positive outcomes (Nelson, Adger, & Brown, 2007).

1.1.2 Hazard. Hazard refers to the frequency or likelihood of a potentially dangerous and damaging phenomenon or threat occurring at a given location in a given period of time (Alexander, 2011; Seemann, 2012). Hazard is often commonly perceived by the public to be synonymous with risk, although in the academic community, these terms are considered quite

different concepts. The general public's perceptions of risk tend to actually outline their expectations of hazard, or components of it such as potential to occur and for negative outcomes, rather than risk itself (Slovic, 1987). For the purposes of this thesis, hazard and likelihood are used interchangeably, whereas risk and hazard are used distinctively in alignment with these definitions.

1.1.3 Consequences. Consequences can be considered as human loss or injury, economic loss or suffering, structural damage or loss and environmental impacts (Kaplan & Garrick, 1981). Consequences can also include negative psychosocial impacts for those affected by a disaster (Joffe, Rossetto, Solberg, & O'Connor, 2013). However, in some instances, consequences can be considered benefits or opportunities that arise following a disaster. For example, building homes in a floodplain increases an area's exposure to negative consequences from flooding such as injury or structural and material damage, which may not happen if the area were not settled. However, opportunities related to development, affordability and ambiance of an area may impact this type of decision-making. This opportunity, combined with an individual's perceived risk, (which may be that the likelihood of a flood happening is low) may lead to an increased risk for an area due to an increase in its exposure (explained below).

1.1.4 Threat. A threat is one of two components (threat and hazard analysis) that form the basis for defining a risk's likelihood (Figure 1.2). Threat refers to any phenomenon or event that may pose a danger to an individual, community or geographic area (Drabek & Evans, 2007). A threat differs from a hazard (defined below) in that a hazard also includes the frequency, rate or probability of occurrence while a threat does not. Threats are independent of the likelihood of an event occurring. For example, earthquakes or floods are generally considered types of threats that pose a potential danger to populations. The earthquake or flood *hazard* is a specific estimate of the frequency, rate, or probability of a threat occurring in a given area within a particular timeframe. Earthquake fault maps outline the distribution of potential earthquake threat in a region, while an earthquake hazard map outlines the likelihood of an earthquake occurring on a

given fault within a particular time frame. Similarly, a flood map identifies the area where flooding may threaten, while a flood hazard map indicates the likelihood of flooding occurring in an area within a given period of time. Hazard analysis typically requires specific threats be identified (*e.g.* the types of earthquake or the types of flood) and analyzed before aggregating and/or comparing the relative hazard (Alexander, 2011; Seemann, 2012).

1.1.5 Types of threats. Three main types of threats are distinguished for the purposes of this thesis. These are: natural, unintentional human-made and intentional human-made.

Natural threats. Natural threats are those that have their origins in the natural environment (Alexander, 2011). Examples of natural threats include earthquakes, floods and hurricanes.

Unintentional human-made threats. Unintentional human-made threats differ from natural threats because their origins are anthropogenic, and they are created *unintentionally*. Examples of unintentional human-made threats include vehicle crashes, toxic spills and failures of major infrastructure such as electric power.

Intentional human-made threats. Intentional human-made threats refer to threats that are anthropogenic in nature, but that are also *intended.* These are often referred to as technological threats or technological disasters (Alexander, 2011). An example of an intentional human-made threat is a targeted shooting.

1.1.6 Vulnerability. Vulnerability is a term that is typically used in the disaster literature to refer to individual or community susceptibility to being harmed (Adger, 2006). Vulnerability can be described as an individual or community's circumstances that make them susceptible to the greater, more damaging consequences of a disaster. Vulnerability affects what an individual or community's risk from a threat is (Wisner et al., 2003) and may play a part in their risk perception from events. There has been much debate and discussion within the literature and research in this field over definitions of vulnerability, and whether vulnerability is an appropriate

and useful aspect to focus on in hazard research (Cutter, 1996). In some literature, vulnerability can be thought of as exposure estimates in relation to other aspects of resilience (Cutter, 1996; Cutter et al., 2008). For example, someone who lives near the ocean would have a greater likelihood of exposure and geographic vulnerability to a disaster such as a tsunami; however, based on their economic circumstances, their economic resilience may be high as they are likely to have the financial means and access to resources for repair and recovery following a disaster like a tsunami.

1.1.7 Resilience. Resilience is a term that is closely related to vulnerability, as resilience refers to strengths and vulnerability refers to weaknesses of an individual, community or organization. Resilience is explained as having two qualities: Inherent and adaptive (Cutter et al., 2008). Inherent qualities of resilience refer to a community that has the ability to function well during times of non-crisis, whereas adaptive communities remain flexible in response to disasters, displaying an ability to perform well under extreme pressures (Cutter et al., 2008). For the purpose of this thesis, both vulnerability and resilience are included as components of consequences (C) in the R = H x C equation that frames the analysis of this thesis (Figure 1.2).

1.1.8 Exposure and opportunity. Exposure has an influence on the likelihood that an individual, community or geographic location will experience a hazard. Exposure is defined as simply a situation whereby any assets, whether social, physical, economic or otherwise, are located in areas at risk from hazards (Rufat, 2012; The United Nations Office for Disaster Risk Reduction, 2009; Wisner et al., 2003). Direct exposure refers to a direct impact from a threat, for example, an individual being displaced from their home due to structural collapse from an earthquake. Indirect exposure refers to a secondary impact influencing an individual's exposure, such as ports being closed from earthquake damage – this may impact individuals not living in an earthquake-affected area because it could impact the ability to move food, fuel and other resources in and out of surrounding areas. Opportunity is typically what an individual or

community would gain from increasing their exposure to hazards. Often, opportunity related to natural hazards has to do with aesthetic or economic factors. An individual may increase their exposure by settling in a hazardous area, but the economic opportunity presented in that hazardous area may be greater than in an area that is not hazardous. Additionally, communities affected by negative consequences of a disaster may be given the opportunity to "build back better" and decrease their exposure from future events. Exposure and opportunity are two factors that strongly influence an individual's consequences as an outcome of risk (Figure 1.2).

1.1.9 Disaster. In order to be classified as a disaster, according to the *Encyclopedia of Disaster Relief*, an event must have "a major impact on people's lives, livelihoods, and property" (Alexander, 2011). It is considered the negative consequence outcome of the R=H x C (Figure 1.2). Charles Fritz, one of the pioneers of disaster research, offers a definition of disaster that remains commonly cited within the social science literature (Fritz, 1961). He describes a disaster as:

> An event, concentrated in time and space, in which a society, or a relatively self-sufficient subdivision of society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of the society is prevented. (p. 65)

Although Fritz's definition is commonly cited (Drabek & Evans, 2007; Nigg, 1982; Tierney, 2014), it is not unanimously accepted. To attach this dispute to an important geographic concept, one must attempt to place the term disaster on a scale. This definition may not be appropriate for a family who has lost all of their personal belongings in a fire, as this would certainly be a disastrous situation to the family, but perhaps not to a society or a community. Therefore, for the purposes of this thesis, the operational definition of disaster will be: The negative outcomes of an adverse event that cause an individual, community or society to interrupt their normal operations to respond to an event, and then to build back (whether physical,

economic, emotional or otherwise) to their previous state, or to a "new normal," based on their experiences.

1.2 Risk Perception

Reactions to perceived dangers and judgments about how to respond to danger can best be understood in terms of risk perception. Risk perception is a subjective conclusion about one's likelihood to be affected by, or to encounter a hazard that is associated with negative consequences (Gierlach et al., 2010). The emergence of studies in risk perception has been, in part, a response to the observation that there are significant disparities in experts' assessments of risk and the general public's intuitive perceptions of risk (Ho, Shaw, Lin, & Chiu, 2008).

An individual's direct experience or a communicated direct experience with a hazard event (*e.g.*, hearing about a personal encounter with a threat from a friend or family member) has been determined to be one of the strongest measures of how a risk is perceived by an individual (Tierney, Lindell, & Perry, 2001). It is uncommon, for individuals who live in regions that are geographically vulnerable to natural threats to be completely unaware of the risks facing their community (Kates, 1976). And yet surprisingly, studies have shown that individuals tend to overestimate risk from rare events, and underestimate risk from more common events (Slovic, 2012; Slovic, Fischhoff, & Lichtenstein, 1979). For example, a 1979 study of risk perceptions found that nuclear power was ranked as the riskiest of 30 activities and events, despite the fact that the same individuals ranked annual fatalities from this activity to be low (Slovic et al., 1979). Following up on this particular type of risk perception in 2012, Slovic (2012) again found that individuals reported nuclear power to be a highly ranked risk, although it was still considered a low rated risk by experts. In addition, it was noted that research conducted following significant nuclear events around the world (for example, the Fukushima Daiichi Nuclear Power Station accident) seemed to impact perceptions, increasing the frequency of negative perceptions among respondents associated with nuclear power (Slovic, 2012). Although these global nuclear events

may not necessarily have been a direct experience of the participants in these research studies, media exposure of the stories could be perceived to have had the same impact as a friend or family member explaining their experience.

Southern Vancouver Island is an area well known for various threats, including significant seismic activity. This leads researchers to hypothesize that individuals living in the region are well aware of general disaster risks, and the specific earthquake risk in their community. Based on the previous example of overestimating nuclear power based on events happening elsewhere in the world, researchers may also hypothesize that individuals living on southern Vancouver Island may overestimate the earthquake risk in their region due to the media coverage of recent significantly damaging earthquake events around the world. For example, the 2011 M9.0 earthquake in Japan and the 2011 M6.3 earthquake in Christchurch, have both been used as examples of the types of earthquake events that could occur in southwestern BC.

Based on anecdotal knowledge, growing coverage in the media and expansion of earthquake drills in schools and workplaces, the threat of a significant seismic event occurring on southern Vancouver Island is a fact that seems to be understood and accepted by most residents. However, due to a lack of damaging seismic events occurring in recent memory, the connection to heightened risk perception through direct experience is not likely to exist for many residents. Studies of risk perception can provide valuable, applicable insights into how people prepare for threats, as many studies have found that as risk perception goes up, particularly for natural threats, household preparedness levels go up as well (Tierney et al., 2001). The literature shows that the way in which messages regarding risk, hazard, and consequences are constructed has a direct effect on how individuals understand their risk, and how they will act to mitigate their personal risk (Rothman & Salovey, 1997; Slovic, 1987).

1.3 Risk Communication

The literature suggests that a key issue with risk communication is that societies rely on receiving protection and education from institutions and professionals (such as scientific organizations) who seem "alien" to citizens and who report in a language that often seems inaccessible to the majority of society members (Beck, 1992). This results in confusion, distrust, and the potential for greater risk due to the inability of the general public to understand the information being presented (Beck, 1992; Mileti & Fitzpatrick, 1992; Wachinger, Renn, Begg, & Kuhlicke, 2013). In response to issues of inaccessibility and miscommunication in information flows, a subfield of risk studies emerged in the late 1980s and early 1990s known as "risk communication," exemplified by research aimed at reducing communication barriers, framing messages effectively and responding to the inaccessibility of scientific information available to the public (Beck, 1992; Rothman & Salovey, 1997; Slovic, 1987). Risk communication research brings attention to this issue, calling on institutions to consider their audience in order to overcome the inaccessibility of scientific information to the public (Beck, 1992; Slovic, 2012). The risk communication and the highlighted issues begs dynamic questions for the field of emergency management: Whose responsibility is it to translate the science of risk, and whose responsibility is it to communicate that science out to the public? Does that responsibility lie within the academic or scientific community, or does it lie within the emergency management community? Or is it expected now, in our instant communication society, be a combination of both?

Within the system that exists in BC, local government emergency managers are typically expected to communicate the local risk and active events (such as imminent storms, potential flooding, or a forecasted tsunami) to the public and therefore they must work to be the knowledge translators between the public who are consuming the risk information and the scientists who are distributing it (Johnston & Paton, 2001; Renteria, 2014). Perhaps, the larger issue is that a greater

capacity for communication and a common language must exist between scientists and emergency managers in order to accommodate the public's ability to make informed decisions related to their risk.

In order for risk communication to be most effective it must cover: The probability of the threat occurring (likelihood/hazard), the severity (exposure) of the possible adverse event and the effect of the event on the possible victim(s) (consequences) (Ahmed, Naik, Willoughby, & Edwards, 2012). It should focus on explaining the scale of the possibly disastrous event, and not avoid reality in order to decrease potential fear among the public (Sandman & Lanard, 2004). The most useful risk communications must also be delivered in a timely fashion (for example, on the heels of a minor threatening event, such as a small earthquake, or surrounding a date of significance, when the attention of the public is captured) and this must be accounted for in planning of risk communication (Slovic, 2012). Crisis communication experts highlight the uncertainty and the probability of the event in an effort to address transparency, as well as to avoid outrage when consequences do not turn out as expected (Sandman, 2003).

Communications related to risk are typically focused on motivating individuals to take proactive actions, specifically about how to know the risks and to become prepared, usually by creating an emergency kit and emergency plan. Research shows that messaging regarding preparedness and risks should be simple, clear and consistent, while being delivered through multiple channels, sources and agencies (Coppola, 2011; Coppola & Maloney, 2009). It is also important for messaging to communicate actionable risk, which refers to presenting individuals with actions they should and can take to minimize risk, rather than what they should not do (Mileti, 1999; Wood et al., 2012). Research also emphasizes the importance of targeting messaging towards the correct audience(s), which requires understanding their needs, beliefs and customs (Munroe, Pennisi, & Mileti, 2004).

The research conducted for this thesis explores disaster risk perception, seismic hazard perception, communications and preparedness. The results of these findings are further framed within the context of the literature reviewed in Chapters 2 and 3.

1.4 Research Scope and Objectives

This thesis explores disaster risk perceptions in populous areas of southern Vancouver Island, with a specific focus on earthquake hazard. It also explores similarities and differences in disaster risk perceptions within and across groups (the general public and emergency managers), to identify potential directions for local and regional emergency management practitioners to enhance preparedness and reduce disaster risk.

The ultimate, overarching goal of the thesis is to contribute to fostering healthier, safer and more disaster resilient communities on Vancouver Island by providing emergency managers and other decision-makers with information about the general public's level of understanding of earthquake hazard and disaster risk.

The specific objectives of this research are:

1) To improve our understanding of the general public's perceptions of threats and disaster risk in their community;
2) To improve our understanding of emergency manager's perceptions of community disaster risk on southern Vancouver Island;
3) To describe and compare the general public's earthquake hazard perceptions to both emergency managers' earthquake hazard perceptions, and to calculated earthquake hazard estimates; and
4) To consider the implications of the research findings for improving hazard communications.

1.5 Thesis Outline

Following this introductory chapter, this thesis offers two paper-based manuscripts. Each manuscript has been developed to stand-alone, and as a result there is a certain degree of overlap and repetition with respect to the description of terms and some of the methodological considerations in this thesis.

The remainder of this thesis is organized as follows:

Chapter 2: This first manuscript provides context for the research, outlining details of the study area, survey design, implementation and sample, as well as detailing the research methodology. It explores disaster risk, earthquake knowledge, risk communication and preferences as well as preparedness among the general public and emergency managers. This chapter addresses research objectives one, two, and four and presents information on general public perceptions and preparedness for disaster and earthquake risk on Southern Vancouver Island, BC, Canada.

Chapter 3: This second manuscript provides a more detailed exploration of the literature specifically related to hazard perceptions and features a comparison of general public and emergency manager perceptions of earthquake hazard on southern Vancouver Island, BC, Canada. This manuscript addresses research objective three, and to some extent, four.

Chapter 4: The final chapter of this thesis summarizes key findings and identifies insights that emerged from both manuscripts, and the study as a whole. It also offers some study limitations, recommendations for emergency management practitioners and considerations for future research.

2.0 EXPLORING DISASTER AND EARTHQUAKE RISK PERCEPTIONS, KNOWLEDGE AND PREPAREDNESS ON SOUTHERN VANCOUVER ISLAND, BRITISH COLUMBIA, CANADA

2.1 Abstract

As population growth continues to rise and infrastructure increases to keep up with demand in hazard-prone areas, consequences from natural and human-made threats continue to increase. Some threats like flooding and wildfires are cyclical and are expected every year. Others, like earthquakes and tsunamis are less frequent and cannot be predicted, creating more challenging tasks for emergency managers, and more pressure for the public to know the threats and to be prepared to protect themselves for extended periods of time. This paper identifies and describes perceptions of disaster risk, earthquake risk, preparedness and more among participants in the Capital Regional District (CRD) and the Cowichan Valley Regional District (CVRD) on southern Vancouver Island, British Columbia (BC). In-person semi-structured surveys were conducted with 105 members of the general public and 13 emergency managers living and working within the CRD and CVRD. Results reveal similarities, differences and trends within each group, in addition to comparing and contrasting findings between the two groups. The key findings of this research suggest that earthquake is the highest perceived risk among both the general public and emergency managers, and that most participants know their community is at risk from an earthquake as well as a tsunami. In addition, while emergency managers consider mostly natural threats to be significant risks, the general public more commonly identify human-made intentional threats as significant risks. Results also show statistically significant relationships between how individuals prefer to receive hazard information according to their gender and geography, as well as how prepared individuals are according to their household income and time spent living on Vancouver Island. This paper offers information for the

emergency managers in the sampled regions to support their public education and outreach efforts with an improved knowledge of the resilience and vulnerability of the public in their jurisdictions.

2.2 Introduction

As the global population and infrastructure continues to grow, impacts from natural and human-made threats are changing rapidly with greater consequences. While annual disaster-related mortality rates are in decline, the economic impacts of disasters are increasingly devastating (Centre for Research on the Epidemiology of Disasters, 2014; Pourghasemi, Moradi, & Fatemi Aghda, 2013). Communities on Vancouver Island, British Columbia, Canada are similarly experiencing a population increase of approximately 30% over the past 30 years (BCStats, 2017). In addition, spending on building permits has increased from just under $600,000 in 1998 to over $1.8 million in 2016 (BC Stats, 2017). While this growth shows positive economic impacts, it simultaneously increases Vancouver Island's exposure to adverse consequences from an array of natural and human-made threats that pose risks in the region. These threats range from potential catastrophic natural threats such as tsunamis on the West Coast, to the potential for intentional human-made threats such as terrorism due to the location of the Provincial capital city, the Legislature and the Canadian Forces Base. In addition, there is potential for unintentional human-made threats that come with any settled place such as motor vehicle accidents and structural fires. Due to the relatively mild climate and desirable Oceanside location, people are drawn to Vancouver Island as a place to visit and live, creating uniquely vulnerable populations among both residents and visitors (Destination British Columbia, 2015).

Vancouver Island is a large island with a mountainous topography, stretching more than 31,000 km^2 north to south, and situated approximately 50 kilometres off the southWest Coast of BC, (Guthrie, 2005). The diversity of both geography and demography on the island makes its threat profile broad and encompassing. Vancouver Island is home to more than 17.1% of BC's population and makes up approximately 6.1% of BC's land mass (BC Stats, 2012a). In addition, the region faces specific human vulnerabilities arising from an aging population, a transient university population, and a mild climate leading to large numbers of homeless people (BC Stats,

2012b, 2012c; City of Victoria, 2012). Vancouver Island's geography is vast and diverse, leading the region as a whole in facing several natural threats including: earthquakes and tsunamis, avalanches, rockslides and landslides, flooding and wildfires (Guthrie, 2005). Many of these types of events are seasonal and cyclical, and are expected by first responders, emergency managers and the public alike, year after year, enabling standard emergency planning to address the considerations needed for local governments and the public to cope with these events with limited assistance (Emergency Management BC, 2016).

With advances in modern technology, scientists can forecast nearly all of these types of threats, except for earthquakes. Earthquakes are considered one of the region's most significant threats as there is no way to predict earthquakes, and their consequences range so substantially, making it difficult to plan for their unpredictability (Emergency Management BC, 2016; Natural Resources Canada, 2016b).

Vancouver Island is at risk from three types of seismic hazard events with potential for catastrophic consequences, including two well-documented scenarios: Shallow crustal or sub-crustal earthquakes below the city centre of Victoria, or a subduction interface earthquake off the coast of British Columbia (Emergency Management BC, 2016; Natural Resources Canada, 2016b; Seemann et al., 2011). These events can occur independent of one another, and each has the potential for devastating environmental, social, economic and physical consequences at the regional scale (Natural Resources Canada, 2016b; Seemann, 2012).

The Pacific Coast is the most seismically active region of Canada, with seismologists recording over 1000 earthquakes in the region each year (Natural Resources Canada, 2013). However, most earthquakes recorded in this region are not felt, and none have caused damage in decades (Natural Resources Canada, 2013). As a result, it is important to consider whether citizens and governing agencies have become complacent regarding levels of risk in the region. In order to reduce disaster risk, it is imperative to explore the extent to which perceptions of seismic risk exist, despite the lack of physical reminders.

2.2.1 Disaster risk and risk perceptions. At the core of the research objectives for this paper is an understanding of the public's perceptions of disaster risk. In order to explore the general public's seismic hazard and risk perceptions, researchers set out to first determine whether the public perceives the seismic threat in the region as a risk at all, and if so, is it considered the greatest risk, or are there others that are much more prominent? Disaster risk, for the purposes of this paper, is defined as the potential product of hazard (or likelihood) and consequences (R= H x C), and is explained as having diverse forms of potential losses such as loss of lives, health status, livelihoods, assets, services and more (Bosher, 2008; The United Nations Office for Disaster Risk Reduction, 2009).

Reactions to perceived dangers and judgment about how to respond to danger can be understood as risk perception. Risk perceptions are subjective conclusions about one's likelihood to be affected by, or to encounter a threat that is associated with negative consequences (Gierlach et al., 2010). The emergence of studies in risk perception has been, in part, a response to the observation that there are significant disparities in experts' assessments of risk and the general public's intuitive perceptions of risk (Ho et al., 2008).

An individual's direct experience or communicated direct experience with an event (such as hearing about a personal encounter with a threat from a friend or family member) has been determined to be one of the strongest measures of how high a risk is perceived by an individual—particularly in the realm of natural hazards research (Tierney et al., 2001).

The literature on risk perception, is vast and global in extent (Kung & Chen, 2012; Lee, Markowitz, Howe, Ko, & Leiserowitz, 2015; Slovic, 1999; Wachinger et al., 2013; Weinstein, 1984). A smaller pool of literature explores disaster risk perception within areas at risk from a broad range of threats, similar to Vancouver Island (Gierlach et al., 2010; Ho et al., 2008; Newton, 1997; Usuzawa et al., 2014). During the literature review for this paper, no research was discovered exploring perceptions of the broad range of disaster risk on Vancouver Island.

Considering Vancouver Island's significant earthquake risk, much of the research reviewed for this paper was done so with an earthquake perception lens. In that regard, studies of earthquake perceptions are limited as well, with the majority having been conducted in communities that have recently experienced a large earthquake (Kung & Chen, 2012; McClure et al., 2014; Nakayachi et al., 2014). Jackson (1981) conducted the only earthquake risk perception study on Vancouver Island over 30 years ago. This study found that only 1.7% of individuals surveyed identified seismic risk to be a disadvantage to living where they do (Jackson, 1981).[1] Shortcomings of the study include the fact that it was conducted over thirty years ago, in addition to the lack of geographical analysis (no distinction in analysis between different study sites). Due to these limitations, there is a need for research to delve deeper into what risks residents on Vancouver Island consider a threat to themselves and their community, as well as how that relates to what the risks are, and correspondingly to how prepared residents may be. The lack of research in the region provides an important rationale for this research.

2.2.2 Individual disaster preparedness. The existing literature on disaster and emergency preparedness in Canada highlights a key fact that most Canadians are neither prepared for an emergency, nor have they taken the recommended minimum precautions of preparing an emergency kit and creating an emergency plan (Levac, Toal-Sullivan, & O'Sullivan, 2012). Historical research tends to blame Canadians' lack of preparedness measures on the country's previously limited experience with the consequences of disasters, as well as an anecdotal perception of apathy and the attitude that "it will not happen to me" (Etkin et al., 2004; Newton, 1997; Renteria, 2014).

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[1] In Jackson's 1981 paper, Victoria, BC, was one of several survey sites in an earthquake-prone area that were analyzed collectively.

Individual perceptions of disaster risk are important indicators of a region's resiliency (Canadian Red Cross, 2013; Emergency Management BC, 2016; Levac et al., 2012). Research has shown that as perceptions of risk increase, household preparedness levels also go up (Tierney et al., 2001). This is important because an increased level of household preparedness increases a community's resilience making individuals and families better able to sustain themselves without assistance following temporary or sustained interruptions associated with a disaster event (Johnston & Paton, 2001).

2.2.3 Research purpose and objectives. Given the lack of research surrounding disaster risk and earthquake risk perceptions on Vancouver Island, the intention of this research is to provide emergency managers and local decision-makers with an appreciation for the general public's understanding of what threats residents perceive they are at risk from, and where gaps in knowledge and communication exist in order to foster healthier, safer and more disaster resilient communities on Vancouver Island. To achieve this, the research attempts to: a) Explore what threats the general public perceive their community to be at risk from; b) Explore emergency manager perceptions of community disaster risk on southern Vancouver Island; c) Understand how the general public comprehends earthquake and other threat risk in order to improve hazard communications; and d) Understand the preparedness level of the general public on southern Vancouver Island.

Data from two surveys, one with members of the general public and one with emergency management practitioners, form the major data sources for this paper. The complete survey instruments are found in Appendix A: Questionnaire Tool: General Public (Group 1) and Appendix B: Questionnaire Tool: Emergency Management Professionals (Group 2). This paper focuses on presenting a broad, descriptive overview of the major findings from these surveys.

2.3 Methodology

Semi-structured interviews were delivered to two distinct groups of stakeholders within the study sites of the Capital Regional District (CRD) located on southern Vancouver Island, and the Cowichan Valley Regional District (CVRD), located just north of the CRD. Participants included 105 members of the general public and 13 emergency management professionals working in these regional jurisdictions. Survey data explored the complexities relating to disaster risk, earthquake risk, associated perceptions and personal preparedness levels on southern Vancouver Island.

2.3.1 Study site. The study sites chosen in this thesis were the CVRD and the CRD; both located on southern Vancouver Island, in the province of British Columbia, Canada (Figure 2.1). Vancouver Island houses the Capital of the province, Victoria, which is the island's southernmost city, located approximately 90 kilometres south of Vancouver, BC and approximately 117 kilometres northwest of Seattle, Washington, United States of America.

The two regional districts selected for this research were chosen as study sites because they represent two geographically neighbouring regional districts, each having a range of municipalities with dynamic characteristics in terms of urban and rural municipalities, varying industries and demographic characteristics that influence their resilience and vulnerability. In addition, the location of these study sites on an island, connected to the mainland by boat or plane transportation only, poses unique emergency management considerations for local emergency management practitioners, as well as having implications for personal preparedness for the general public.

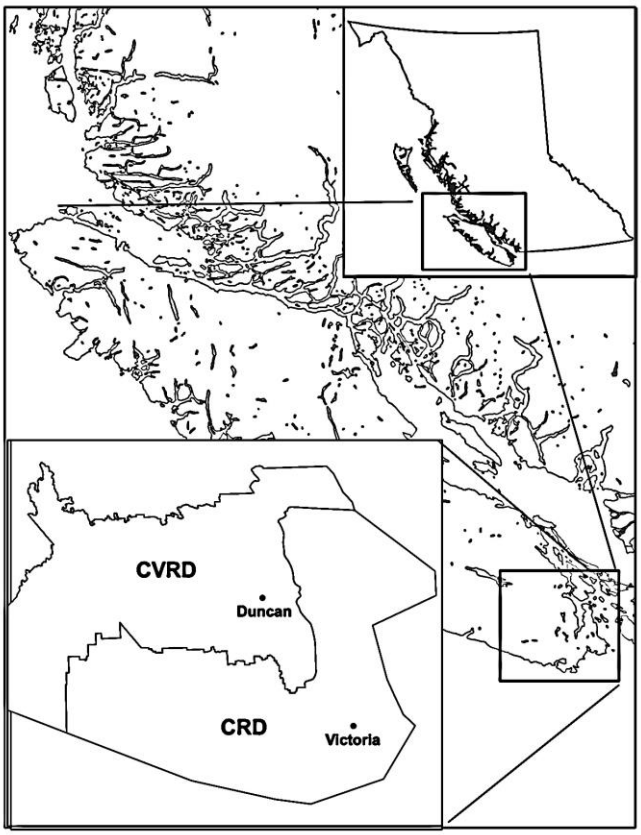

Figure 2.1 Map of study site showing Capital Regional District (CRD) and Cowichan Valley Regional District (CVRD) in relation to Vancouver Island, and the Province of British Columbia

The literature suggests that demographic makeup can influence perceptions of risk (Armaş, 2008; Flynn, Slovic, & Mertzl, 1994). Studies highlight significant disparities in risk perceptions in men compared to women, and in individuals according to varying socio-economic backgrounds, ethno-cultural backgrounds, age and income brackets (Armaş, 2008; Flynn et al., 1994). The demographic and socio-economic makeup of the CRD and the CVRD helps to frame the context of social and economic vulnerability and resilience of the regions.

The CRD is comprised of 13 municipalities, and had a population of 382,646 in 2016, with a land area of 2,341square kilometres (BC Stats, 2012b, 2016). The CVRD is just north of the CRD and has four municipalities and a total population of 84,013 in 2016, with a land area of 3,473 square kilometres (BC Stats, 2015, 2016). The CRD is more urbanized than the CVRD.

Both the CRD and the CVRD have a larger proportion of people aged 65 and older living in the region compared to the provincial average. Both also have a lower percentage of individuals identifying as visible minorities. While the CRD has a smaller proportion of First Nations individuals than the province, the CVRD has a greater proportion (Table 2.1).

The average household income of families is greater in the CRD than the CVRD, with the provincial average falling between the two regional averages (Table 2.1). In both regional districts, the majority of the adult population have post-secondary qualifications, although in the CRD there are a greater proportion of individuals with a post-secondary degree or higher, compared to the provincial average, whereas in the CVRD, this proportion is lower than the provincial average (Table 2.1).

Table 2.1 Comparing demographic information for the Capital Regional District, the Cowichan Valley Regional District and the Province of British Columbia

	Capital Regional District	**Cowichan Valley Regional District**	**Province of British Columbia**
Number of municipalities	13	4	162
Total population (2016)	382,646	84,013	4,751,612
Proportion of individuals aged 65 and older (2012)	19.1%	20.4%	15.9%
Proportion of individuals identifying as a visual minority (2012)	10.1%	4.2%	24.8%
Proportion of individuals identifying as Aboriginal (2012)	3.3%	9.7%	4.8%
Average household income (2012)	$84,032	$71,597	$80,511
Proportion of adult population with post-secondary qualifications (2012)	66.7%	57.3%	61.8%
Proportion of adult population with a university degree or higher (2012)	29.0%	14.6%	24.1%

Source: (BC Stats, 2012b, 2012c, 2016)

2.3.2 Survey design and development. Surveys were used as the primary data collection tool for this research. Two survey tools were developed and rigorously edited by the principal researcher and the supervisory committee. Prior to implementation, the questionnaire tools were piloted on 5 participants to ensure comprehensibility and to test the length of time required to complete the survey. This pilot was undertaken in October of 2015, two months prior to commencement of formal data collection. Upon completion of the pilot surveys, minor edits were made to the language and structure of the surveys to ensure comprehension during implementation.

Data collection began in December 2015 and was completed in May 2016. The general public (group 1) and emergency management practitioners (group 2) were each surveyed using in-person semi-structured questionnaires created to explore risk perceptions in relation to all types of threats and seismic-specific threats. The questionnaire for the general public consisted of 21 questions, some of which allowed for multiple responses. These 21 questions fit into four main sections pertaining to: participant background data, questions about risk perceptions and perceived threats, seismic-specific questions about perceived seismic hazard, and a fourth section on mitigating damage to buildings. The questionnaire for the emergency managers included the same questions asked of the public, as well as some additional questions pertaining to their perceptions of the public in their jurisdiction. Prior to beginning the survey, participants were provided with no additional contextual information about the content of the survey with the exception of the general topic of emergency preparedness. The intention of this was to inform participants of the general topic, but not to lead their answers. Additional details of the structure and content of the two surveys are outlined below (full survey instruments are attached in Appendix A: Questionnaire Tool: General Public (Group 1)Appendix B: Questionnaire Tool: Emergency Management Professionals (Group 2)). Sections A to D, explained below, were consistent throughout both surveys, and additional information related to the emergency managers' surveys are outlined subsequently.

Section A –participant data. The first section of the survey began with a preamble thanking participants for agreeing to participate and framing the structure of the survey (see questions 1 to 7 in Appendix A: Questionnaire Tool: General Public (Group 1). This portion of the survey focused on collecting useful demographic information such as age, gender, household income, highest level of education, municipality, residence type and more. This section was also used to segue into asking participants more thought-provoking questions about risks in their community.

Section B – Risk. The second section of the survey asked five questions about the types of threats participants saw as possible risks to their community. The first question in the section asked about risk generally (question 8), and participants were then encouraged to share whatever came to mind, with little direction from the interviewer. As the questions progressed, participants were given more explanation as to the three different types of threats being explored (natural, human-made unintentional and human-made intentional). One question asked about the likelihood of the threats and the consequences of threats (question 11). At the end of the section, participants were then asked to reassess the most significant risk to their community after having reflected on the types, likelihood and consequences of threats (question 12).

Section C – Earthquakes. In the third section of the survey, participants were asked specific, detailed questions about their perceptions of earthquake risk and hazard. These questions began with their perception of earthquake and tsunami threat on different parts of Vancouver Island (question 13a-d) and their perception of the probability of a non-structurally damaging earthquake happening where they live (question 14). Following these questions, the survey asked participants about their sources of obtaining knowledge about earthquakes in the past (question 15), as well as their preferred avenues for receiving hazard information and communication at present (question 18). Participants were then asked a series of questions relating to different

components of preparedness ranging from whether they have a plan or kit at home to whether they have earthquake insurance (question 17a-h).

Section D – Mitigating damage. In the final section of the survey, participants were asked to rate how strongly they felt certain structure types (for example, a single-family house, a high-rise residential apartment and others) should be built to seismic design standards (question 19). Following this series of questions, participants were asked a series of questions about their thoughts regarding retrofitting buildings and related policies (questions 20-21).

Emergency managers survey. The survey for emergency managers was created on the basis of the survey for the general public. Its intention was to be used as a comparative tool between the two groups. Therefore, it consisted of the same 21 questions that were asked of the general public, followed by an additional 14 sub-questions that asked emergency managers about their opinions regarding how they felt the general public in their jurisdiction would answer specific questions. For example, both groups were asked the question "In your community, what do you think are the chances (in percentage terms) that an earthquake strong enough to crack windows will happen in the next 10 years?" Following this question, the emergency managers were asked an additional sub-question, "How would you expect residents in your jurisdiction to respond to this question?" (questions 14a-b and vi-vii in Appendix B: Questionnaire Tool: Emergency Management Professionals (Group 2)).

2.3.3 Survey implementation and sample. Prior to data collection, approval was sought from the University of Victoria Human Research Ethics Board to ensure the methods used were ethically sound, and conformed to the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans standards. Ethics approval was received in June 2015 and renewed annually as needed.

Prior to implementation, the questionnaire tools were piloted on 5 participants to ensure comprehensibility and to test the length of time required by participants to complete the survey.

This pilot was undertaken in October of 2015 (two months prior to commencement of formal data collection). Upon completion of the pilot surveys, minor edits were made to the language and structure of the surveys to ensure success in comprehension during implementation.

On average, surveys for the general public participants ranged from approximately seven to 20 minutes to complete, and surveys for the emergency management professional participants took approximately 30 minutes each to complete. Survey implementation began in December 2015 and concluded in May 2016.

General public participant sampling. General public participants were approached in public spaces in different communities in the two study sites, the CVRD and the CRD. These public spaces included libraries and recreation centres in a range of municipalities and neighbourhoods. These sites were chosen to promote diversity of the sample, assuming the more geographically diverse locations were selected, the more geographically and demographically diverse a sample would be obtained. A key consideration as to the selection of these sites was also that administration was supportive of the research project and granted permission to use the spaces. Inclusion criteria for participating in the general public participant group required participants to be residents of Vancouver Island and to be over the age of 18.

The general public survey represents a non-representative, non-random sample because individuals were approached at specific sites, and therefore there was not an equal chance that any member of the population could be selected. The total *n* for group 1 was 105 participants. This sample was comprised of 52 males and 53 females. A total of 69 individuals lived in the CRD, while 33 were from the CVRD, and three lived in the Regional District of Nanaimo. These three interviews were added to the CVRD sample. See Table 2.2 for a breakdown of the background demographic and socio-economic characteristics of the general public participants.

Emergency manager participant sampling. Emergency managers were surveyed one-on-one in their offices located within the CRD and the CRVD boundaries. These individuals were

invited to participate during a presentation delivered to the Local Government Emergency Program Advisory Commission at their monthly meeting. During this presentation, the principal researcher and paper author (Schina) outlined the research objectives, and therefore potential participants had a prior knowledge of the topic and the intention of the surveys. In addition to this presentation for emergency managers, other participants were sought from organizations recommended by other professionals. Inclusion criteria for participating in the emergency management professional participant group was restricted to individuals working as emergency managers within a professional jurisdiction that encompassed the study sites specified (within the CRD and CVRD), or emergency management professionals who worked at other levels of government and industry, but who were residents of either the CRD or CVRD.

In total, 13 interviews were conducted with emergency managers. Emergency managers were chosen purposively as key informants because of their experience and expertise in the area of emergency management. Due to the small amount of emergency managers sampled, the analysis conducted on this group is exploratory and descriptive only. See Table 2.2 for a detailed breakdown of the demographic and socio-economic characteristics of the emergency management participants.

2.3.4 Data analysis. After all of the data were collected, data from both groups (general public and emergency managers) were analyzed using the Statistical Package for the Social Sciences (SPSS) Version 23. Descriptive analyzes were undertaken and trends identified. Because of the non-representativeness of the sample, tests were largely non-parametric tests ranging from frequencies to cross tabulations to Chi-square tests.

2.4 Results

Specific results related to the following are presented in this section: Perceptions of risk to participant communities; emergency managers' disaster risk perceptions; emergency managers' predictions of the public's perceptions; knowledge, expectations and preferred

methods of communication from the general public; general public preparedness levels; and emergency manager professionals' preparedness levels.

Table 2.2 Demographics and socio-economic characteristics of all participants

Characteristics	General Public (*n*=105)		Emergency Managers (*n*=13)	
	Frequency (*n*)	Percent of sample (%)	Frequency (*n*)	Percent of sample (%)
Age				
18-24	7	6.7	0	0.0
25-34	11	10.5	1	7.7
35-44	19	18.1	2	15.4
45-54	25	23.8	5	38.5
55-64	19	18.1	4	30.8
65 and older	24	22.9	1	7.7
Gender				
Male	52	49.5	9	69.2
Female	53	50.5	4	30.8
Highest Level of Education				
High school diploma or less	16	15.2	0	0.0
Some post-secondary	26	24.8	3	7.7
Post-secondary degree	36	34.3	9	69.2
Graduate degree	27	25.7	1	23.1
Household Income				
Less than $30,000	20	19.0	0	0.0
$30,000 – $60,000	32	30.5	1	7.7
$70,000 or greater	42	40.0	12	92.3
Prefer not to disclose	11	10.5	0	0.0

2.4.1 General public participants. Of the 105 respondents who participated in the general public survey, 49.5% were male and 50.5% were female; 72.4% lived in urban areas and 27.6% lived in rural areas (Table 2.2, Table 2.3). A total of 69 respondents (65.7%) resided in the CRD while 33 (31.4%) resided in the CVRD and the remaining three resided in the Regional District of Nanaimo (RDN). The latter two regional districts (CVRD and RDN) were therefore aggregated for the purposes of analysis and all were included in the CVRD sample, as that is where they were sampled and where they worked. Participants resided in a total of 18 unique municipalities or electoral areas within the two regional districts. A full list of locations and dates

of sampling for the general public participants are included in Appendix C: Schedule of Sampling and Locations.

Socio-economic and demographic data collected from participants addressed factors such as age, gender, income and highest level of education. Most respondents had relatively high levels of education, with the greatest proportion of all respondents having obtained a post-secondary degree (34.3%), followed by a graduate degree (25.7%) and some post-secondary, no credential or credential lower than a degree (24.8%) (Table 2.2). Total annual household income data were collected where provided. The majority of respondents identified themselves as being in the highest household income bracket ($70,000 or greater), and less than 20% reported being in the lowest income bracket (Less than $30,000) (Table 2.2).

Table 2.3 Geographic characteristics of general public participants (*n*= 105)

Characteristics	**Frequency (*n*)**	**Percent of sample (%)**
Regional District		
Capital Regional District	69	65.7
Cowichan Valley Regional District[a]	36	34.3
Urban/Rural		
Urban	76	72.4
Rural	29	27.6

Notes: [a]For the purposes of analysis, individuals who identified as living in the Regional District of Nanaimo (*n*=3) were included in analysis for CVRD, as they were sampled in the CVRD.

General public participation was limited to individuals who were over the age of 18 to ensure only consenting adults were involved in data collection. While an effort was made to obtain an even number of respondents in all age categories, due to the voluntary nature of the sampling strategy, the largest proportion of participants were within the age categories of 45-54 (23.8%), and 65 and older (22.9%). Individuals in the age categories of 18-24 and 25-34 had lower participation rates at 6.7% and 10.5%, respectively (Table 2.2). This may have also been influenced by the location of sample sites.

2.4.2 Emergency manager participants. Participation for emergency managers included

practitioners working in local, regional or provincial entities of government, other public organizations, or in industry (Table 2.2). These 13 individuals were purposively sampled for their expertise and experience in emergency management. Their opinions and responses were essential to draw comparisons between an expert group (these emergency managers) and the general public and the corresponding regional district.

Emergency managers exhibited characteristics that were both similar and different from the general public (Table 2.2). Emergency manager participants spanned a range of age categories, with similar representation to the general public, and included nine males (69%) and four females (31%) (Table 2.2). This gender distribution is in contrast to the general public who were almost even in terms of males and females. Education levels were high for emergency managers (92.3% with a post-secondary degree or higher), and all but one participant fell into the highest household income level. Education levels of emergency managers followed a similar pattern to that of the general public, where the greatest proportion of participants had obtained a post-secondary degree (34.3% of the general public and 69.2% of emergency managers) and the next highest proportion had obtained a graduate degree (25.7% of the general public and 23.1% of emergency managers). The two groups also had consistency with highest proportions of respondents being within the highest household income bracket (40.0% of the general public and 92.3% of emergency managers), although there was much more variation of responses among the general public (Table 2.2). Emergency manager participants spanned two regional districts, the CRD and the CVRD, and resided in seven unique communities or municipalities.

2.4.3 Perceptions of general public participant disaster risk. Responses to the questions about perceptions of risk generated a broad range of various threats of concern to respondents. The total number of unique responses provided by participants for all risk perception questions was 95. To simplify these data, responses for all risk-related questions (questions 8-12) were distilled into 24 unique response categories, some encompassing multiple answers. Table 2.4 outlines response categories for commonly identified similar threats, however, it is not a

comprehensive list of hazards or categories of hazards identified by all respondents. A comprehensive list can be found in Appendix D: Comprehensive List of Hazards Identified by Respondents.

Table 2.4 Response categories for commonly identified threats among general public participants (*n*=105) and emergency manager participants (*n*=13)

Threat category	**Examples of common threats identified**
Crime and Violence	Assault, Breaking and entering, Drug trafficking, Crime, Kidnapping, Robbery
Environmental	Air pollution, Climate change, Loss of habitat (wildlife), Water pollution
Economic	Housing prices, Insurance rates, Government overspending, Economics
Gas leaks, Hazmat and Industry	Industrial hazard/accident, Gas leaks, Hazardous material release, Radiation
Social Welfare	Lack of social welfare, Poverty, Homelessness, Unemployment

Note: This table outlines some common categories of threats identified that encompassed many unique responses. This table is not exhaustive and does not include the most commonly identified individual hazards.

Figure 2.2 outlines general public responses to the question that asked participants to identify what they considered to be the most significant risks to their community. Respondents had not yet received any indication as to the specific content of the survey when asked this question. Respondents were able to indicate as many threats as they wanted. Despite not being prompted to the content of the survey or the researchers' interests, "earthquakes" were the most popular response recorded (21.9% of responses), followed by "crime and violence" (13.5%), "environmental" threats (10.7%), "social welfare" (6.20%) and "tsunami" (5.60%). Threats that were included in the "Other Natural Hazards" category included: "flooding" (3.40%), "landslide" (0.60 %), and "drought" (1.70%). Threats that were included in the "Other Unintentional Hazards" category included: "food security" (2.20%), "apathy" (2.20%) and "hazardous material release" (1.70%).

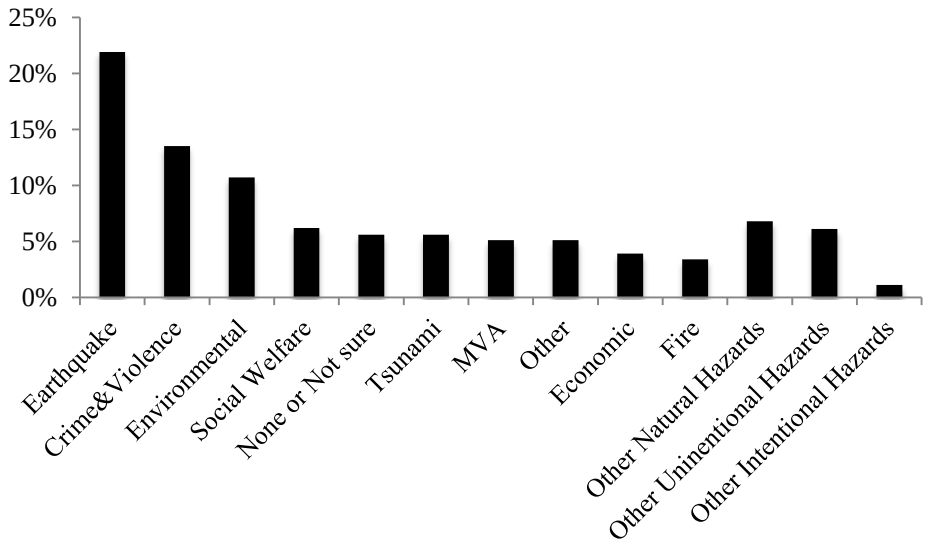

Figure 2.2 Threats identified as a "most significant risk" to respondents' communities (before reflection), multiple responses allowed

Notes: Responses in the "Other Natural Hazards," "Other Unintentional Hazards" and "Other Intentional Hazards" include the responses with the lowest proportions, combined into one other category for clarity.

Risk perception before reflection. To explore the data in greater depth, the general public responses were cross-tabulated by: Regional district, gender and whether participants lived in an urban or rural location. Responses by regional district revealed that a higher proportion of participants in the CRD than the CVRD believed that "crime and violence" was a significant threat (15.7% compared to 9.5%), whereas participants in the CVRD believed that "environmental" threats were of greater concern (19.0% compared to 6.1%). The percentage of respondents who indicated "earthquakes" was nearly equal by regional district (21.7% of responses within the CRD compared to 22.2% in the CVRD).

Comparisons by gender across both regional districts revealed that slightly more females reported "earthquakes" (23.1% compared to 20.7% of men) and "social welfare" concerns (7.7% compared to 4.6% of men) as significant threats, while males were more likely to perceive "environmental" (14.9% compared to 6.6% of women) and "crime and violence" (16.1% compared to 11.0% of women) as significant threats.

Responses by urban and rural location were also distinctive with respondents living in urban areas identifying “earthquakes” (24.2% compared to 16.0%), and “crime and violence” (16.4% compared to 6.0%) more often than those living in rural areas. Proportionally more rural respondents cited “environmental” threats (20.0% compared to 7.0%) than urbanites.

Overall trends within groups. When asked to consider the three categories of threat (natural, intentional human-made and unintentional human-made) “earthquakes” were the most common answer provided for possible natural threats to respondents’ communities (47.4%), followed by “severe weather” (10.4%). The most common response to unintentional human-made threats was overwhelmingly “motor vehicle accidents” (MVAs) (32.8%), followed by “gas leaks, hazardous material releases and industrial accidents” (hazmat) (16.4%) and “environmental” threats (13.1%). “Crime and violence” was overwhelmingly the most common response to potential intentional human-made threats (48.9%), followed by “environmental” threats (10.7%).

Individuals were asked what they perceived to be: a) the most likely, and b) the most consequential threats to their community. Again, respondents were able to provide their own answers with little prompting, and they were able to provide as many responses as they wanted. “MVA” were cited as the most likely threat (20.3%), followed by “earthquakes “(18.8%) and “crime and violence” (16.7%). The most consequential threat identified was “earthquakes” (41.8%) by a broad margin, followed by “tsunami” (10.4%).

Gender. We explored differences in the various types of threats by gender and found some differences as well as similarities in many identified threats. Slightly more females cited “earthquakes” than males (32.7% compared to 26.9%) and more males cited “crime and violence” events than females (39.6% compared to 18.9%) when identifying most significant threats. Males and females provided similar responses to potential unintentional human-made threats to their community, with only slightly more females citing “MVAs” (39.6% compared to 36.5%) and slightly more males citing “environmental” threats (19.2% compared to 11.3%). When potential intentional human-made threats were cross-tabulated with gender, results showed

that more females cited “crime and violence” than males (64.2% compared to 57.7%), whereas more males cited intentional “environmental” threats than females (21.2% compared to 5.7%).

When asked to consider the most likely threats to their community, females were more likely to cite “MVAs” (32.1% compared to 21.2%), whereas more males cited both “earthquakes” (26.9% compared to 22.6%) and “crime and violence” (25.0% compared to 18.9%) more often than females. Slightly more females than males chose “earthquakes” as the most consequential threat (56.6% compared to 50.0%).

Geography. In addition to gender differences, geography played a role in what threats participants perceived their community to be at risk from. Geography was determined on the basis of the regional district, as well as whether participants lived in an urban or rural location. Results showed that more respondents from the CRD and more respondents from urban areas (68.1% and 69.7%, respectively) cited “earthquakes” as a potential natural threat to their community compared to respondents in the CVRD and rural areas (47.2% and 37.9%, respectively). Individuals in the CRD cited “MVAs” (42.0% compared to 30.6%) and “hazmat” (23.2% compared to 11.1%) more than individuals in the CVRD. Individuals living in the CVRD were more likely to cite “environmental” threats as unintentional human-made threats than individuals in the CRD (19.4% compared to 13.0%). Individuals living in urban areas provided similar responses to those in the CRD, which is a largely urban region. In urban areas, more individuals identified “crime and violence” as an intentional human-made threat (69.7% compared to 37.9%) while more rural respondents cited “environmental” threats (27.6% compared to 7.9%).

When considering the most likely threat, a higher proportion of CRD respondents cited “MVAs” (33.3% compared to 13.9%) and “crime and violence” (21.7% compared to 22.2%) whereas a higher proportion of CVRD residents cited “earthquakes” (27.8% compared to 23.2%). These results were consistent when exploring differences between urban and rural participants, with the largest discrepancy being “MVAs” (31.6% of urbanites considered this the most likely

threat compared to 13.8% of rural participants) and "environmental" threats (20.7% rural compared to 6.6% urban).

In urban areas, more individuals cited earthquakes as the most consequential threat than those in rural areas (57.9% compared to 41.1%). Conversely, over 20% of individuals in rural areas cited environmental threats as the most consequential risk compared to less than five percent of urbanites.

Risk perception upon reflection. Participants were asked a series of questions related to their perceptions of risk, and then again asked a few minutes later if they would alter these categories upon reflection. "Earthquakes" were consistently the most common response, with 21.9% of total responses both before and after reflection, followed by "crime and violence" (decreasing 2.6% to 10.9%) and "environmental" threats (decreasing 1.2% to 9.5%) (Table 2.5, Figure 2.3).

Table 2.5 Comparing most significant threats before and after reflection, and between the general public (*n*=105, multiple responses provided) and emergency managers (*n*=13, multiple responses provided)

	General Public		**Emergency Managers**	
Threat	**Before reflection (% of total responses)**	**Change after reflection (+/- %)**	**Before reflection (% of total responses)**	**Change after reflection (+/- %)**
Earthquakes	21.9	0.0	23.9	+6.5
Crime and Violence	13.5	-2.6	0.0	+4.3
Environmental	10.7	-1.2	4.3	0.0
Social Welfare	6.2	-2.6	0.0	+4.3
Tsunami	5.6	-1.2	8.7	-4.4
Motor Vehicle Incident	5.1	+4.4	2.2	-2.2
Other	5.1	+0.7	6.5	+2.2
Fire	3.4	+1.7	0.0	+8.7
Economic	3.4	-0.5	0.0	0.0
Apathy	2.2	+2.2	2.2	-2.2
Gas leaks, Hazmat & Industry	1.7	+1.9	19.6	-15.3
Wildfire	0.6	+1.6	10.9	-2.2
Flooding	3.4	-1.2	6.5	-6.5
Power outages	0.0	+1.5	6.5	-2.2

2.4.4 Emergency managers' disaster risk perceptions. Almost all emergency manager participants (84.6%) perceived "earthquakes" to be one of the most significant risk to their communities, however, as a proportion of total threats identified, "earthquakes" accounted for 23.9% of total responses from emergency managers (Table 2.5). After some reflection time, 30.4% of emergency manager respondents chose "earthquakes" again. While respondents in both groups (emergency managers and the general public) were similar in their identification of "earthquakes" as the most commonly perceived risk, the remainder of responses among groups show some differences.

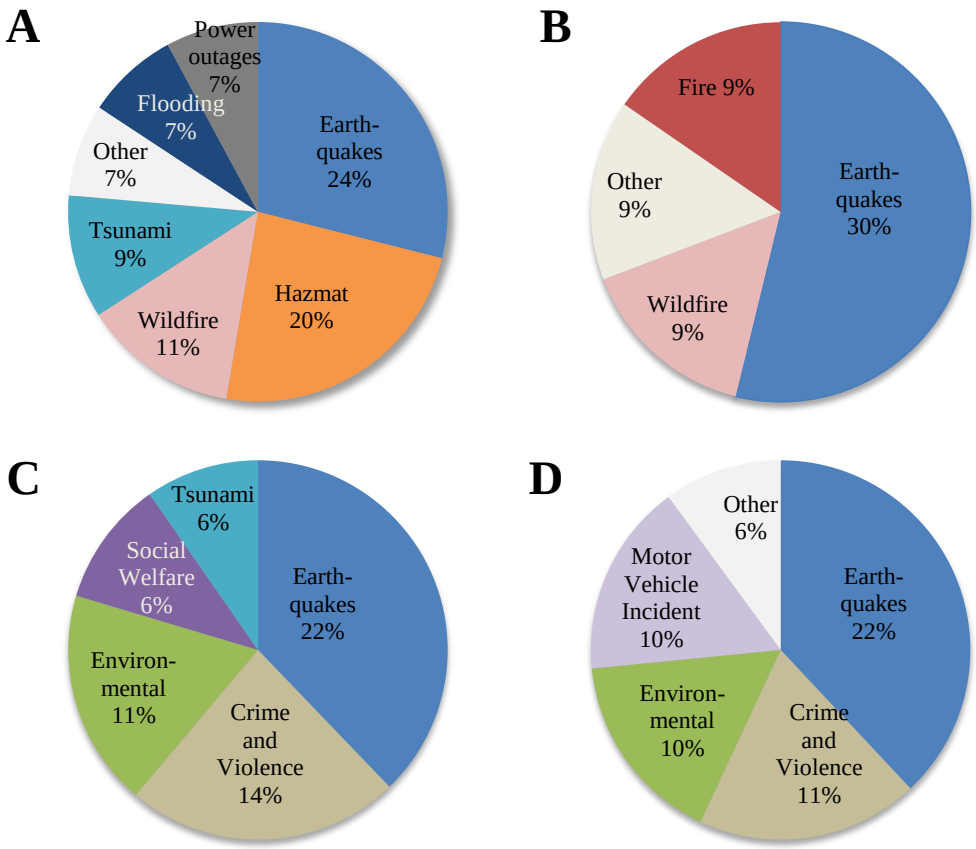

Figure 2.3 Comparison of emergency managers' perception of most significant risks before (A) and after (B) reflection and the general public's most significant risks before (C) and after (D) reflection (% of total responses presented, multiple responses were allowed)

Before reflection, and following their identification of "earthquakes" as their primary response, the second most commonly identified significant risk for emergency managers was

"hazmat" (19.6%), which did not appear in the top risks for the general public. Conversely, the general public identified "crime and violence" as being a significant risk before reflection (13.5%), which did not appear among the top risks identified for emergency managers.

A divergent trend between the two groups was the frequency of human-made threats identified by general public respondents in contrast to natural threats identified by emergency manager respondents. "Crime and violence," "social welfare," "environmental" threats and "MVAs" were all common threats identified by the general public participants. The general public outlined a wide range of varying threats from various sources (natural, human-made intentional and human-made unintentional). In contrast, responses from emergency managers were almost exclusively confined to a small number of categories, with majority focussed on natural threats, with the exception of "hazmat" (Table 2.5).

Prior to reflection, emergency managers expressed a broad range of threats that they identified as risks to their community, including "earthquakes," but accompanied by a cascade of other threats. However, after reflection, "earthquakes" were by far the most common response (30.4%) (Table 2.5), followed by the next most commonly identified responses of "fire," "wildfire" and "severe weather" all at a proportion of 8.7%. When comparing responses between groups before and after reflection, earthquakes were consistently the most common response between both groups both before and after reflection (Table 2.5). A trend among emergency managers is the high frequency of "hazmat" before reflection (19.6%), which virtually disappeared after reflection (change of -15.3%) (Table 2.5). Flooding and tsunami also drop in frequency among emergency managers after reflective time was incorporated (Table 2.5).

Emergency managers were also asked to predict what threats they thought the general public would identify as the most significant risks to their community. "Earthquakes" were the most common response, which was congruent with the general public's actual responses. Exclusive of "earthquakes," the general public provided responses that were not necessarily expected by the emergency managers. "Severe weather" was the second most common prediction

provided by emergency managers (15.4%), which only 3.4% of the general public identified as a significant risk (Figure 2.4). The third most common response given by the general public was environmental threats (10.7%), which were not predicted by a single emergency manager. This is also true of social welfare (6.2% of the general public) and motor vehicle accidents (5.1% of the general public) (Figure 2.4).

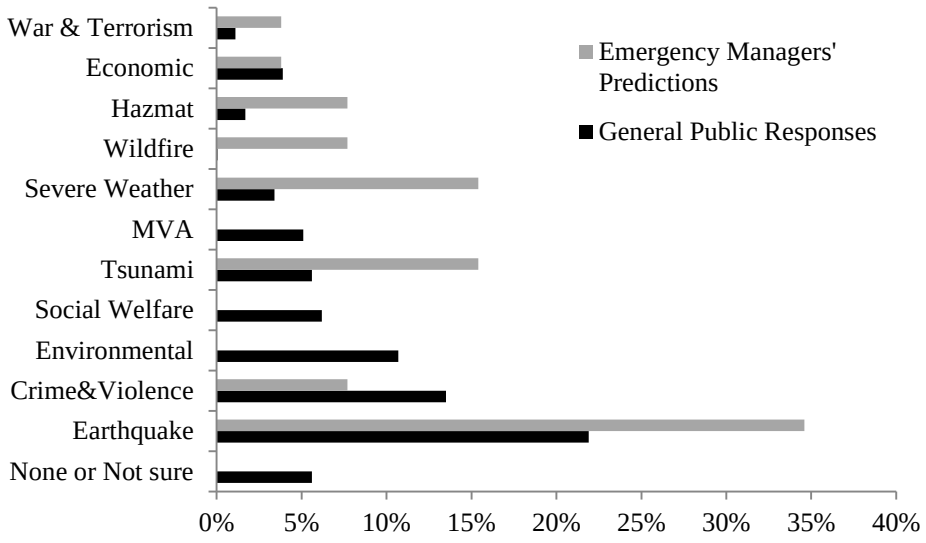

Figure 2.4 Comparison of emergency managers' predictions of public's top perceived risks and public's actual top perceived risks

2.4.5 General public earthquake knowledge and expectations. A total of 91.4% of general public respondents indicated their community is at risk from earthquakes, while 3.8% said their community is not at risk from earthquakes and another 2.8% said they were not sure. Participants were then shown a map of Vancouver Island, with colour-coded regions, and were asked to identify all areas that they believed are at risk (Figure 2.5). Almost half of respondents (49.5%) identified the whole island as being at risk of earthquakes, whereas other respondents identified specific parts of the island as being at risk (Table 2.6).

A majority of general public respondents (80.0%) indicated Vancouver Island was at risk of a tsunami, while 4.8% said they did not believe so and 13.3% indicated "partially". When given the same map (Figure 2.5) and asked to identify what areas they thought face tsunami risk,

the West Coast areas (Figure 2.5, areas 6 and 4) were the most commonly identified responses (75.2% and 79.0%, respectively), with a smaller proportion also identifying the southern tip (area 1, Figure 2.5) of the island (40.0%) (Table 2.6).

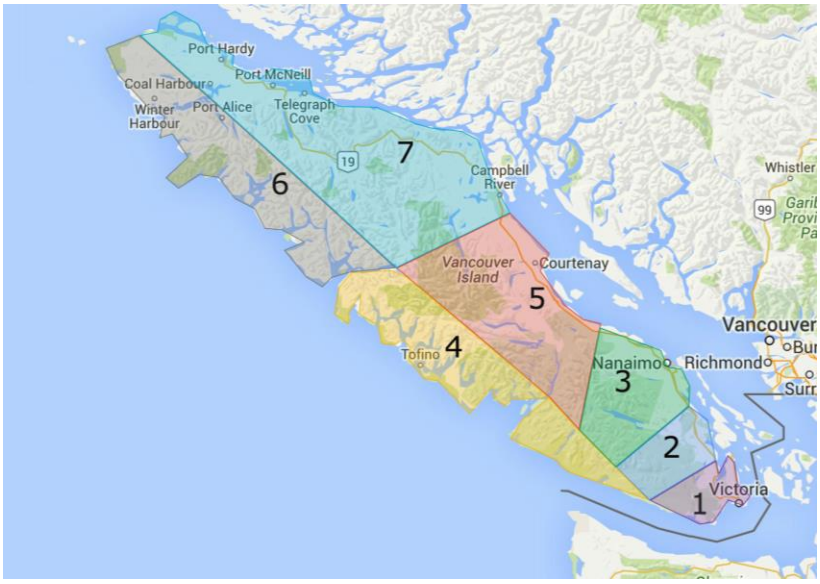

Figure 2.5 Map of Vancouver Island used in data collection and for analysis purposes

Table 2.6 Areas of Vancouver Island identified by respondents as being at risk from earthquakes and tsunamis (n=105, multiple responses were allowed)

Region	**Earthquake Risk (%)**	**Tsunami Risk (%)**
All (All regions on Vancouver Island had some risk)	49.5	12.4
1: South Island (Capital Regional District)	23.8	40.0
2: Southeast Island (Cowichan Valley Regional District)	11.4	6.7
3: Mideast Island (Regional District of Nanaimo)	9.5	1.9
4: Southwest Island (Tofino to Sooke)	27.6	79.0
5: Mideast Island (Courtenay)	7.6	1.9
6: Northwest (Winter Harbour)	21.9	75.2
7: Northeast (Port McNeill)	9.5	2.9

Notes: Regions are associated with a map (Figure 2.5) that was used in surveying respondents, breaking down Vancouver Island into numbered regions. Participants were allowed to give multiple responses. Respondents who identified "all" as their response did not provide additional responses, therefore the total proportions are not on an additive scale.

2.4.6 General public's earthquake knowledge and preferred hazard communication methods. In addition to testing participants' knowledge regarding earthquake and tsunami risk on Vancouver Island, researchers wanted to gain an appreciation for how participants have gained knowledge about earthquakes in the past, and how they would like to receive it in the future. The most frequent responses regarding how information has been obtained were print media, followed by radio, television and government/emergency websites. Among the most common "other" answers provided by participants themselves were: colleagues/work, word of mouth, experience and personal research. Results showed that male respondents acquired knowledge of earthquakes through radio (69.2% of men compared to 50.9% of women), television (65.4% of men compared to 47.2% of women) and the school system (38.5% of men compared to 34.0% of women) more often, whereas women were more likely to obtain knowledge through print media (69.8% of women compared to 61.5% of men), social media (47.2% of women compared to 34.6% of men) and government/emergency websites (54.7% of women compared to 40.4% of men) (Table 2.7).

Chi-square tests were performed to determine whether gender or geography affected participants' previous earthquake knowledge. The Chi-square test found that gender had a statistically significant influence on how participants had obtained knowledge about earthquakes in the past (X^2=17.118, p<0.05) (Table 2.7). Conversely, undertaking a Chi-square test to compare geography (specifically, regional district) showed no statistically significant differences by groups (p<0.589) (Table 2.8, Table 2.7).

Table 2.7 General public knowledge sources for earthquake threats by gender (Chi-square analysis, n=105, multiple responses allowed)

Knowledge source*	**Male (%)**	**Female (%)**
School system	38.5	34.0
Seminars/workshops	28.8	41.5
Print media	61.5	69.8
Radio	69.2	50.9
Social media	34.6	47.2
Television	65.4	47.2
Government/emergency websites	40.4	54.7
Other education	5.8	1.9
Other[a]	51.9	37.7

Notes: [a] The most frequent responses given associated with other include: Colleagues/work, discussions with friends, experience, internet research and word of mouth.
*p<0.05 confidence interval.

Table 2.8 General public knowledge sources for earthquake threats by regional district (Chi-square analysis, n=105, multiple responses allowed)

Knowledge source	**Capital Regional District (%)**	**Cowichan Valley Regional District (%)**
School system	39.1	30.6
Seminars/workshops	31.9	41.7
Print media	63.8	69.4
Radio	59.4	61.1
Social media	34.8	52.8
Television	58.0	52.8
Government/emergency websites	47.8	47.2
Other education	4.3	2.8
Other[a]	44.9	44.4

Notes: [a] The most frequent responses given associated with other include: Colleagues/work, discussions with friends, experience, internet research and word of mouth.

The questionnaire also asked participants what type of media or communication avenues and outreach techniques would be best to reach general public participants with hazard information in their everyday life, in order to inform them of what they should do in the event of specific threats and how to prepare for an emergency. A majority of individuals chose TV/radio advertisements (67.0%) followed by social media (47.6%).

Table 2.9 General public identified preferred media and communication avenues for targeted hazard information by gender (Chi-square analysis, *n*=105, multiple responses allowed)

Media or communication*	**Male (%)**	**Female (%)**
Formal education	15.4	15.1
Community workshops	21.2	45.3
Print advertisements	23.1	43.4
TV/Radio advertisements	67.3	64.2
Media stories	36.5	39.6
Social media	32.7	60.4
Other	23.1	30.2

Notes: *p<0.05 confidence interval.

Different trends emerged in how males and females preferred to receive hazard information. In general, females had a more broad range of avenues they'd like to receive hazard information through (Table 2.9). More women preferred community workshops (45.3% of women compared to 21.2% of men), print advertisements (43.4% of women compared to 23.1% of men) and social media (60.4% of women compared to 32.7% of men) than men did. A majority of both men and women identified TV/Radio advertisements as a preferred method of communication regarding hazards (64.2% of women and 67.3% of men) (Table 2.9).

Table 2.10 General public identified preferred media and communication avenues for targeted hazard information by regional district (Chi-square analysis, *n*=105, multiple responses allowed)

Media or communication***	**Capital Regional District (%)**	**Cowichan Valley Regional District (%)**
Formal education	21.7	2.8
Community workshops	42.0	16.7
Print advertisements	40.6	19.4
TV/Radio advertisements	71.0	55.6
Media stories	42.0	30.6
Social media	49.3	41.7
Other	17.4	44.4

Notes: *** p<0.0001confidence interval.

A Chi-square test was performed to examine whether the relationship between preferred types of media or communication and gender was statistically significant. The Chi-square test

indicated that there were statistically significant differences regarding how males and females preferred to receive hazard information (X^2=12.917, p<0.05) (Table 2.9).

Some differences were identified among geographical groups and their preferred forms of media or communication. Individuals in the CRD preferred to receive information through formal education (21.7% of CRD compared to 2.8% of CVRD), community workshops (42.0% of CRD compared to 16.7% of CVRD), and print advertisements (40.6% of CRD compared to 19.4% of CVRD), whereas individuals from the CVRD preferred other forms of media and communication that did not fall into the categories offered (44.4% of CVRD respondents chose "other" compared to only 17.4% of CRD). Similar to the trends observed among both males and females, individuals from both regional districts preferred TV/Radio advertisements above all other forms of communication (71.0% of CRD and 55.6% of CVRD).

A Chi-square test was also performed to examine the relationship between preferred types of media or communication and geography. The Chi-square test indicated that there were statistically significant differences among how participants from the CRD preferred to receive hazard information compared to participants from the CVRD (X^2=40.227, p<0.0001) (Table 2.10).

2.4.7 General public preparedness levels. Preparedness levels were measured by a series of six questions that indicated whether individuals have taken specific precautions towards preparedness for an earthquake (or other emergencies). The questions asked if participants had an emergency plan at home, school or work; if their hot water tank at home was strapped; if they had secured large items to the walls (such as bookcases or large appliances); if they had an earthquake or emergency kit at home and if they had earthquake insurance. The proportion of respondents that indicated they had taken the precautionary actions asked in each question is outlined in Figure 2.6 Preparedness precautions taken by respondents

To examine trends in preparedness, a scale of preparedness levels was developed from the data to capture mean levels of preparedness among respondents. To create the scale, the

number of preparedness precautions participants had taken was added, and that sum corresponded with their rank on the scale. For example, a respondent with a preparedness level of three would have responded 'yes' to three of the six preparedness-related questions asked in the survey, a respondent with a preparedness level of one would have said yes to only one of the measures of preparedness, and so forth. Each preparedness strategy was weighted equally. The results produced a scale that ranged from zero to six with an overall general public mean and median of 2.62 and 2.00, respectively.

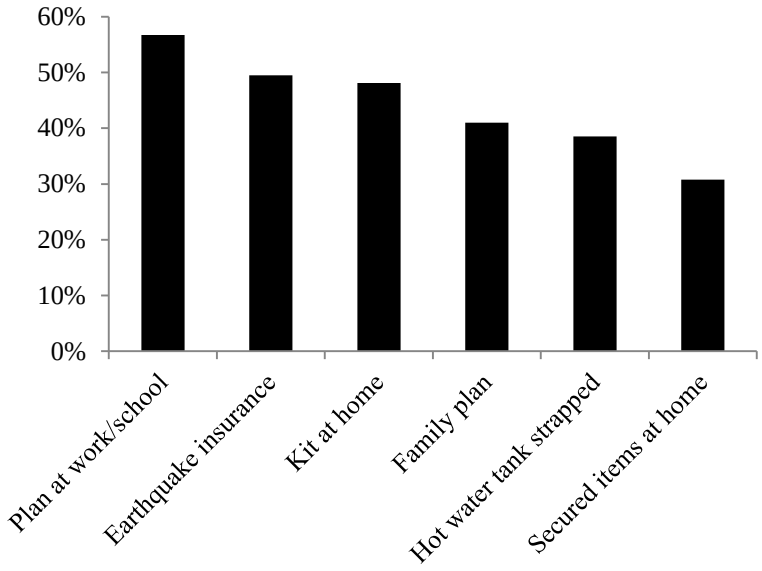

Figure 2.6 Preparedness precautions taken by respondents

Preparedness data were analyzed using a Chi-square test. In order to assess preparedness as a categorical variable, the six-item preparedness scale was converted into two categories of preparedness: Less than or equal to 3 representing "not prepared" or 4 and greater representing "greater levels of preparedness".

Overall, the results from this preparedness analysis suggest that older individuals are more prepared than younger individuals. Preparedness levels were highest for the two age categories of 25-44 and 55-65. Men and women were closely aligned in preparedness levels, with 38.5% of men and 32.1% of women having "greater levels of preparedness." When preparedness

was cross-tabulated by geography, almost no trends emerged. Urbanites and individuals living in rural areas exhibited similar levels of preparedness (Table 2.11). The Chi-square analysis indicated that preparedness was significantly influenced by household income ($p < 0.001$) and time spent living on Vancouver Island ($p < 0.05$) (Table 2.11).

Table 2.11 Comparison of general public preparedness and various demographic characteristics (Chi-square analysis, n=105)

Demographic characteristics	**Proportion of respondents with greater levels of preparedness[a] (%)**	***p***
Age		0.138
18-34	22.2	
35-44	42.1	
45-54	28.0	
55-64	57.9	
65 and older	29.2	
Highest level of education		0.184
High school diploma or less	12.5	
Some post-secondary	34.6	
Post-secondary degree	38.9	
Graduate degree	44.4	
Household income* **		0.000
Less than $30,000	0.0	
$30,000 to $60,000	25.0	
More than $70,000	57.1	
Prefer not to disclose	45.5	
Regional district		0.892
Capital Regional District	34.8	
Cowichan Valley Regional District	36.1	
Urban/rural		0.920
Urban	35.5	
Rural	34.5	
Gender		0.493
Male	38.5	
Female	32.1	
Time living on Vancouver Island*	0.0	0.033
≤ 4 years	28.6	
5-10 years	47.6	
11-20 years	29.7	
21-40 years	52.2	
40 + years		

Notes: [a]For this analysis, preparedness was measured on a binary scale, with respondents that were identified as having a "greater level of preparedness" having responded "yes" to four or more preparedness-related questions.
*p<0.05, ***p<0.0001 confidence intervals.

2.4.8 Emergency managers' preparedness levels. In order to assess levels of preparedness, emergency managers were asked the same six preparedness questions asked of the general public, as explained previously. Emergency managers' levels of preparedness are notably higher and, as a group, emergency managers have a mean preparedness level more than double that of the general public (Table 2.13).

Table 2.12 Emergency managers' perception of general public preparedness levels

Preparedness precaution	**Emergency manager's prediction of public who have taken precaution (mean, %)**	**Proportion of general public respondents who have taken precaution (%)**	**Difference (+/- %)**
Household plan	14.58	45.70	+31.12
Plan at work or school	61.54	62.80	+1.26
Some household mitigations taken[a]	29.23	N/A[b]	N/A
Earthquake insurance	39.42	54.30	+14.88

Notes: [a] Some household mitigations include any of the six preparedness indicators mentioned in the survey, including: a household plan, a plan at work or school, strapping their home hot water tank, securing large items like bookcases or large appliances, an emergency kit, earthquake insurance. [b]This question is not applicable for comparison because it does not align with a direct comparison to the general public survey.

Emergency managers were asked about their perceptions of the proportion of the general public who have taken certain steps towards preparedness (Table 2.12). In most cases, the mean levels of emergency manager expectations of the proportion of the general public in their jurisdiction who had taken certain preparedness precautions (for example, having a household plan or kit) was low, and although mean preparedness levels for the general public were relatively low (a mean preparedness level of 2.62, meaning they had taken between 2 and 3 of the precautions asked about), many of the predictions provided by emergency managers regarding specific precautions were much lower than what was actually reported by the general public

(Table 2.12). However, in the case of the proportion of the public who had plans at work or school, emergency managers predictions almost mirrored the public's responses.

Because the sample of emergency managers was largely affluent with almost all respondents having similar levels of education and similar household income levels, there were few categories to draw comparisons or discrepancies between. However, comparisons by gender and urban compared to rural are explored in Table 2.13.

Table 2.13 Comparison of mean preparedness[a] levels between general public and emergency managers

Mean level of preparedness	General Public	Emergency Managers	Difference (EM-GP)
Male	2.58	5.33	+2.96
Female	2.66	5.50	+2.63
Urban	2.64	5.28	+2.64
Rural	2.55	5.50	+2.95
Total	2.62	5.38	+2.76

Notes: [a] For the purposes of this analysis, level of preparedness was interpreted through a series of six yes or no questions related to respondents taking certain steps towards preparedness. Each yes response corresponded with one point on the six-point scale.

2.5 Discussion

This paper addressed the objectives of: a) Exploring the threats that the general public perceived their community to be at risk from; b) Exploring emergency manager perceptions of community disaster risk on southern Vancouver Island; c) Understanding how the general public comprehends earthquake and other threat risk in order to improve hazard communications; and d) Understanding the preparedness level of the public on southern Vancouver Island.

Key findings that emerged throughout this paper included differences in perceived risk between emergency managers and the general public. Findings showed that while both the general public and emergency managers perceived earthquakes as the most significant disaster risk both before, and after time for reflection, other risks identified by these groups differed. Emergency managers identified more natural threats whereas the public identified more

intentional man-made threats. Key findings also showed significant differences between gender and geography on several variables, notably how individuals prefer to receive hazard communications in the future, and how they had learned about earthquakes in the past. In addition, household income and time spent living on Vancouver Island were found to have statistically significant effects on preparedness.

2.5.1 Disaster risk perceptions and seismic hazard perception. Overall, there was divergence between the general public and emergency managers in terms of their perceptions of disaster risk. The top risks identified by the general public were focused on human-made, largely intentional threats, whereas emergency managers' top threats were mostly natural, with some human-made unintentional threats. The limited research that does exist regarding differences in emergency managers' and public's perceptions suggests that the two groups tend to have divergent perceptions of significant risks, with the general public identifying more rare risks as significant, and emergency managers identifying more common, consistent risks as significant (Ho et al., 2008; Slovic, 2012; Wachinger et al., 2013). To a certain extent, this emerged in the findings, as emergency managers identified events like power outages and fires in their top five threats, which happen relatively frequently, as a common risk, whereas the public did not consider power outages or fires at all (Figure 2.3). Emergency managers also tended to identify cyclical and seasonal risks such as wildfires and floods, and common accidents such as gas leaks and hazmat events, consistent with the annual planning their offices take on and reflective of their personal experience (Renteria, 2014).

Another divergent trend between these two groups' disaster risk perceptions is the changes before and after reflection. When analyzing the data, researchers predicted that the general public respondents, who presumably consider risk much less often than emergency managers do, would be more likely to change their opinions about what threats are most significant upon discussion and reflection. Similarly, researchers expected emergency managers to be more stable with their responses before and after reflection given their education and

training. In fact, the opposite was found to be true. Emergency manager's perceptions changed substantially, in some cases fluctuating more than 15%, whereas the general public perceptions remained within less than five percent of their original response for all identified risks. This may be related to the participants not only reflecting on their responses, but also formulating their own definition of what they consider "most significant risks," after being asked about most likely, most consequential and other types of risk.

The literature explains that individuals living in areas at risk from natural threats tend to have general knowledge about those natural threats. Therefore, researchers predicted that earthquakes would be a disaster risk identified by high proportions of both the general public and emergency managers (Kates, 1976; Tierney et al., 2001). Indeed, results showed that earthquakes were the most common response among both groups, both before being prompted about the topic of disaster risk (21.9%), and after an opportunity for reflection (21.9%), which included being asked about a broad range of different types of threats including natural threats, unintentional human-made threats, and intentional human-made threats, illustrated by examples. The last major study to explore earthquake risk perceptions was undertaken by Jackson in 1981. In Jackson's paper, "Response to Earthquake Hazard", Victoria and Vancouver were grouped into a large sample of West Coast cities that included other cities (in the United States) that had experienced damaging earthquakes in the past (Jackson, 1981). Jackson's study asked open-ended questions such as, "What, if any, are the disadvantages of living in this city?" In his study, he found that only 1.7% of respondents mentioned earthquakes as a disadvantage (Jackson, 1981). Although the questionnaire used by Jackson was different from the questionnaire employed in this research, it seems evident that earthquake risk perceptions have indeed grown over the past 30 years.

Geography appeared to have an influence on what disasters participants perceived to have the most consequential risk. For example, urbanites and individuals living in the CRD, a largely urban area, considered "earthquakes" to be the most significant risk, whereas individuals living in rural areas, which are more common in the CVRD, considered "environmental" threats to be the

most significant. These results are reflective of what the literature says about individuals' perceptions of risks: Individuals tend to know when they live in an area at risk from natural hazards, and they also tend to identify with their own previous experience and perceive risks higher if they have had direct experience with that risk or have seen others in a similar situation (Kates, 1976; Tierney et al., 2001). Although the CRD has not experienced a significant earthquake in recent years, a short few months prior to data collection, the region experienced a M4.7 earthquake that caused no damage, but was strong enough to wake many residents of southern Vancouver Island up from their sleep and remind them that they live in an earthquake zone (Hager, 2015). Publicity about recent earthquakes around the globe, as well as the risk in the Pacific Northwest, may also have influenced respondents' perceptions (Burke, 2015; Hager, 2015; Schulz, 2015). In addition, urbanites have seen the destruction from earthquakes in urban centres across the world in the media, and know that their turn may be next. Similarly, rural-dwellers in the CVRD, in the months prior to data collection, had been duelling with the Provincial government regarding the legalities of dumping of toxic sludge into a site that many locals feared was putting their drinking water at risk (Stueck, 2016). It is possible that these events influenced individuals' perceptions of their risk of particular events within their geographic borders.

2.5.2 Risk knowledge and communication. Researchers were interested in exploring what proportion of respondents understood that they lived in a seismically active zone, as well as what proportion understood the tsunami risk on Vancouver Island more generally. Results showed that just fewer than nine percent of respondents did not believe that their community was at risk for earthquakes. Although this percentage is small, it highlights an important area for additional work by emergency managers whose job it is to ensure that residents know the risk where they live, as part of the emergency program objectives outlined in many local government bylaws (City of Victoria, 2004; Province of British Columbia, 1996; The Corporation of the District of Saanich, 2001). Conversely, the fact that more than 90% of respondents are aware that

they live in a seismically active zone is consistent with some of the historical and foundational hazard literature that states that individuals who live in areas of geographic risk to natural hazards are typically aware of their risk (Armaş, 2008; Burton et al., 1968; Kates, 1976; Wachinger et al., 2013). Findings related to tsunami knowledge was similar to earthquakes, although fewer respondents understood what regions were at risk from tsunamis, and nearly 20% of respondents either did not think Vancouver Island was at risk from tsunamis at all, or were not sure.

Only 14% of respondents believed that the Mideast Island region (Courtenay, Figure 2.5) was at risk from tsunamis. This is an important finding for emergency managers as the most recent significantly damaging earthquake on Vancouver Island, which occurred in 1946, claimed the life of one man whose boat was swept away by a significant wave in a bay south of Courtenay (Hoekstra, 2016). Thus, there is an opportunity for emergency managers to leverage historical experiences to show residents that the risk is real, and that they can learn from past events.

Results showed statistically significant differences in participants' preferred methods for targeted outreach and communication related to hazards, as well as in ways they had obtained knowledge in the past. Males and females were observed to have significantly different ways of obtaining knowledge about earthquakes in the past, as well as different views of how they would like to be targeted for relevant hazard information in the future. When it comes to social media, a majority of females (60.4%) preferred this method of communication, similar to other studies (Taylor, Wells, Howell, & Raphael, 2012). Community workshops were similarly important for females with 45.3% recommending community workshops as a preferred method of outreach compared to 21.2% of men. In addition, significant differences were observed between regional districts regarding formal education, community workshops and print advertisements. Specifically, residents in the CRD preferred these methods, while individuals in the CVRD preferred "other" methods such as discussing issues with friends or colleagues. Across all groups, regardless of gender or geography, the most preferred method of outreach was TV/Radio advertisements. Emergency managers can use these insights to target their public outreach and

education initiatives according to these different preferences for receiving information. The existing literature explains that best practices in public education and outreach for emergency managers state that the most effective way to make a behavioural change among the public is to ensure positive, consistent messages come from multiple sources, using multiple platforms and different methods of communication, consistently over time (Coppola, 2011; Coppola & Maloney, 2009; Mileti, 1999).

2.5.3 Preparedness. Socio-economic factors and vulnerability are known to have an effect on an individual's ability or willingness to take precautionary actions towards preparedness, and also to influence how an individual perceives their risk (Armaş, 2008; Cutter et al., 2008; Dooley, Catalano, Mishra, & Serxner, 1992; Tierney et al., 2001). This paper's findings support this trend. Household income was found to be a strong statistically significant predictor of an individual's preparedness levels, such that those individuals with higher household incomes tend to have taken more steps towards being prepared. However, some of the literature exploring preparedness related to intentional human-made threats (specifically terrorism), rather than natural threats, indicates the opposite: That individuals with lower socio-economic status (income, education) were found to have taken more preparedness precautions such as preparing an emergency kit and an emergency plan (Eisenman et al., 2006). Because preparedness questions were specifically related to earthquakes, this trend was not explored further. In addition, in this research, statistically significant relationships were also found between preparedness levels and length of time living on Vancouver Island, with individuals who have lived on Vancouver Island for five years or longer being more prepared than those who have lived on Vancouver Island for four years or less. This is again indicative of trends in the literature related to residents understanding the risk where they live (Armaş, 2008; Burton et al., 1968; Kates, 1976; Wachinger et al., 2013).

Another trend to emerge in this research regarding preparedness and communication combined, is the divide in gender preferences and what that may mean about residents' abilities to

increase their personal and household resilience by learning about the threats, getting a kit and making a plan (Levac et al., 2012). Research regarding gender roles, perceptions and preparedness in other regions of the world suggest that although women tend to perceive their risks higher than males, they may not be the main decision-makers in the household, and therefore there could be fewer opportunities for women to prepare their households. However, research in North America shows that, although historically men were typically the household decision-makers due to their economic circumstances, in modern society, many households are comprised of dual-income earners, and the decision-making trend among males and females has generally shifted to female members of the household making daily household decisions, which could encompass preparedness and planning decisions (Bartley, Blanton, & Gilliard, 2005). In addition, recent research shows that households with partners who make joint decisions tend to be more prepared (Hung, 2017). These findings provide emergency managers with important recommendations on how to strategically target their outreach efforts in order to increase the public's knowledge about hazards and to encourage residents to make a kit, and make a plan, while also simply increasing their preparedness levels more generally.

2.5.4 Limitations. Sample size and nature of sampling may be considered limitations to this research. Researchers initially set out to obtain a larger, broader sample by sampling the general public at a wider cross-section of locations, and especially those that were likely to be frequented by the widest range of members of the general public. Initially, the strategy was to conduct sampling at locations such as grocery stores, and to strive to obtain a sample of roughly double what was obtained in the end (n=105). However, several grocery store owners or managers were not receptive to the research being conducted at their sites. As a consequence, public locations such as recreation centres and libraries were used. These public locations tended to be more supportive of the research and therefore were the primary sample locations. This led to the collection of a more purposive, convenience sample as opposed to a larger, more representative, though still non-random sample. The range of participants sampled was generally

reflective of the populations in both the CRD and the CVRD, according to demographic make-up in comparison with data from BC Stats.

Another limitation of this study was the survey tool itself. Although the survey only took 20 minutes on average, per person to complete, the length discouraged some individuals from participating. In addition, despite pilot testing, some of the terms used within the survey had to be explained by the researcher, potentially influencing the validity of some of the responses, although every attempt was made to avoid this. An example of this was questions 8-12 (Appendix A: Questionnaire Tool: General Public (Group 1)), which asked participants what they considered the most significant risk to their community. In many cases, participants wanted the questionnaire to provide examples to explain to them of what type of risks researchers were interested in and requested examples. Conversely, researchers were interested in their interpretation of risk as part of their answer and did not want to bias participants by giving them a list of threats in advance.

2.6 Conclusion

Based on this paper's findings and compared to the limited previous literature (Jackson, 1981), over the past three decades, perceptions of earthquake risk on southern Vancouver Island have increased. It is now clear to most south island residents that they live in an active seismic zone where earthquakes are a primary threat of concern. However, this perception does not necessarily translate into action among individual residents in terms of their levels of preparedness. Consequently, many participants have not taken the necessary precautions to increase their personal and household resilience such as getting an emergency kit, creating a plan, or other important precautions. Therefore, in the event of an emergency, most hard-hit residents may be relying on external help that may not arrive for several days, if not weeks, following a significant earthquake or similar disaster (Lindell & Whitney, 2000; Renteria, 2014).

Our findings also showed key gaps in knowledge among residents on southern Vancouver Island that can be addressed by emergency managers in order to increase the

resilience of their jurisdictions. Although most residents are aware of the seismic risk where they live, there is still a small portion that does not agree or is not aware, which highlights a gap for emergency managers in the region to fill. The way in which the public processes information has also changed significantly in modern times. Social media has emerged as an essential way to receive information, however, there are important gender and geographical differences in the way in which information is taken up and used by the public. This finding, among others, emphasizes the importance for emergency managers of focusing their efforts on public education and outreach in different ways for specific target audiences, for example, by gender and geography (Coppola, 2011; Coppola & Maloney, 2009; Mileti, 1999). Emergency programs within the CRD and CVRD must focus their efforts by potentially choosing certain target groups and by planning their messaging and outreach accordingly.

Future recommendations for further research based on the implications of these findings could include further statistical analysis of the relationships between some key variables. For example, this research explores preparedness and perception, but based on the type of data collected, there is not an extensive statistical analysis conducted that examines whether perceptions has a statistically significant impact on preparedness. This should be addressed in future research as it has implications for emergency management as well as individual and community resilience. Further, this research starts by examining disaster risk perceptions, but then focuses solely on earthquake risk perception and preparedness and knowledge related to earthquakes. Future research would benefit from exploring other natural and human-made threats and discovering whether there are similar trends related to perceptions, preparedness and knowledge.

References

Armaş, I. (2008). Social vulnerability and seismic risk perception. Case study: The historic center of the Bucharest Municipality/Romania. Natural Hazards, 47(3), 397–410. http://doi.org/10.1007/s11069-008-9229-3

Bartley, S. J., Blanton, P. W., & Gilliard, J. L. (2005). Husbands and wives in dual-earner marriages: Decision-making, gender role attitudes, division of household labor, and equity. Marriage & Family Review, 37(4), 123–141. http://doi.org/10.1300/J002v37n04

BC Stats. (2012a). Socio-economic profile Health Authority 4 - Vancouver Island. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/Profiles.aspx

BC Stats. (2012b). Socio-economic profile Regional District 17 - Capital demographic profile, 1–11. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/Profiles.aspx

BC Stats. (2012c). Socio-economic profile Regional District 19 - Cowichan Valley demographic profile, 1–11. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/Profiles.aspx

BC Stats. (2015). 2014 Sub-Provincial Population Estimates, 1–8. Retrieved from http://www.bcstats.gov.bc.ca/apps/PopulationEstimates.aspx

BC Stats. (2016). Population Estimates. Retrieved from http://www.bcstats.gov.bc.ca/apps/PopulationEstimates.aspx

BCStats. (2017). Building permits, housing starts and sales. Retrieved March 17, 2017, from http://www.bcstats.gov.bc.ca/StatisticsBySubject/Economy/BuildingPermitsHousingStartsa

ndSales.aspx

Bosher, L. (2008). Hazards and the built environment: Attaining built-in resilience. Routledge, Taylor & Francis Group.

Burke, J. (2015, April 29). Nepal earthquake: Fears grow over fate of thousands near epicentre. The Guardian. Gorkha. Retrieved from https://www.theguardian.com/world/2015/apr/29/fears-grow-over-fate-thousands-near-epicentre-nepal-earthquake-gorkha

Burton, I., Kates, R. W., & White, G. F. (1968). The human ecology of extreme geophysical events. Natural Hazard Center Collection, 1, 1–33.

Canadian Red Cross. (2013). Red Cross urges Canadians to know the risks. Retrieved February 9, 2017, from http://www.redcross.ca/about-us/newsroom/news-releases/latest-news/red-cross-urges-canadians-to-know-the-risks

Centre for Research on the Epidemiology of Disasters. (2014). Disaster trends. Retrieved March 18, 2017, from http://www.cred.be/node/1360

City of Victoria. Emergency Program Bylaw No. 04-23 (2004).

City of Victoria. (2012). Census information. Retrieved November 9, 2016, from http://www.victoria.ca/EN/main/residents/about/census.html

Coppola, D. P. (2011). Introduction to international disaster management (Third). Boston: Butterworth-Heinemann.

Coppola, D. P., & Maloney, E. K. (2009). Communicating emergency preparedness strategies for creating a disaster resilient public. Boca Raton: Auerbach Publications.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. Global Environmental Change, 18(4), 598–606. http://doi.org/10.1016/j.gloenvcha.2008.07.013

Destination British Columbia. (2015). Vancouver Island regional tourism profile. Retrieved from http://www.destinationbc.ca/getattachment/Research/Research-by-Region/Vancouver-

Island/RegionalProfiles_Vancouver-Island_2014.pdf.aspx

Dooley, D., Catalano, R., Mishra, S., & Serxner, S. (1992). Earthquake preparedness: Predictors in a community survey. Journal of Applied Social Psychology, 22(6), 451–470. http://doi.org/10.1111/j.1559-1816.1992.tb00984.x

Eisenman, D. P., Wold, C., Fielding, J., Long, A., Setodji, C., Hickey, S., & Gelberg, L. (2006). Differences in individual-level terrorism preparedness in Los Angeles County. American Journal of Preventive Medicine, 30(1), 1–6. http://doi.org/10.1016/j.amepre.2005.09.001

Emergency Management BC. (2016). PreparedBC: Know the risks. Retrieved September 22, 2016, from http://www2.gov.bc.ca/gov/content/safety/emergency-preparedness-response-recovery/preparedbc/know-the-risks

Etkin, D., Haque, E., Bellisario, L., & Burton, I. (2004). An assessment of natural hazards and disasters in Canada: A report for decision-makers and practitioners.

Flynn, J., Slovic, P., & Mertzl, C. K. (1994). Gender, race, and perception of environmental health risks. Risk Analysis, 14(4), 1101–1108.

Gierlach, E., Belsher, B. E., & Beutler, L. E. (2010). Cross-cultural differences in risk perceptions of disasters. Risk Analysis : An Official Publication of the Society for Risk Analysis, 30(10), 1539–49. http://doi.org/10.1111/j.1539-6924.2010.01451.x

Guthrie, R. H. (2005). Geomorphology of Vancouver Island: Mass wasting potential. Victoria, BC.

Hager, M. (2015, December 30). Earthquake with 4.7 magnitude felt throughout B.C.'s South Coast. The Globe and Mail. Vancouver. Retrieved from https://www.theglobeandmail.com/news/national/bc-struck-by-moderate-earthquake/article27956563/

Ho, M.-C., Shaw, D., Lin, S., & Chiu, Y.-C. (2008). How do disaster characteristics influence risk perception? Risk Analysis: An Official Publication of the Society for Risk Analysis, 28(3), 635–43. http://doi.org/10.1111/j.1539-6924.2008.01040.x

Hoekstra, G. (2016, October 29). A 1946 Vancouver Island earthquake survivor remembers. The Province. Vancouver. Retrieved from http://theprovince.com/news/local-news/a-1946-vancouver-island-earthquake-survivor-remembers

Hung, L.-S. (2017). Married couples' decision-making about household natural hazard preparedness: A case study of hurricane hazards in Sarasota County, Florida. Natural Hazards, 87(2), 1057–1081. http://doi.org/10.1007/s11069-017-2809-3

Jackson, E. L. (1981). Response to earthquake hazard: The West Coast of North America. Environment and Behavior, 13(4), 387–416. http://doi.org/0803973233

Johnston, D., & Paton, D. (2001). Disasters and communities: Vulnerability, resilience and preparedness. Disaster Prevention and Management, 10(4), 270–277.

Kates, R. W. (1976). Experiencing the environment as hazard. In S. Wapner, S. Cohen, & B. Kaplan (Eds.), Experiencing the Environment (pp. 133–156). Plenum Press.

Kung, Y. W., & Chen, S. H. (2012). Perception of earthquake risk in Taiwan: Effects of gender and past earthquake experience. Risk Analysis, 32(9), 1535–1546. http://doi.org/10.1111/j.1539-6924.2011.01760.x

Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C.-Y., & Leiserowitz, A. a. (2015). Predictors of public climate change awareness and risk perception around the world. Nature Climate Change, (July). http://doi.org/10.1038/nclimate2728

Levac, J., Toal-Sullivan, D., & O'Sullivan, T. L. (2012). Household emergency preparedness: A literature review. Journal of Community Health, 37(3), 725–733. http://doi.org/10.1007/s10900-011-9488-x

Lindell, M. K., & Whitney, D. J. (2000). Correlates of household seismic hazard adjustment adoption. Risk Analysis, 20(1), 13–25. http://doi.org/10.1111/0272-4332.00002

McClure, J., Johnston, D., Henrich, L., Milfont, T. L., & Becker, J. (2014). When a hazard occurs where it is not expected: risk judgments about different regions after the Christchurch earthquakes. Natural Hazards, 75, 635–652. http://doi.org/10.1007/s11069-014-1338-6

Mileti, D. S. (1999). Disasters by design: A reassessment of natural hazards in the United States. Washington, D.C.: Joseph Henry Press.

Nakayachi, K., Yokoyama, H. M., & Oki, S. (2014). Public anxiety after the 2011 Tohoku earthquake: Fluctuations in hazard perception after catastrophe. Journal of Risk Research, (February 2015), 1–14. http://doi.org/10.1080/13669877.2013.875936

Natural Resources Canada. (2013). Seismic zones in Western Canada. Retrieved March 5, 2015, from http://www.earthquakescanada.nrcan.gc.ca/zones/westcan-eng.php#Cascadia

Natural Resources Canada. (2016). Natural hazards. Retrieved September 22, 2016, from https://www.nrcan.gc.ca/hazards/natural-hazards

Newton, J. (1997). Federal legislation for disaster mitigation: A comparative assessment between Canada and the United States. Natural Hazards, 219–241. http://doi.org/10.1023/A:1007976800302

Pourghasemi, H. R., Moradi, H. R., & Fatemi Aghda, S. M. (2013). Landslide susceptibility mapping by binary logistic regression, analytical hierarchy process, and statistical index models and assessment of their performances. Natural Hazards, 69(1), 749–779. http://doi.org/10.1007/s11069-013-0728-5

Province of British Columbia. Emergency Program Act (1996). Canada: Queen's Printer. Retrieved from http://www.bclaws.ca/Recon/document/ID/freeside/00_96111_01

Renteria, H. (2014). British Columbia earthquake preparedness consultation report.

Schulz, K. (2015, July). The really big one. The New Yorker. Retrieved from http://www.newyorker.com/magazine/2015/07/20/the-really-big-one

Seemann, M. (2012). A disaster risk management approach to seismic risk on Vancouver Island, British Columbia. University of Victoria.

Seemann, M., Onur, T., & Cloutier-Fisher, D. (2011). Earthquake shaking probabilities for communities on Vancouver Island, British Columbia, Canada. Natural Hazards, 58(3), 1253–1273. http://doi.org/10.1007/s11069-011-9727-6

Slovic, P. (1999). Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield. Risk Analysis, 19(4), 689–701. http://doi.org/10.1111/j.1539-6924.1999.tb00439.x

Slovic, P. (2012). The perception gap: Radiation and risk. Bulletin of the Atomic Scientists, 68(3), 67–75. http://doi.org/10.1177/0096340212444870

Stueck, W. (2016, January 22). Worried residents head to court over drinking water concerns in Shawnigan Lake. The Globe and Mail. Victoria, BC. Retrieved from https://www.theglobeandmail.com/news/british-columbia/worried-residents-head-to-court-over-drinking-water-concerns-shawnigan-lake/article28359674/

Taylor, B. M., Wells, G., Howell, G., & Raphael, B. (2012). The role of social media as psychological first aid as a support to community resilience building. The Australian Journal of Emergency Management, 27(1), 20–26.

The Corporation of the District of Saanich. Bylaw No. 8212 (2001).

The United Nations Office for Disaster Risk Reduction. (2009). Terminology. Retrieved December 30, 2016, from https://www.unisdr.org/we/inform/terminology

Tierney, K. J., Lindell, M. K., & Perry, R. W. (2001). Facing the unexpected. Washington, D.C.: Joseph Henry Press.

Usuzawa, M., O Telan, E., Kawano, R., S Dizon, C., Alisjahbana, B., Ashino, Y., … Hattori, T. (2014). Awareness of disaster reduction frameworks and risk perception of natural disaster: a questionnaire survey among Philippine and Indonesian health care personnel and public health students. The Tohoku Journal of Experimental Medicine, 233(1), 43–8. http://doi.org/10.1620/tjem.233.43.Correspondence

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox--implications for governance and communication of natural hazards. Risk Analysis: An Official Publication of the Society for Risk Analysis, 33(6), 1049–1065. http://doi.org/10.1111/j.1539-6924.2012.01942.x

Weinstein, N. D. (1984). Why it won't happen to me: Perceptions of risk factors and susceptibility. Health Psychology, 3(5), 431–457. http://doi.org/10.1037/0278-6133.3.5.431

3.0 COMPARING CALCULATED AND PERCEIVED SEISMIC HAZARD AMONG THE GENERAL PUBLIC AND EMERGENCY MANAGERS ON SOUTHERN VANCOUVER ISLAND, BRITISH COLUMBIA, CANADA

3.1 Abstract

Southern Vancouver Island, British Columbia (BC), Canada, is exposed to many natural and human-made hazards due to its physical geography and demographic composition. Perhaps the most significant threat the region faces is low frequency, high consequence earthquake events due to the Cascadia Subduction Zone, a region exposed to crustal, sub-crustal and subduction interface earthquakes. This paper explores perceptions of seismic hazard between and within two groups: Members of the general public and professional emergency managers, living and working in the Capital Regional District (CRD) and the Cowichan Valley Regional District (CVRD). Using data derived from in-person interviews using two semi-structured survey tools, this paper 1) Provides descriptive data from interviews conducted with the general public (n=105) and emergency managers (n=13) about perceptions of seismic hazard on southern Vancouver Island, identifying differences within each group; 2) Examines discrepancies between perceptions of seismic hazard among the general public and emergency managers compared to actual calculated seismic hazard, identifying differences within each group; and, 3) Explores differences between the seismic hazard perceptions of the general public and emergency managers, against calculated seismic hazard estimates. Descriptive analyses show that factors such as household income, education levels and time spent living on Vancouver Island influence respondent perceptions. Generally, emergency managers have higher perceptions of hazard than the general public, while the general public in the CVRD perceive their hazard to be higher than respondents in the CRD. These findings offer an initial survey of seismic hazard perceptions to enhance public outreach and preparedness efforts.

Keywords: Earthquake, Seismic hazard, Seismic hazard perceptions, Emergency managers, Vancouver Island, Canada

3.2 Introduction

Southern Vancouver Island, British Columbia (BC), Canada, is exposed to many natural and human-made hazards such as climate change, severe weather, flood, drought, hazardous material spills, disease outbreaks and power outages (Emergency Management BC, 2016; Natural Resources Canada, 2016b; Stevens & Hanschka, 2014; Zhang & Hebda, 2005). However, the most prominent risk facing the area is the risk associated with earthquakes in the region. Damaging earthquakes are inevitable in the region and are a potentially catastrophic threat, subject to triggering a number of cascading threats from tsunamis to fires to landslides (Emergency Management BC, 2016; Natural Resources Canada, 2013; Office of the Auditor General of British Columbia, 2014; Renteria, 2014). For this reason, emergency managers on southern Vancouver Island focus much of their planning, preparedness and public outreach efforts on informing local residents about earthquakes and earthquake preparedness, with the assumption that if you are prepared for an earthquake, you are prepared for most threats (Emergency Management BC, 2016; Renteria, 2014).

Emergency managers and policy makers across the province agree that the development of disaster resilient communities is a shared responsibility (Levac et al., 2012; Office of the Auditor General of British Columbia, 2014; Renteria, 2014). A "disaster resilient" community is one in which all community members know the threats and their hazard, understand the consequences, and are prepared to respond and recover (Canadian Red Cross, 2013; Emergency Management BC, 2016; Government of Canada, 2016; Johnston & Paton, 2001; Levac et al., 2012). The more aware, knowledgeable, and personally prepared individuals are for an emergency event, the more likely they are to respond effectively and recover quickly, and with limited assistance, thereby increasing resilience and reducing environmental, social, economic and physical impacts to communities (Dooley et al., 1992; Johnston & Paton, 2001; Levac et al.,

2012; Verrucci et al., 2016). Conversely, a lack of hazard knowledge among community members can increase a community's risk.

In this paper, "hazard" refers to the frequency or likelihood of a potentially dangerous and damaging phenomenon or threat occurring (Alexander, 2011; Seemann, 2012). Hazard is often perceived by the public to be synonymous with risk (Slovic, 1987). However, in engineering, insurance and academic communities, hazard is considered the likelihood of a threat occurring in a given location within a given time. It is considered to be a component of risk, distinct from consequences, which is best represented by the equation: Risk (R) = Hazard (H) x (C) Consequence (Figure 3.1). It is important to note that the definition of hazard used in this paper differs from the colloquial use of the term, which loosely refers to any type of risk, threat or event. For the purposes of this paper, hazard and likelihood are used interchangeably, and risk is defined as the product of a threat's hazard and the consequences that will follow, whether environmental, material, economic, social or otherwise (Gierlach et al., 2010; Seemann, 2012). These relationships are depicted in Figure 3.1.

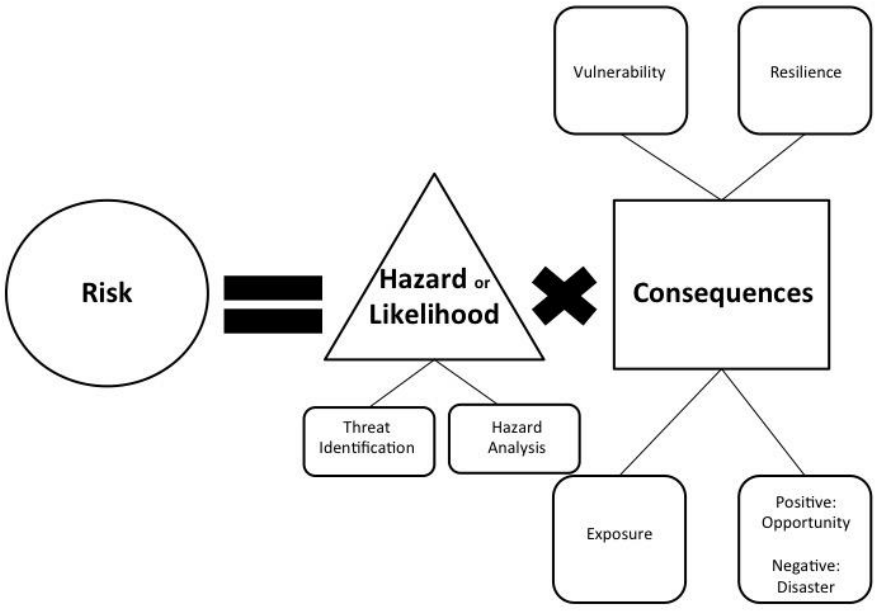

Figure 3.1 Visual explanation of the relationship between risk, hazard and consequences
Adapted from: Wisner et al. 2003; Cutter et al. 2008; Gierlach et al. 2010; Seemann 2012

The risk and hazard communication literature outlines the importance of several key factors in encouraging residents to take action to become prepared. These include understanding the audience and targeting messaging accordingly, ensuring positive, consistent messages from multiple sources over time, and using multiple platforms and different methods of communication, particularly ensuring relevance to the audience being targeted (Coppola, 2011; Coppola & Maloney, 2009; Mileti, 1999). Despite the fact that local and provincial entities are partnering to deliver this consistent messaging (Emergency Management BC, 2016), the literature on disaster preparedness in Canada reports that most Canadians have not taken the recommended minimum precautions of learning about the hazards in their area, preparing an emergency kit and creating an emergency plan (Levac et al., 2012). Historically, research tends to base Canadians' lack of preparedness measures on the country's limited experience with the consequences of disasters (Newton, 1997). However, in the past four years, Western Canada has seen two of the most costly insurable disasters in its lifetime: The northern Alberta wildfire of 2016, and the southern Alberta floods of 2013 (Insurance Bureau of Canada, 2016). These two disasters cost approximately $3.58 billion and $1.7 billion, respectively, in insurable losses alone (Insurance Bureau of Canada, 2016). These significant events serve as important examples to persuade British Columbians and Canadians alike to become better prepared by recognizing that disaster can strike close to home. Further, the insurable losses for these events pale in comparison to the expected financial losses predicted for a large West Coast earthquake event. A study conducted by the Insurance Bureau of Canada found that a M9.0 scenario Cascadia Subduction Zone event, approximately 11 km deep and 75 km off the coast of Vancouver Island would result in more than an estimated $20 billion in insurable losses and more than $74 billion in total direct and indirect losses (Insurance Bureau of Canada, 2013).

3.2.1 Emergency management in BC. In BC, planning for and responding to emergencies is the responsibility of local governments (either municipalities or regional districts, for electoral areas), as legislated by the province, under the *Emergency Program Act* (Province of

British Columbia 1996), and is supported by the Provincial government when an event exceeds the local government's ability to respond. Most local governments manage this responsibility by designating an emergency program coordinator within their administrative structure. For many smaller communities and organizations, meeting the requirements of the legislation without significant designated staff and financial resources can make sustaining a successful emergency program challenging (Renteria, 2014).

As part of the planning of emergency program responsibilities, a common function of local emergency programs in BC is a public education and community outreach strategy at the local level, which the province is legislated to support (Province of British Columbia, 1996; Renteria, 2014). Emergency program coordinators often deliver workshops, create informational brochures and run preparedness media and social media campaigns. These measures are typically reflected in municipal emergency management bylaws (where they exist), and are part of emergency coordinators' responsibility for the "encouragement of public emergency preparedness [or management]" (City of Victoria, 2004; The Corporation of the District of Saanich, 2001). However, in order for these efforts to be successful, emergency managers must know their audience and have an appreciation for how they receive and comprehend risk-related information (Coppola, 2011; Coppola & Maloney, 2009; Mileti, 1999; Rothman & Salovey, 1997; Slovic, 1987).

3.2.2 Study area and demographics. Vancouver Island is a large island, stretching more than 31,000 km^2 from north to south, and situated approximately 50 kilometres off the southWest Coast of BC, with a mountainous topography (Guthrie, 2005). The two regions selected for this research were the CRD and the CVRD, the two southernmost regional districts on Vancouver Island (Figure 3.2). Both regional districts include urban and rural municipalities, and have varying economic and demographic characteristics influencing their vulnerability. In addition, the location of these study sites on an island, connected to the mainland by boat or plane

transportation only, poses additional planning considerations for the emergency managers in the region, as well as having implications for the public's personal preparedness.

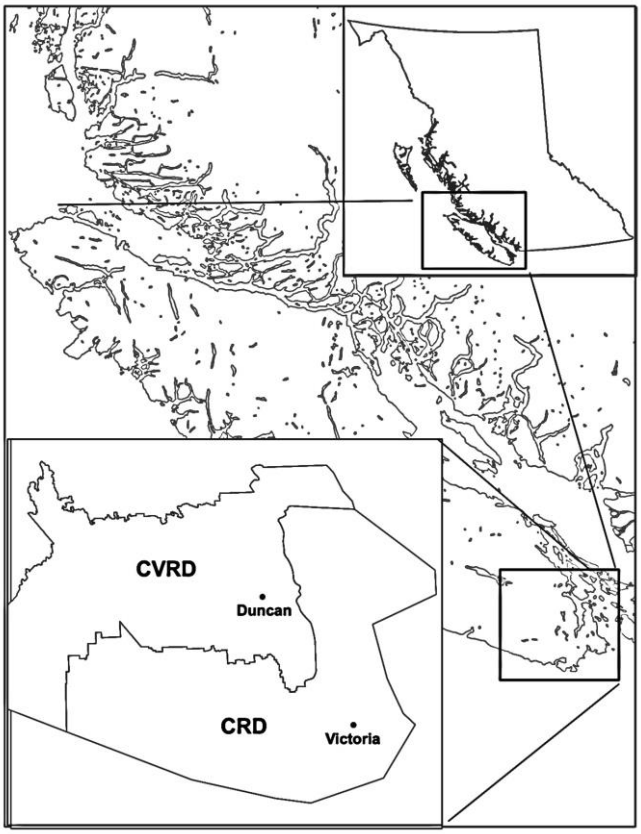

Figure 3.2 Map of study site showing Capital Regional District (CRD) and Cowichan Valley Regional District (CVRD) in relation to Vancouver Island, and the Province of British Columbia

The CRD is comprised of 13 municipalities, with a population of 382,646 in 2016, and a land area of 2,341square kilometres (BC Stats, 2012b, 2016). The CVRD connects Vancouver Island's two most populous regional districts, and is home to both urban and rural communities. It has four municipalities and a total population of 84,013 in 2016, with a land area of 3,473 square kilometres (BC Stats, 2015, 2016). The CRD is more urbanized than the CVRD, with a much larger population living in a smaller, more densely populated land area.

Both the CRD and the CVRD have a larger proportion of people aged 65 and older living in the region compared to the province as a whole (Table 3.1). Both regional districts also have a

lower percentage of individuals identifying as a visible minority. While, the CRD has a smaller proportion of Aboriginal peoples than the province, the CVRD has a greater proportion.

The average household income of families in the CRD is greater than the CVRD, with the provincial average between the two (Table 3.1). In both regional districts the majority of the adult population have post-secondary qualifications, although in the CRD there is a greater proportion of individuals with a post-secondary degree or higher, compared to the provincial average, whereas in the CVRD this proportion is lower than the provincial average.

Depending on an individual's physical mobility, knowledge of threats, local knowledge of community geography and resources, different demographic attributes have the ability to drive both resilience and vulnerability in a region. Therefore, it is important for planners to understand their community's demography. Generally speaking, older adults and younger children tend to be more vulnerable than able-bodied younger adults. Similarly, socio-economic factors like income and education tend to influence individuals' ability to both respond and recover from emergencies. In addition, typically individuals with more education and higher income levels are expected to be more resilient than those with little education and low incomes.

Table 3.1 Demographics of the Capital Regional District, the Cowichan Valley Regional District and the Province of British Columbia

	Capital Regional District	Cowichan Valley Regional District	British Columbia
Number of municipalities	13	4	
Total population (2016)	382,646	84,013	4,751,612
Proportion of individuals aged 65 and older (2012)	19.1%	20.4%	15.9%
Proportion of individuals identifying as a visual minority (2012)	10.1%	4.2%	24.8%
Proportion of individuals identifying as Aboriginal (2012)	3.3%	9.7%	4.8%
Average household income (2012)	$84,032	$71,597	$80,511
Proportion of adult population with post-secondary qualifications (2012)	66.7%	57.3%	61.8%
Proportion of adult population with a university degree or higher (2012)	29.0%	14.6%	24.1%

Source: (BC Stats, 2012b, 2012c, 2016)

3.2.3 Tectonic setting and physiography. Vancouver Island's tectonic setting is visual to the naked eye. Its mountainous surface is divided by the Vancouver Island Ranges, which consist of steep mountains made up of volcanic and sedimentary rocks ranging from sea level to 2200m (Guthrie, 2005), showing evidence of earthquakes having occurred in the past.

The Pacific Coast is the most seismically active region of Canada, with seismologists recording over 1000 earthquakes in the region each year (Natural Resources Canada, 2013). In the past 70 years, there have been over 100 earthquake events occurring at a magnitude of greater than 5.0 in the region (Natural Resources Canada, 2013). However, most earthquakes recorded in this region are not felt, and have not caused substantial damage in decades (Natural Resources Canada, 2013).

Earthquakes in southwestern BC are the result of movements between three active plates: The Pacific, North America and Juan de Fuca plates (Clague, 2002). The relationship between these three active plates creates the potential for different types and magnitudes of quakes. The

Juan de Fuca oceanic plate, located west of Vancouver Island and extending from the northernmost point of Vancouver Island to northern California, is moving towards North America at the speed of 2-5 centimetres per year, and subducting beneath the continental plate, creating the Cascadia Subduction Zone (Figure 3.3) (Natural Resources Canada, 2013). These plates are locked, creating strain that will eventually be released during a large subduction interface earthquake (Clague, 2002; Rogers, 1988). Subduction interface earthquakes are among the largest earthquakes recorded across the world and are typically greater than M8.0 and cause the earth to shake for more than two or three minutes, with aftershocks occurring within an order of magnitude of the original quake (Seemann, 2012). A Cascadia Subduction Zone event could cause widespread damage along the West Coast of North America from northern Vancouver Island to northern California (Clague, 2002; Rogers, 1988), not just from the initial event, but from the triggered aftershocks, landslides, and tsunamis as well as numerous tertiary impacts. An event of this magnitude has not been seen in modern history in this region and the potential consequences are unsettling to emergency managers and the public alike.

In addition to the long duration shaking threat that comes with subduction interface earthquakes, southwestern BC is also at risk from crustal and sub-crustal earthquakes (Clague, 2002; Hyndman & Rogers, 2010; Natural Resources Canada, 2013; Rogers, 1988). Crustal earthquakes typically have shallow epicentres, usually occurring between 20 and 30km of the earth's surface, with magnitudes of less than 7.5 and shaking that usually lasts less than one minute (Seemann, 2012). Sub-crustal earthquakes occur at greater depths, typically between 30-45km beneath the earth's surface, also with shaking intensities of less than M7.5 and shaking that lasts less than one minute (Seemann, 2012). Because sub-crustal earthquakes occur farther from the surface, they tend to result in less damage than crustal earthquakes but can affect a broader geographic region (Seemann, 2012). Crustal earthquakes tend to affect a much smaller geographic area, but have the potential to cause severe localized damage (Seemann, 2012).

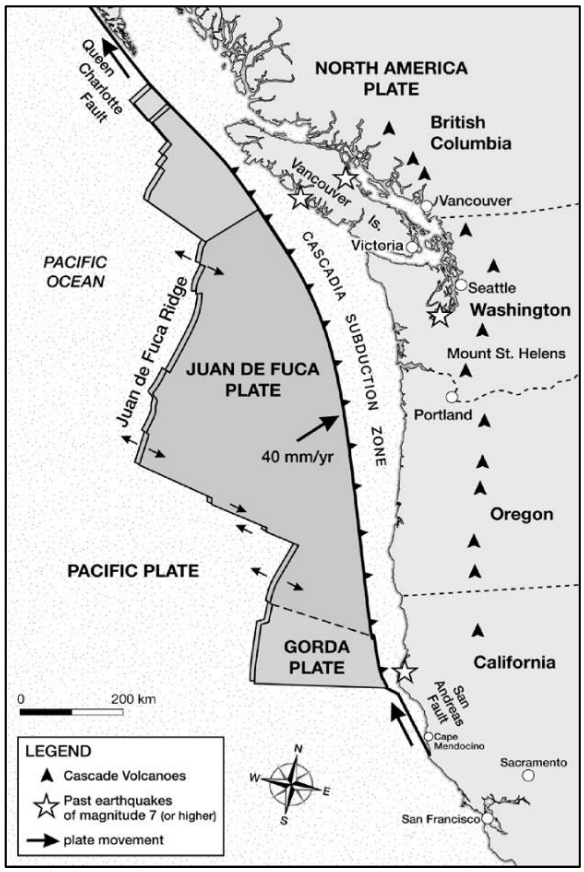

Figure 3.3 Cascadia Subduction Zone (Thompson, 2011)

3.2.4 Seismic hazard estimates. This paper explores perceptions of hazard from a non-structurally damaging earthquake held by members of the general public and emergency managers compared to calculated seismic hazard estimations. Seemann et al. (2011) calculated earthquake shaking probabilities for crustal, sub-crustal and subduction interface earthquakes in various geographic locations on Vancouver Island. They provide probabilities for three levels of shaking intensity: widely felt, non-structurally damaging and structurally damaging (Seemann et al., 2011). The type of shaking expected from a non-structurally damaging earthquake (as outlined by the Modified Mercalli Intensity Scale [MMI ≥ VI]) is described as an earthquake event that is felt by all, indoors and outdoors, that would cause some damage in poorly built buildings, broken dishes and glassware, some broken windows and some cracks in plaster and chimneys (Seemann et al., 2011). Non-structurally damaging earthquakes were chosen as

appropriate to test general public perceptions because this type of earthquake scenario was more likely to produce some damage to their home and community, but not to be an earthquake so violent as to promote distress by considering it. Shaking probabilities for Victoria and Duncan are presented in Table 3.2, and values given are mid-range shaking probabilities of a non-structurally damaging earthquake.

Examining aggregate earthquake probabilities, Seemann et al. (2011) report that within the next 10 years there is a 21% probability of a non-structurally damaging earthquake occurring in Victoria, and an 18% probability in Duncan (Table 3.2) (Seemann et al., 2011). In the next 25 years, the probabilities are 38% and 33%, respectively (Seemann et al., 2011). These two locations are the central urban hubs of the south island, Victoria being the second-most populous municipality in the CRD as well as the Provincial capital, and Duncan being the primary urban centre and most populous municipality in the CVRD.

Table 3.2 Calculated earthquake shaking probabilities for non-structurally damaging (MMI ≥ VI) crustal, sub-crustal and subduction interface earthquakes in Victoria and Duncan, BC

	Victoria		Duncan	
	10 years (%)	25 years (%)	10 years (%)	25 years (%)
Crustal and sub-crustal	14	32	11	26
Aggregate (crustal, sub-crustal and subduction interface)	21	38	18	33

3.2.5 Hazard perceptions. The threat of a significant seismic event affecting southern Vancouver Island is a fact accepted by most residents (Hyndman & Rogers, 2010; Renteria, 2014). However, in the last 100 years, Vancouver Island has experienced only a handful of large earthquake events that have caused damage in the Pacific Northwest including two approximately M7.0 earthquakes that caused damage on Vancouver Island in 1918 and 1946 (Hyndman & Rogers, 2010) and one M6.8 quake that caused damage in South Seattle, United States, in 2001

(Joffe et al., 2013). Given that these damaging local seismic events occurred many years ago, many residents may have not experienced them and may never have experienced a significant earthquake in their community. There have been more recent 'felt' events in Victoria and Duncan, such as the M4.7 earthquake that occurred under Sidney, BC on December 29, 2015 (Hager, 2015), but these did not cause damage and could lead to a sense of complacency around earthquakes. Therefore, many residents may not have directly experienced a strong or damaging earthquake, which the literature indicates influences individuals to have a high perception of particular threats (Tierney et al., 2001).

Studies of hazard perception can provide valuable, applicable insights into how resilient communities are, as knowledge of threats is considered to be an imperative step in preparedness (Canadian Red Cross, 2013; Dooley et al., 1992; Emergency Management BC, 2016). Results of hazard perception studies can also identify gaps in knowledge that can be improved through outreach techniques and preparedness campaigns (Johnston and Paton 2001; Levac et al. 2012; Canadian Red Cross 2013; Emergency Management BC 2016; Government of Canada 2016). In addition, Slovic (1987) suggests that when defining their perception of risk, lay people often rank risks in terms of what has the greatest potential to have risky consequences, to be out of their control and to have an inevitable outcome, making their risk perception akin to their perception of hazard, or a ranking of the probability of a risky event occurring (Slovic, 1987). This therefore enables researchers to potentially infer important hazard information from risk perception studies. However, studies of both seismic hazard perceptions and seismic risk perceptions are limited, with the majority being risk perception studies conducted in communities that have recently suffered a large earthquake (Kung & Chen, 2012; McClure et al., 2014; Nakayachi et al., 2014).

3.2.6 Research gaps. There are very few published studies examining perceptions of seismic hazard for either the general public or emergency managers in BC, or elsewhere in Canada. Nor does there appear to be studies in BC or elsewhere in Canada that explore the

discrepancies between the general public and emergency managers' perceptions and calculated seismic hazard estimations. Research exploring the differences between the general public and experts' risk perceptions does exist, and highlights disparities between experts' assessments of risk, and the general public's intuitive perception (Grothmann & Reusswig, 2006; Ho et al., 2008; Lindell & Perry, 2000; Slovic, 1987, 1999, 2012). This American research finds that lay people have the tendency to identify rare hazards as significant risks, while experts identify more frequent threats as significant risks. This research is virtually nonexistent in Canada, let alone Vancouver Island, and only one dated study explores seismic perceptions among the general public. In this 1981 study by Jackson, Victoria, BC was included among other earthquake-prone West Coast cities including Vancouver, BC. Jackson's research showed that only 1.7% of all respondents (not categorized geographically) considered earthquakes to be a disadvantage to living in their city, while the remaining respondents did not mention earthquakes at all. This research would more likely be considered risk perception than hazard perception, however, from Slovic's (1987) findings, researchers can infer that this risk perception could provide an idea of how likely seismic events were perceived to occur at the time of Jackson's research (Jackson, 1981; Slovic, 1987). This limited research on seismic perceptions highlights the gap in our understanding of current earthquake perceptions, and offers an opportunity to inform community decision-makers, emergency managers, as well as the community at large, about any discrepancies between seismic hazard perceptions and calculated estimates. This research has the potential to aid elected officials, risk and emergency managers, and first responders by better informing themselves as well as the public they serve in their jurisdictions. In turn, this information has the potential to improve individual and community preparedness.

To address this gap in knowledge, this paper: 1) Provides descriptive data from interviews conducted with the general public and emergency managers about perceptions of seismic hazard on southern Vancouver Island, identifying differences within each group; 2) Examines discrepancies between the perceptions of seismic hazard for members of the general

public and emergency managers compared to actual calculated seismic hazard, identifying differences within each group; and, 3) Explores differences between the seismic hazard perceptions of the general public compared to perceptions of emergency managers, all compared to calculated seismic hazard estimates. In so doing, valuable information is presented for the emergency management community to support potential improvements to risk governance to ultimately foster healthier, safer and more disaster resilient communities on southern Vancouver Island.

3.3 Methods

3.3.1 Data collection and analysis. Prior to designing the study, some members of the emergency management community in the region were consulted for guidance regarding the research objectives to ensure the results would be applicable to emergency managers once the data were collected and analyzed. Before conducting the interviews, approval was received from the University of Victoria's Human Research Ethics Board. The questionnaire for both groups was rigorously pilot-tested to improve clarity and ease of completion, and to be sensitive to time required to complete it. Data collection began in December 2015 and was completed in May 2016.

During data collection, semi-structured surveys were administered to the two different groups: The general public and emergency managers living and working within the boundaries of the CRD and CVRD. The questionnaires were structured into five sections that asked a series of questions related to: 1) Demographics, 2) Disaster risk perceptions, 3) Earthquake hazard perceptions, 4) Earthquake knowledge, and 5) Expectations and household preparedness. In completing the surveys, participants could often select multiple responses, and provide their own open-ended responses in some cases. The surveys also included opportunities for participants to share their opinions beyond the specific questions asked. For the purposes of this paper, the questions analyzed focused on what participants perceived the seismic hazard from a non-

structurally damaging earthquake to be in the next 10 and 25 years. In answering this question, participants responded by estimating probabilities as a percentage based on what they thought the chances of a non-structurally damaging earthquake occurring in their community would be in these two time periods.

A total of 105 members of the general public and 13 emergency managers were surveyed. Participants from the general public were approached in public locations in different communities in the two study sites. These public spaces included libraries and recreation centres in a range of municipalities and neighbourhoods within the regional districts included in the study sites. Within the CRD, sampling took place in a total of three municipalities, and at six different locations. Within the CVRD, sampling took place in two municipalities, at three different locations. Emergency managers in the CRD were asked for their endorsement and participation following a presentation to the Local Government Emergency Program Advisory Commission at their monthly meeting, held in Victoria in September 2015. Following this meeting, interviews were scheduled and took place at the participants' office, or at an alternate location of their choice. Additional interviews were based on a snowball sampling approach of participants recommended by other participants.

The 13 emergency managers who were sampled as part of this study worked for a range of organizations including local and regional government, industry, academic institutions, health institutions and others. The role of these emergency managers is to either carry out the activities of, or to oversee the emergency program within their organization. These activities include creating emergency plans for response and recovery, organizing and overseeing volunteer groups and responding to emergencies within their municipality or organization. Many, if not all, emergency managers surveyed had significant experience with emergency response in emergency operations centres.

Based on the small, convenience sample collected for this research, descriptive analyses were the most appropriate. Results were analyzed using the Statistical Package for the Social Sciences (SPSS) Version 23.

3.4 Results

Combining surveys by the general public and emergency managers resulted in a total of 118 surveyed individuals for this research (Table 3.3). About 31.4% of the sample resided in the CVRD, while the remaining 68.6% resided in the CRD. Generally, the makeup of the population in terms of overall demographics (such as age and gender) and socio-economic status (such as average income and education levels) for the sample population was similar to the averages for each region respectively (Table 3.1, Table 3.3). The greatest proportion of respondents self-identified as having a household income of more than $70,000 and the majority of participants had some level of post-secondary qualification (Table 3.3). This is reflective of the socio-economic characteristics of the area according to demographic data compiled by BC Stats for both regions (Table 3.1). Among the general public participants, there was almost an even representation of males and females (52 and 53, respectively). However, among the emergency managers, there were a higher proportion of male participants (69.2% males compared to 30.8% females).

Table 3.3 Demographics and socio-economic characteristics of all participants

Characteristics	General Public (*n*=105)		Emergency Managers (*n*=13)	
	Frequency (*n*)	**Percent of sample (%)**	**Frequency (*n*)**	**Percent of sample (%)**
Age				
18-24	7	6.7	0	0.0
25-34	11	10.5	1	7.7
35-44	19	18.1	2	15.4
45-54	25	23.8	5	38.5
55-64	19	18.1	4	30.8
65 and older	24	22.9	1	7.7
Gender				
Male	52	49.5	9	69.2
Female	53	50.5	4	30.8
Highest Level of Education				
High school diploma or less	16	15.2	0	0.0
Some post-secondary	26	24.8	3	7.7
Post-secondary degree	36	34.3	9	69.2
Graduate degree	27	25.7	1	23.1
Household Income				
Less than $30,000	20	19.0	0	0.0
$30,000 – $60,000	32	30.5	1	7.7
$70,000 or greater	42	40.0	12	92.3
Prefer not to disclose	11	10.5	0	0.0

General public participants in both the CRD and the CVRD on average estimated the seismic hazard in their community to be higher than the calculated estimates presented by Seemann et al. (2011) (Table 3.4). A descriptive analysis was conducted to determine if there were divergent trends between the two groups (general public and emergency managers) and within the groups (for example, differences related to gender, socio-economic status, or other variables). This analysis revealed that there did not appear to be a trend among different age categories of participants in relation to seismic hazard perception. However, relationships were observed in relation to time living on Vancouver Island, education levels and income levels (Table 3.5).

Table 3.4 Comparison of reported probability estimates and public perceptions for a non-structurally damaging earthquake[a] [MMI≥ VI][b] (%) on southern Vancouver Island

Hazard	**10 years**		**25 years**	
	CRD[c]	**CVRD**[d]	**CRD**	**CVRD**
Hazard Estimates[e] **(%)** (Seemann et al. 2011)	21.00	18.00	38.00	33.00
Hazard Perception General Public Estimates (mean,%)	35.35	39.27	47.87	53.55
Hazard Perception, Emergency Manager Estimates (mean, %)	46.75	30.00	54.92	50.00
Emergency Managers' Predictions of General Public's Perceptions (mean, %)	25.42	25.00	35.00	50.00

Notes :[a]These probabilities include crustal, sub-crustal and subduction sources.
[b]Non-structurally damaging as measured on the Modified Mercalli Intensity Scale (MMI ≥ VI) is described as: Felt by all, indoors and outdoors. Damage slight in poorly built buildings. Fall of plaster, cracks in plaster and fine cracks in chimneys in some instances. Broken dishes, glassware in considerable quantity, as well as some windows. Overturned furniture in many instances (Seemann, 2012).
[c]Capital Regional District
[d]Cowichan Valley Regional District
[e]Calculated estimates source: Seemann et al., 2011.

On average, individuals who have lived on Vancouver Island for four years or less, and who have lived on Vancouver Island for between 21 and 40 years perceived the seismic hazard in the next ten years to be lower than those who have lived on Vancouver Island for between five and 20 years, or for 41 or more years (Table 3.5). Results also showed that higher education levels were linked to lower levels (also, closer to the actual hazard) of seismic hazard perception (Table 3.5). A similar trend was found for household income, where, generally, the higher the income, the lower the perception of seismic hazard (Table 3.5). For seismic hazard in the next 25 years, almost all respondents perceived a probability of close to 50% regardless of time living on Vancouver Island, education levels, income or age.

Table 3.5 Descriptive results of public perceptions of seismic hazard from a non-structurally damaging earthquake in the next 10, 25 years

Demographics	10 years		25 years	
	n	**Mean (%)**	***n***	**Mean (%)**
Age				
18-34	18	38.83	18	48.78
35-44	19	38.47	18	53.06
45-54	25	36.00	25	54.44
55-65	18	30.83	18	41.94
65 and older	22	38.64	21	49.74
Gender				
Male	50	38.18	50	51.10
Female	52	35.12	50	48.38
Regional district				
Capital Regional District	69	35.35	67	47.87
Cowichan Valley Regional District	33	39.27	33	53.55
Time on Vancouver Island				
≤ 4 years	10	32.70	10	52.30
5 – 10 years	14	37.50	14	46.79
11 – 20 years	21	40.95	21	55.95
21 – 40 years	37	33.24	36	47.11
41 + years	20	39.65	19	48.68
Highest level of education				
High school diploma or less	15	37.60	14	49.07
Some post-secondary	26	39.15	26	52.58
Post-secondary degree or higher	61	35.30	60	48.67
Household income				
Less than $30,000	20	42.15	19	58.68
$30,000 – $60,000	30	34.93	29	45.21
$70,000 or greater	41	34.00	41	49.34
Prefer not to disclose	11	40.91	11	47.73

On average, the public in both the CRD and the CVRD overestimated the hazard in their community in every scenario asked about in the survey, ranging from a mean overestimation of nine percent in the smallest instance to 21% in the largest. Therefore, the average participant surveyed thought that a non-structurally damaging earthquake occurring where they live is a probable event, even more probable than estimates suggested by science. Although the calculated

hazard estimates are higher for those living in the CRD than the CVRD, residents in the CVRD perceived the hazard to be higher than those in the CRD.

Similar to members of the general public, emergency managers estimated the hazard from a non-structurally damaging earthquake in their community to be higher than the calculated scientific hazard estimate. Overestimations occurred in every scenario asked about in the questionnaire (CRD and CVRD in the next 10, and 25 years), similar to the general public. Mean responses ranged from an overestimation of 12% in the lowest instance and 25% in the largest.

Emergency managers were also asked an additional question about their perception of how the general public in their jurisdiction would respond about seismic hazard in their community for a non-structurally damaging earthquake. The emergency managers' predictions of the general public's responses were on average much lower than the public's actual responses, but were closer to the calculated hazard (Figure 3.4). In most cases, the emergency managers' predictions of the general public's perceptions were noticeably lower than the emergency manager's own perceptions. Based on this, it appears that emergency managers do not believe that the public in their jurisdictions consider earthquake a probable event.

Generally, each group's perception of a non-structurally damaging earthquake occurring in their community in the next 10 or 25 years was higher than the calculated estimations (Figure 3.4). However, in some cases, participants within the general public were so uncertain of the response that they declined to answer the question entirely (eight [3.8%] declined answers total for both questions). Many more portrayed uncertainty or explained that they were guessing. However, generally speaking, all groups overestimated the hazard of a non-structurally damaging earthquake. It is important to point out this is not an overestimation of risk, rather an overestimation of the likelihood of this level of ground shaking occurring. Earthquake risk was not analyzed.

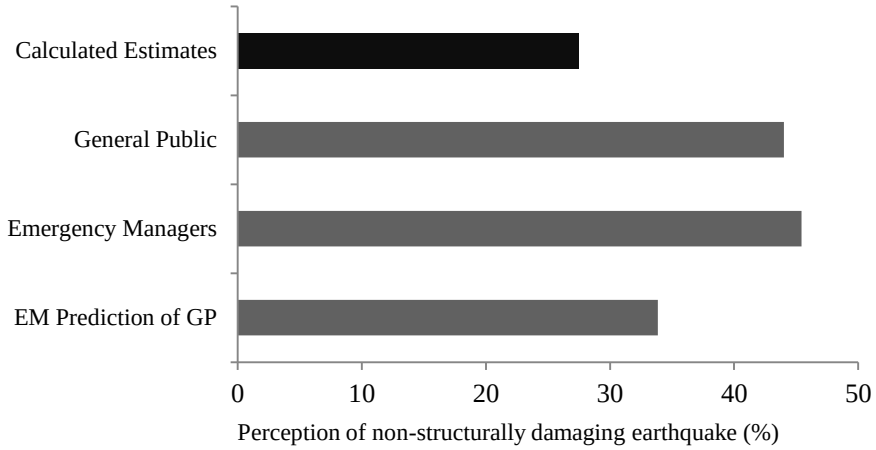

Figure 3.4 Seismic hazard perceptions among emergency managers and the general public compared to calculated seismic hazards

Calculated Estimates Source: Seemann et al. 2011, Note: Perception values have been translated into an average of total responses for the next 10 and 25 years in two locations: Capital Regional District and Cowichan Valley Regional District.

3.5 Discussion

Understanding public perceptions of seismic hazard is fundamental for building knowledge and fostering healthier, safer and more disaster resilient communities on southern Vancouver Island. The results of this descriptive analysis compared hazard perceptions of those surveyed to the calculated scientific estimations reported in Seemann et al (2011). This paper found that both the general public and emergency managers overestimate the seismic hazard of a non-structurally damaging earthquake occurring in their community, and that emergency managers generally overestimate the hazard more so than the public does. Results also showed that emergency managers underestimate the public's perceptions of seismic hazard, but that their prediction of the public's perception is closest to the calculated hazard estimations. Some trends were found within groups related to hazard perception. For example, time living on Vancouver Island influenced participant perceptions, as well as education and household income.

3.5.1 Limitations. While this study was the first of its kind to evaluate perceptions of seismic hazard on Vancouver Island and compare them to scientific estimates, there are some limitations worth noting. One of the main limitations of this study is the inability to make causal

inferences based on the type of data that were collected. Specifically, the small, non-random data collected limited the statistical analysis that could be employed for this research. Therefore, the analysis shown in this paper is limited to descriptive methods. Among the emergency management population, the small sample size was deliberate and purposive, as the intention was to sample the right individuals with direct emergency management experience and expertise in the areas under study, rather than a large, random sample of individuals working in the realm of emergency management in any jurisdiction. Among the general public, the sample size was appropriate for an array of statistical tests, however, the convenience sample collected and the data analyzed for this paper did not allow for inferential statistical testing.

3.5.2 Seismic perceptions over time. While there are no recent, comparable studies that examine perceptions of seismic hazard in BC, Jackson (1981) evaluated perceptions of seismic risk as a disadvantage to living in an earthquake-prone region, and reported an incredibly low perception of seismic risk. At that time, only 1.7% of respondents considered an earthquake as a disadvantage of the city in which they lived (Jackson, 1981). Although this research is not directly comparable because it explores seismic risk and not hazard, based on Slovic's (1987) explanation that lay people's perceptions of risk are reflective of their perceptions of probability and consequence, and therefore hazard, a general comparison could be made to suggest that perceptions of seismic hazard have grown in the region over the past several decades. A change in public perception over this amount of time could be due to several societal changes over the past few decades, including increased media coverage of seismic events both locally and across the globe, changes to our education system over time incorporating an understanding and awareness of earthquakes into the curriculum, and scientific knowledge becoming more accessible to the population in the information age we are currently living in.

3.5.3 Hazard perceptions: Differences between groups. Differences between the two different population groups as well as the two regional districts emerged as key findings in this

research. Although both groups overestimated their hazard, some additional trends were discovered.

General public and emergency managers. Perceptions of seismic hazard among the general public and emergency managers were higher than the calculated hazard estimates (Seemann et al., 2011) in both the 10 and 25 year periods, with an average overestimation of 17%. This information can be shared with emergency managers in order to consider how to address the gap between scientific estimates of seismic hazard and public perceptions in order to improve the way that hazard is communicated to the public. Enhanced knowledge of a threat's likelihood gives residents the ability to make informed decisions about reducing their personal and household risk.

Regional districts. According to the calculated seismic hazard estimates, individuals living in the CRD face a higher likelihood of a non-structurally damaging earthquake event occurring in their community than individuals in the CVRD. However, results showed that individuals in the CVRD perceived the hazard to be higher than those in the CRD. One possible reason for this could be the sample size—a smaller sample in the CVRD translates to larger proportions per response.

3.5.4 Hazard perceptions: Differences within groups. Differences within the general public group emerged as key findings in this research. However, some variables within groups were not found to show differences in perception. For example, no trends emerged in relation to age or gender. Explanations of trends within groups are explained below, although these findings were not tested for statistical significance because the data were not appropriate for this type of testing.

Time spent living on Vancouver Island. Time spent living in the area had an influence on perceived seismic hazard such that individuals who have lived on Vancouver Island for more than 4 years perceived the seismic hazard in their community to be lower (between approximately 5% to 8%) than those who had lived on Vancouver Island for 5 years or more. Within this trend,

there was also an outlying group: those who had lived on Vancouver Island for between 21 and 40 years. Respondents in this group perceived the hazard to be only slightly higher (less than 1%), on average, than individuals who had lived on Vancouver Island for four years or less. Several factors related to geography and demographics could explain this trend. Individuals who have lived on Vancouver Island for less time may not be aware of risks in the same way as individuals who have lived here for many years. Alternatively, the literature suggests that one of the strongest indications of how high an individual's perception of a risk will be is their experience with that threat in the past (Shaw et al. 2004; Kung and Chen 2012). Therefore, individuals who have lived on Vancouver Island for between 21 and 40 years may have lived on Vancouver Island for so long without experiencing a consequential seismic event that they have lowered their perception of the seismic hazard. Additionally, the fact that there were relatively few noticeable differences among groups in regards to their perceptions may indicate a lack of specific information regarding hazard being shared to the general public.

While it is clear from the results of this survey that the general public is aware that they live in an earthquake zone, participants appear to lack the information and knowledge to accurately be able to quantify their perceived seismic hazard as a probability and to prepare accordingly. This exposes a gap in hazard communications that may be negatively impacting community resilience.

Household income and education. Results showed that generally, the lower the household income level, the higher the respondents' perception of seismic hazard was. This trend was particularly evident among those in the highest and lowest annual income brackets ($70,000 or greater, and less than $30,000). The same trend was observed for education levels—the higher the level of education, generally, the lower the perception of seismic risk. This trend is consistent with trends reported in the literature outlining that individuals of lower income and education levels express higher vulnerability (Armaş, 2008; Cutter, Boruff, & Shirley, 2003). This also provides some direction for targeted outreach by emergency managers in the regions sampled.

Based on this research, it is evident that individuals with lower income and education levels should be identified as target audiences for potential preparedness campaigns or incentives to increase community resilience.

Emergency managers' predictions of public perceptions. In this study, emergency managers provided their own perceptions of seismic hazard and then were subsequently asked about their perceptions of the general public's responses. Emergency managers' predictions of the general public's perceptions of seismic hazard underestimated the public's perceptions by about 10% on average. However, their predictions of the public's perceptions were the results closest to the actual calculated seismic hazard (average responses for emergency managers' predictions of public perceptions for both locations and both time frames were 33.85% compared to the calculated hazard average of 27.5%). These predictions were lower than both the emergency managers' own perceptions, as well as the perceptions given by the general public. This result could suggest that emergency managers believe the general public tends to underestimate the hazard in their community, when in fact the general public actually overestimate the hazard. It is possible that this finding could be explained through the emergency managers' interactions with the public in their communities. Based on their interactions with the public in their jurisdiction, emergency managers may derive the perception that the public is generally unprepared, so therefore they must have a lower perception of seismic hazard. However, although the survey tool used for this research explored preparedness, this paper did not examine its relationship related to hazard, and therefore does not explore whether these heightened perceptions are related to an increased level of preparedness. Additional research and analysis must be undertaken to determine the relationship between perception and preparedness among the general public.

3.5.5 Recommendations for future research. Changing the sampling strategy and increasing the sample size could address some of the limitations of this research and provide a more robust statistical baseline of hazard perceptions for the region. In addition, future research could look at correlations between hazard perceptions and household preparedness and mitigation

levels, in order to explore whether increased perception in the region translates to increased preparedness and mitigation measures, or whether more accurate perceptions (in relation to the calculated hazard estimations) influence preparedness actions in comparison to less accurate perceptions. Because the general public's perception of seismic hazard was greater than the calculated estimation, one might expect levels of preparedness to be higher and reflective of this heightened perception. Future research would benefit from addressing the relationship between hazard perception and preparedness. In addition, repeating this study in different regions of earthquake-prone North America would enable researchers to derive whether there are similarities or differences related to more wide-spread geography than two neighbouring regional districts.

Another recommendation for future research would be to conduct a similar study to this one, in the same locations, following a significant earthquake event, and to analyze whether the results are in alignment with other studies where seismic perceptions have been measured in a location that has recently suffered a significant seismic event (Kung & Chen, 2012; McClure et al., 2014; Nakayachi et al., 2014). Conducting pre- and post-testing of hazard perceptions could provide interesting insights to how perception is influenced by actual experience with hazards and disasters.

3.6 Conclusion

Vancouver Island faces unique risks, specifically related to the potential for seismic events in the region. Although the south island is at risk from various types of earthquakes and sits on numerous active faults, the region has only experienced a small number of earthquake events strong enough for residents to feel; and only two have caused significant damage (Hyndman & Rogers, 2010). This lack of strong quakes may translate into hazard perceptions that reflect a lack of urgency among the public to be better prepared for earthquakes (Clague, 2002; Coppola & Maloney, 2009; Levac et al., 2012; Natural Resources Canada, 2013). This is

unfortunate since, despite a lack of high impact events, the potential for seismic activity, and seismic risk in the region is an important enough issue for the emergency management community and the media alike to start to raise the profile of disasters and resilience (CBC News, 2014; Meissner, 2015; Schulz, 2015; Wagstaffe, 2016).

Emergency managers, on average, overestimate the seismic hazard in their region even more so than the general public does. However, based on their occupation, there is an assumption that their knowledge of how to mitigate their risk and respond to an earthquake is much greater than that of the general public. Many general public respondents, however, seemed to portray a degree of uncertainty when asked to quantify their perception of earthquake hazard. This was shown through delayed responses, further questions of the data collection teams, and by some members refusing to answer that particular question because they did not want to guess. The lack of confidence among respondents suggests that there may be a gap in communication between the scientists who estimate hazard and the emergency management community who distributes such information to the public. Further, this opens up a greater conversation about roles and responsibilities of constructing knowledge and delivering knowledge to end audiences. Ultimately, as local emergency managers have a legislated responsibility prepare their jurisdiction for emergencies, it is in their best interest to consider ways to better integrate knowledge and communications between themselves, the public, scientists and others who have a stake in emergency management.

Another issue that has emerged from this research is perhaps a greater challenge of the scientific and numerical literacy of the general public and how they consume information. Emergency managers should consider this as they are working to increase the public's awareness and knowledge of hazard and risk from various threats. Not only do emergency managers have a responsibility to inform their residents of threats in their region, but they must also do so in a way that is consumable and actionable. This should be a shared responsibility between the field of emergency management and the academic and scientific community.

In addition to highlighting misperceptions in seismic hazard knowledge, this research explored how seismic hazard perceptions are influenced by demographics. Given the results presented in this paper, perceptions of seismic hazard were higher than the scientific data would suggest. Therefore, emergency managers and scientists alike can take this information and translate it into an opportunity to invest in and mobilize hazard knowledge and preparedness efforts throughout the Capital and Cowichan Valley Regional Districts. Based on these results, which identify perceptions that are greater than the actual hazard, researchers can infer that if residents are unprepared, it is not because they do not believe the hazard is probable, but instead, there may be barriers in preparedness and resilience that are unrelated to perception. Emergency managers can use the results of this research to craft public outreach campaigns that are targeted and strategic in their efforts to help residents have more information to assess the seismic hazard in their region, and prepare and mitigate their risk accordingly.

References

Alexander, D. (2011). Glossary. In Encyclopedia of Disaster Relief (pp. 807–819). SAGE Publications, Inc. Retrieved from http://knowledge.sagepub.com.ezproxy.library.uvic.ca/view/disasterrelief/SAGE.xml

Armaş, I. (2008). Social vulnerability and seismic risk perception. Case study: The historic center of the Bucharest Municipality/Romania. Natural Hazards, 47(3), 397–410. http://doi.org/10.1007/s11069-008-9229-3

BC Stats. (2012a). Socio-economic profile Regional District 17 - Capital demographic profile, 1–11. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/Profiles.aspx

BC Stats. (2012b). Socio-economic profile Regional District 19 - Cowichan Valley demographic profile, 1–11. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/Profiles.aspx

BC Stats. (2015). 2014 Sub-Provincial Population Estimates, 1–8. Retrieved from http://www.bcstats.gov.bc.ca/apps/PopulationEstimates.aspx

BC Stats. (2016). Population Estimates. Retrieved from http://www.bcstats.gov.bc.ca/apps/PopulationEstimates.aspx

Canadian Red Cross. (2013). Red Cross urges Canadians to know the risks. Retrieved February 9, 2017, from http://www.redcross.ca/about-us/newsroom/news-releases/latest-news/red-cross-urges-canadians-to-know-the-risks

CBC News. (2014, December 22). Earthquake “swarm” strikes off B.C. coast, but no sign of the “Big One.” CBC News. Retrieved from http://www.cbc.ca/news/canada/british-columbia/earthquake-swarm-strikes-off-b-c-coast-but-no-sign-of-the-big-one-1.2881700

City of Victoria. Emergency Program Bylaw No. 04-23 (2004).

Clague, J. J. (2002). The Earthquake Threat in Southwestern British Columbia : A Geologic Perspective. Natural Hazards, 26, 7–34.

Coppola, D. P. (2011). Introduction to international disaster management (Third). Boston: Butterworth-Heinemann.

Coppola, D. P., & Maloney, E. K. (2009). Communicating emergency preparedness strategies for creating a disaster resilient public. Boca Raton: Auerbach Publications.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. Global Environmental Change, 18(4), 598–606. http://doi.org/10.1016/j.gloenvcha.2008.07.013

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. Social Science Quarterly, 84(2), 242–261. http://doi.org/10.1111/1540-6237.8402002

Dooley, D., Catalano, R., Mishra, S., & Serxner, S. (1992). Earthquake preparedness: Predictors in a community survey. Journal of Applied Social Psychology, 22(6), 451–470. http://doi.org/10.1111/j.1559-1816.1992.tb00984.x

Emergency Management BC. (2016). PreparedBC: Know the risks. Retrieved September 22, 2016, from http://www2.gov.bc.ca/gov/content/safety/emergency-preparedness-response-recovery/preparedbc/know-the-risks

Gierlach, E., Belsher, B. E., & Beutler, L. E. (2010). Cross-cultural differences in risk perceptions of disasters. Risk Analysis: An Official Publication of the Society for Risk Analysis, 30(10), 1539–49. http://doi.org/10.1111/j.1539-6924.2010.01451.x

Government of Canada. (2016). Get prepared. Retrieved February 9, 2017, from https://www.getprepared.gc.ca/index-en.aspx

Grothmann, T., & Reusswig, F. (2006). People at risk of flooding: Why some residents take precautionary action while others do not. Natural Hazards, 38(1–2), 101–120.

http://doi.org/10.1007/s11069-005-8604-6

Guthrie, R. H. (2005). Geomorphology of Vancouver Island: Mass wasting potential. Victoria, BC.

Hager, M. (2015, December 30). Earthquake with 4.7 magnitude felt throughout B.C.'s South Coast. The Globe and Mail. Vancouver. Retrieved from https://www.theglobeandmail.com/news/national/bc-struck-by-moderate-earthquake/article27956563/

Ho, M.-C., Shaw, D., Lin, S., & Chiu, Y.-C. (2008). How do disaster characteristics influence risk perception? Risk Analysis: An Official Publication of the Society for Risk Analysis, 28(3), 635–43. http://doi.org/10.1111/j.1539-6924.2008.01040.x

Hyndman, R. D., & Rogers, G. C. (2010). Great earthquakes on Canada's West Coast: A review. Canadian Journal of Earth Sciences, 47(5), 801–820. http://doi.org/10.1139/E10-003

Insurance Bureau of Canada. (2013). Study of impact and the insurance and economic cost of a major earthquake in British Columbia and Ontario/Québec. Boston, MA.

Insurance Bureau of Canada. (2016). Northern Alberta wildfire costliest insured natural disaster in Canadian history - Estimate of insured losses: $3.58 billion. Retrieved January 13, 2017, from http://www.ibc.ca/bc/resources/media-centre/media-releases/northern-alberta-wildfire-costliest-insured-natural-disaster-in-canadian-history

Jackson, E. L. (1981). Response to earthquake hazard: The West Coast of North America. Environment and Behavior, 13(4), 387–416. http://doi.org/0803973233

Joffe, H., Rossetto, T., Solberg, C., & O'Connor, C. (2013). A study of people living in three highly seismic areas. Earthquake Spectra, 29(2), 367–397. http://doi.org/10.1193/1.4000138

Johnston, D., & Paton, D. (2001). Disasters and communities: vulnerability, resilience and preparedness. Disaster Prevention and Management, 10(4), 270–277.

Kung, Y. W., & Chen, S. H. (2012). Perception of earthquake risk in Taiwan: Effects of gender and past earthquake experience. Risk Analysis, 32(9), 1535–1546.

http://doi.org/10.1111/j.1539-6924.2011.01760.x

Levac, J., Toal-Sullivan, D., & O'Sullivan, T. L. (2012). Household emergency preparedness: A literature review. Journal of Community Health, 37(3), 725–733. http://doi.org/10.1007/s10900-011-9488-x

Lindell, M. K., & Perry, R. W. (2000). Household adjustment to earthquake hazard: A review of research. Environment and Behavior, 32(4), 461–501. http://doi.org/10.1177/00139160021972621

McClure, J., Johnston, D., Henrich, L., Milfont, T. L., & Becker, J. (2014). When a hazard occurs where it is not expected: Risk judgments about different regions after the Christchurch earthquakes. Natural Hazards, 75, 635–652. http://doi.org/10.1007/s11069-014-1338-6

Meissner, D. (2015, January 18). B.C. megathrust earthquake could rupture like a zipper, expert says. The Canadian Press.

Mileti, D. S. (1999). Disasters by design: A reassessment of natural hazards in the United States. Washington, D.C.: Joseph Henry Press.

Nakayachi, K., Yokoyama, H. M., & Oki, S. (2014). Public anxiety after the 2011 Tohoku earthquake: Fluctuations in hazard perception after catastrophe. Journal of Risk Research, (February 2015), 1–14. http://doi.org/10.1080/13669877.2013.875936

Natural Resources Canada. (2013). Seismic zones in Western Canada. Retrieved March 5, 2015, from http://www.earthquakescanada.nrcan.gc.ca/zones/westcan-eng.php#Cascadia

Natural Resources Canada. (2016). Natural hazards. Retrieved September 22, 2016, from https://www.nrcan.gc.ca/hazards/natural-hazards

Newton, J. (1997). Federal legislation for disaster mitigation: A comparative assessment between Canada and the United States. Natural Hazards, 219–241. http://doi.org/10.1023/A:1007976800302

Office of the Auditor General of British Columbia. (2014). Catastrophic earthquake preparedness.

Province of British Columbia. Emergency Program Act (1996). Canada: Queen's Printer.

Retrieved from http://www.bclaws.ca/Recon/document/ID/freeside/00_96111_01

Renteria, H. (2014). British Columbia earthquake preparedness consultation report.

Rogers, G. C. (1988). An assessment of the megathrust earthquake potential of the Cascadia Subduction Zone. Canadian Journal of Earth Sciences, 25(6), 844–852.

Rothman, A. J., & Salovey, P. (1997). Shaping perceptions to motivate healthy behavior: The role of message framing. Psychological Bulletin, 121(1), 3–19. http://doi.org/10.1037//0033-2909.121.1.3

Schulz, K. (2015, July). The really big one. The New Yorker. Retrieved from http://www.newyorker.com/magazine/2015/07/20/the-really-big-one

Seemann, M. (2012). A disaster risk management approach to seismic risk on Vancouver Island, British Columbia. University of Victoria.

Seemann, M., Onur, T., & Cloutier-Fisher, D. (2011). Earthquake shaking probabilities for communities on Vancouver Island, British Columbia, Canada. Natural Hazards, 58(3), 1253–1273. http://doi.org/10.1007/s11069-011-9727-6

Shaw, R., Kobayashi, K. S. H., & Kobayashi, M. (2004). Linking experience, education, perception and earthquake preparedness. Disaster Prevention and Management, 13, 39–49. http://doi.org/10.1108/09653560410521689

Slovic, P. (1987). Perception of risk. Science, 236(4799), 280–285.

Slovic, P. (1999). Trust, emotion, sex, politics, and science: Surveying the risk-assessment battlefield. Risk Analysis, 19(4), 689–701. http://doi.org/10.1111/j.1539-6924.1999.tb00439.x

Slovic, P. (2012). The perception gap: Radiation and risk. Bulletin of the Atomic Scientists, 68(3), 67–75. http://doi.org/10.1177/0096340212444870

Stevens, M. R., & Hanschka, S. (2014). Multilevel governance of flood hazards: Municipal flood bylaws in British Columbia, Canada. Natural Hazards Review, 15(February), 74–87. http://doi.org/10.1061/(ASCE)NH.1527-6996.0000116.

The Corporation of the District of Saanich. Bylaw No. 8212 (2001).

Thompson, J. (2011). Cascadia's fault (First). Toronto, Ontario: HarperCollins Publishers Ltd.

Tierney, K. J., Lindell, M. K., & Perry, R. W. (2001). Facing the unexpected. Washington, D.C.: Joseph Henry Press.

Verrucci, E., Perez-Fuentes, G., Rossetto, T., Bisby, L., Haklay, M., Rush, D., … Joffe, H. (2016). Digital engagement methods for earthquake and fire preparedness: a review. Natural Hazards, 83(3), 1583–1604. http://doi.org/10.1007/s11069-016-2378-x

Wagstaffe, J. (2016, October 11). The "Big One" near Vancouver you may not know about. CBC News. Vancouver.

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2003). At risk: Natural hazards, people's vulnerability and disasters (Second). London and New York: Routledge, Taylor & Francis Group.

Zhang, Q. B., & Hebda, R. J. (2005). Abrupt climate change and variability in the past four millennia of the southern Vancouver Island, Canada. Geophysical Research Letters, 32(16), 1–4. http://doi.org/10.1029/2005GL022913

4.0 DISCUSSION AND CONCLUSIONS

The southwest coast of British Columbia is at risk from many natural threats from severe weather to fires to floods. The most consequential threat is projected to be a large earthquake event, which will occur as an outcome of movements between the Pacific, North American and Juan de Fuca plates (Clague, 2002). Research on the seismic hazard within the Cascadia Subduction Zone continues to grow and knowledge of the region's risk is improving constantly (Cruikshank & Peterson, 2017; Gao, Wang, Davis, Insua, & He, 2017; Morell, Regalla, Leonard, Amos, & Levson, 2017; Wells, Blakely, Wech, & Mccrory, 2017). However, research regarding the public's perceptions of disaster risk and seismic hazard in the region is almost nonexistent. In order to understand the resilience and potential risk of residents in the region, researchers must first understand what residents perceive as a disaster risk, whether they have an accurate understanding of seismic hazard, and how both of those perceptions relate to whether they are prepared for a disaster event. Further, in addition to obtaining an understanding of public perceptions, an effort must also be made to understand how to deliver the right information to the public to improve their understanding of disaster risk and earthquake hazard in order to decrease risk and increase resilience.

Emergency management is a shared responsibility between different levels of government and the public alike (Emergency Management BC, 2016; Government of Canada, 2016; Lara, Garcia, Bucci, & Ribas, 2016; Levac et al., 2012; Renteria, 2014). The emergency management community has a role to play in understanding hazard information and translating it into a format that is consumable for decision-makers and the broader general public. In conjunction with this translation, emergency managers must pair that hazard information with possible mitigative actions and solutions that can decrease resident, visitor and community risk and thereby increase community resilience. Members of the public are responsible for taking the information provided by emergency management professionals and incorporating that knowledge

into their daily decisions to decrease their vulnerability, increase their resilience and reduce personal and household risk. Best practices in the emergency management field provide emergency managers with the guidance to create appropriate risk communications and preparedness information. Researchers and emergency managers agree that messaging should be simple, consistent, and delivered from multiple channels, sources and agencies (Coppola, 2011; Coppola & Maloney, 2009; Renteria, 2014). Messaging should provide individuals with instruction on what they should do, rather than what they should not do, and should be targeted for the audience (Mileti, 1999; Munroe et al., 2004; Wood et al., 2012). In addition, those delivering messaging should not be overly concerned about mass panic and instead should focus on reporting the facts rather than reassuring the public and downplaying the risk (Sandman & Lanard, 2004). However, in order for individuals to take action to reduce their risk by becoming prepared, they must first understand the risk they face. The key piece missing in this equation is the ability to make scientific hazard and consequence information comprehensible for the public.

This thesis used the framework Risk (R) = Hazard/Likelihood (H/L) x Consequence (C) to explore the concept of risk and hazard perceptions. Using this framework, the chapters within this thesis identify public perceptions of both risk and hazard, and their interactions between each other. This stated, the objectives of this thesis were 1) To improve our understanding of the general public's perceptions of threats and disaster risk in their community; b) To improve our understanding of emergency manager's perceptions of community disaster risk on southern Vancouver Island; c) To compare the general public's earthquake hazard perceptions to both emergency manager's earthquake hazard perceptions, and to calculated earthquake hazard estimates; and d) To consider the implications of the research findings for improving hazard communications. The overarching goal of this thesis is to contribute to fostering healthier, safer and more disaster resilient communities on Vancouver Island by providing emergency managers and other decision-makers with information about the general public's level of understanding of earthquake hazard and disaster risk. This concluding chapter highlights the main findings in

relation to the original research objectives. For transparency and accountability, uncertainties and limitations of the study are then identified and discussed, and areas for future research are presented.

Little research has been conducted on either disaster risk perceptions or seismic hazard perceptions on southern Vancouver Island. This thesis found that the general public and emergency managers across two regional districts all identified earthquakes as the highest perceived risk to their community, however, among the additional risks identified there were divergent trends between the two groups. Further, both the public and emergency managers overestimated the seismic hazard in their community, when compared to the calculated seismic shaking probabilities. Results revealed gender and geography influenced how participants had received earthquake information in the past and how they'd like to receive hazard information in the future. In addition, time spent living on Vancouver Island and household income was found to have a significant influence on how likely respondents were to be prepared.

4.1 Limitations

4.1.1 Sample size and type. The data collected in this project would have benefitted by being both a random sample as well as a more comprehensive sample. Due to the limited resources available to this project (time and funding), the data collected for both the general public and the emergency managers was essentially a non-random, convenience sample for each with a total *N* of 118 (n=105 for the general public, n=13 for emergency managers). Due to the limited number of participants surveyed, particularly among the emergency managers, the statistical analysis was limited to non-parametric tests. Despite the fact that the sample size for emergency managers was small and may not represent the larger population, these individuals were chosen for their subject matter expertise and therefore for the purposes of this research their participation was sufficient to draw meaningful descriptive information from.

In addition, because participating in the research was voluntary, those who did participate may be biased towards those who hold a particular viewpoint relative to hazard perceptions. Individuals were approached in public locations such as libraries and recreation centres because administration at these locations were supportive of the research. However, this also provides a potential bias for the results, as not all members of the communities sampled may use these sites. These considerations influence the generalizability of the findings, although the general public sample reflected the broad demographics of the population according to BC Stats.

4.1.2 Survey tool. The questionnaire tool was piloted to ensure comprehensibility. However, in administering the survey, there were times when participants needed further explanation about certain concepts and terms (e.g. different types of threats such as unintentional human-made, intentional human-made and natural). In addition, there were instances where the terms used in the survey, such as risk and hazard, that have specific definitions within the academic literature, that differ from the colloquial use of the terms. This may be considered a limitation as the question that was asked was analyzed using slightly different terms. While the majority of respondents completed the survey in its entirety, for some questions, a small number of individuals refrained from answering because they did not feel confident in their knowledge or ability to answer the question, which may have influenced the results. While non-responsiveness was not tracked, approximately five percent of respondents omitted answering at least one question.

In order to create a survey that was easily understood by most individuals, plain language was adopted to ensure comprehension and to avoid leading participants by influencing their responses. In doing this, some of the colloquial language used in the original surveys differs from the academic language used in this thesis. By defining the terminology in Chapter 1, and by including both surveys in the Appendices (Appendix A: Questionnaire Tool: General Public (Group 1), Appendix B: Questionnaire Tool: Emergency Management Professionals (Group 2)), readers can compare slight differences regarding the terminology.

4.1.3 Influence of media and current events. In discussions with participants during the data collection process, at times it appeared that current events and media coverage influenced individual responses and perceptions of risk. For example, just two weeks prior to the start of data collection for the general public, on December 29, 2015, Vancouver Island experienced a M4.7 earthquake just beneath Sidney, BC, that shook many residents awake at 11:39 p.m. (Hager, 2015). Although no damage or injuries were reported, it was apparent in discussions with research participants that the quake may have been the physical reminder needed to bring earthquakes to the forefront of everyone's minds, thus potentially impacting perceptions.

In addition to the December 29 earthquake, it seems that media in the time leading up to data collection began to report more consistently on earthquake risk in the region. In July of 2015, about six months prior to data collection, The New Yorker magazine published an article entitled "The really big one," which profiled the seismic risk that faces the southWest Coast of North America (Schulz, 2015). This article gained so much popularity, it later went on to win a 2016 Pulitzer Prize and a National Magazine Award, in addition to worldwide attention (Schulz, 2015). Following the buzz created by this article, as well as the quake experienced six months later beneath Sidney, many media outlets ran stories about the risk in the region.

Based on conversations with respondents, it appeared that responses were impacted not only by the topics listed above, but also by the media of the day, and issues in the local community. As explained in depth in Chapter 2, toxic dumping in one of the sampled communities lead to environmental concerns taking the forefront of perception ranking (Stueck, 2016). Sampling also took place on the provincial government's budget day, which led participants to discuss some of the risks to the economy like housing prices and lack of social supports (Keller, 2016).

4.2 Research contributions

This study highlighted a number of trends in disaster risk perception and earthquake hazard perception. The key findings show that the largest proportion of respondents among both the general public and emergency managers identified earthquake as the most significant risk to their community and that both groups overestimated the earthquake hazard in their community. In addition, some divergent findings emerged between gender and geographic location in relation to knowledge of earthquakes and communication. Finally, significant trends were found related to preparedness that indicated that certain factors such as income and location impact an individual's likelihood to have greater levels of preparedness.

4.2.1 Disaster risk perceptions on southern Vancouver Island. This research showed that earthquakes are the highest perceived disaster risk among both the general public and emergency managers both before and after reflection on the frequency and severity of various threats. Before reflection, participants provided an array of responses regarding various risks. For the general public, the top five risks before reflection were: "earthquake," "crime and violence," "environmental" threats, "social welfare" and "tsunami;" whereas after reflection, the top three risks remained "earthquake," "crime and violence" and "environmental," but the remainder of the top five included "motor vehicle accidents" (MVAs) and "other" risks. "Other" included any risks that were identified only once that were not considered natural threats.

Emergency managers listed a broad range of threats, mostly natural. Emergency managers' top four risks before reflection were: "earthquakes," "gas leaks, hazmat and industry" (hazmat), "wildfire" and "tsunami," with "other,[2]" "flooding" and "power outages" all equally

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[2] Responses that were identified as "other" included responses provided by participants that were unique and were only answered by one to three individuals during data collection. For a detailed list of "other" responses, see Appendix D: Comprehensive List of Hazards Identified by Respondents.

ranked in fifth place for the highest perceived threat. Trends showed that after being allowed some time to reflect on their answers, emergency managers' perceptions changed more than the general public. The top five risks after reflection for emergency managers were "earthquakes," "wildfires," "other," "fire" (structural) and "hazmat".

Changes in responses after reflection varied more widely for emergency managers than for the public. After reflection, emergency managers' highest perceived risk of "earthquakes" were 21.7% above the next ranked risk. The public, on the other hand, ranked "earthquakes" only 11% higher than the next ranked risk after reflection. Another variation between the two groups' risk perceptions was the type of threat identified. Emergency managers' concerns were mostly linked to natural threats, with some human-made unintentional threats such as hazmat spills, whereas the general public focused on mostly human-made intentional threats (see top five risks identified by both groups in paragraph above).

4.2.2 Seismic hazard perceptions on southern Vancouver Island. Perceptions of seismic hazard were assessed among both the general public and emergency managers and compared to calculated hazard estimations (Seemann et al., 2011). Both the general public and emergency managers overestimated the calculated seismic hazard on southern Vancouver Island from a non-structurally damaging earthquake affecting their community by several percentage points. For example, in the next 10 years, the general public in the CRD overestimated the seismic hazard in their community, on average, by more than 14% and the general public in the CVRD overestimated the seismic hazard in their community, on average, by more than 21%. Emergency managers in the CRD overestimated the hazard even more so than the public (more than 25.0% higher than the calculated hazard), whereas emergency managers in the CVRD overestimated the hazard, but not as much as the public (12.0% more than the calculated hazard).

4.2.3 Emergency managers' perceptions of public perceptions. Emergency managers' predictions of what the general public perceive to be the greatest seismic hazards were found to underestimate the public perceptions of the hazard. So, while both groups inaccurately perceive

seismic hazard (by overestimation), emergency management professionals also tend to inaccurately predict public understanding of the hazard. In summary, they feel that the public underestimates the hazard, when actually they overestimate it. This highlights an area where emergency managers may need to further their own knowledge of the hazard, and find ways to communicate a more accurate picture of hazard to the general public. One possible explanation for this finding may be that perhaps emergency managers perceive that the public underestimate the hazard because they believe that the public is unprepared for an earthquake, and so they must not appreciate the hazard. Using some key principles of risk communication, emergency managers can overcome this through public outreach and identification of the proper hazards in their community. Future research could explore this trend in a more focused way, exploring not only what the perceptions are, but also what the reasons are for coming to those perceptions.

4.2.4 Gender, earthquake knowledge and hazard communications. This study found that gender had a statistically significant influence on how participants had both obtained earthquake knowledge in the past, as well as how they wanted to receive hazard information in the future. Women identified that they had learned about earthquakes from social media, seminars and workshops, print media and government websites, whereas men had learned from radio, television and "other" methods such as friends or personal research. In regards to what media or communication they preferred to receive hazard information through in the future, women preferred community workshops, print advertisements and social media again while men preferred TV/radio advertisements.

4.2.5 Geography and hazard communications. Findings showed that geography had a statistically significant influence on how participants preferred to receive future hazard information. Residents in the CRD preferred community workshops, print advertisements and TV/radio advertisements, whereas residents in the CVRD preferred "other" methods of outreach, such as workplace training.

4.2.6 Income and preparedness. With respect to levels of preparedness among the general public, results showed that household income was associated with whether a participant was prepared or not. This finding is consistent with trends in the literature, but provides some useful information for emergency managers to consider when planning for public preparedness initiatives.

4.2.7 Length of residency on Vancouver Island and preparedness. Time spent living on Vancouver Island was found to have a statistically significant relationship with preparedness. Some possible explanations for this may be that living on an island encourages residents to become more prepared, or it may be the fact that the unique risks associated with Vancouver Island (for example, seismic exposure, tsunami risk and others) become more apparent the longer individuals live here through either media or personal conversations, which also encourages them to become prepared.

4.2.8 Emergency managers' perceptions of public preparedness. While emergency managers perceived the general public to be poorly prepared, and their average preparedness levels were quite low (most participants had a mean preparedness level of 2.62 on a six-point scale, meaning they have taken on average less than three of the six preparedness precautions explored in Chapter 2), emergency managers had underestimated the proportion of residents who had taken individual preparedness precautions. For example, emergency managers estimated that less than 15% of residents had a household emergency plan, however, actually more than 45% of respondents surveyed reported having a household emergency plan. While preparedness measures used in this research explore several core components of traditional emergency preparedness, preparedness is a subjective topic and there may be other measures of preparedness taken by residents that were not reflected in the questions asked and therefore not reflected in the results.

4.2.9 Linking results to objectives. This thesis set out to achieve the following objectives: 1) To improve our understanding of the general public's perceptions of threats and disaster risk in their community; 2) To improve our understanding of emergency manager's

perceptions of community disaster risk on southern Vancouver Island; 3) To describe and compare the general public's earthquake hazard perceptions to both emergency managers' earthquake hazard perceptions, and to calculated earthquake hazard estimates; and 4) To consider the implications of the research findings for improving hazard communications; Ultimately, the overarching goal of the thesis was to contribute to fostering healthier, safer and more disaster resilient communities on Vancouver Island by providing emergency management practitioners and other decision-makers with information about the general public's level of understanding of earthquake hazard and disaster risk.

Objectives one and two were explored in detail and directly addressed in Chapter 2 and in this chapter's findings related to disaster risk perceptions on southern Vancouver Island, with differences between the general public and emergency managers identified, and differences within groups emerging before and after reflection. Chapter 3 explored in-depth the findings related to objective three, outlined further in this chapter's findings related to seismic hazard perception on southern Vancouver Island, highlighting how both groups overestimated the seismic hazard in their region. Objective four is explored in Chapter 2 and outlined in this concluding chapter by examining the relationship between preferred methods of communication related to hazards and respondent preferences, which emerged as trends related to gender and geography. Further implications of objective four are also addressed in future opportunities, as there are more recommendations for future research that this objective would benefit from in future work.

4.3 Future opportunities

The ultimate goal of this thesis was to provide disaster perception information to improve public health and safety, disaster preparedness and community resilience on southern Vancouver Island by addressing four gaps in research that have not been closely examined in this region. Southern Vancouver Island's unique physical geography and demographic structure is unlike

many other regions in the world, which makes dedicated research necessary to get an understanding of public perceptions, knowledge and preparedness in the region and to support emergency managers. This research provides important information to support emergency managers with baseline information about individual disaster risk and seismic hazard perceptions – not only in the public arena but also within the emergency management community. While study limitations and uncertainties may inhibit the transferability of these findings, they identify and suggest disaster perception trends, which may be useful information for emergency managers in similar jurisdictions in Canada and around the Pacific Rim.

4.3.1 Recommendations for researchers. The methodology used for this research serves as a starting point for future researchers interested in risk and hazard perception, public knowledge of threats, preparedness and damage expectations. While this study was limited by its sampling methods and sample size, the survey tool captured a breadth of information and can serve as a foundation from which future researchers interested in similar topics can build upon.

Much of the risk perception research that exists in the literature has occurred in regions that have recently suffered a significant event, and focuses on perceptions of that particular hazard, whether it is earthquake, flood, landslide or otherwise. Because Vancouver Island has not suffered a significant earthquake in more than 50 years, this research puts future researchers with useful baseline information for a meaningful pre- and post-event analysis when an earthquake does occur in this region. In addition, future research could explore the reasons for particular risk perceptions among both the general public and emergency managers, not just what those perceptions are.

This research also compares seismic hazard perceptions with calculated seismic hazard estimations to identify gaps in knowledge and key areas of importance to support the work of emergency managers. Similar future research would benefit from both quantifying the hazard related to other threats such as wildfire, flooding or tsunami on southern Vancouver Island, and comparing these values to public perceptions of these hazards. Not only would this allow for

similar comparative studies, it would also allow for a ranking of hazards and of hazard perceptions. Conducting this type of research could provide important information for emergency managers and the general public and aid in strengthening southern Vancouver Island's disaster preparedness in the future.

This research also highlights findings related to the general public's preferred methods of hazard communications, as well as ways they have obtained information specific to earthquakes in the past. The survey tool undertaken for this research also asked respondents about what format of hazard probability would be most meaningful, whether percentage, fraction, graph or otherwise. However, analysis of this question did not reveal any trends nor did it show clear preferences for a particular format among groups of participants. Future research would benefit from further exploring this concept and researching not only what format of hazard is most meaningful, but also delving deeper to ask participants why they choose a certain format and what their understanding of that format is. This may reveal important information about the general public's hazard competence and provide particular recommendations not only for emergency managers, but also for scientists and academics.

4.3.2 Recommendations for emergency management practitioners. Several recommendations for emergency management practitioners emerged from this research that are relevant for practitioners living living and working in the regions of the CRD and the CVRD. In addition, emergency managers in surrounding, similar areas may well find use of the results presented in this thesis.

Specifically, the results of all chapters of this thesis identify gaps and differences in perception among both the general public and emergency managers. Findings related to general public preparedness, earthquake knowledge and hazard information should be used as recommendations for targeted outreach related to knowledge and preparedness. These results point to the importance of targeting information in different ways on the basis of factors such as gender and geography (region) to help emergency managers to be more strategic in their delivery

of these types of programs to meet not only the most vulnerable populations, but also those that tend to be underprepared. In addition, understanding what disaster risks the public are concerned about provide an opportunity for emergency managers to identify and clarify the threats that are perceived to be higher risks for local residents.

Finally, in addition to providing emergency managers with recommendations for outreach and for their work with the public, the findings presented in this thesis provide recommendations for emergency managers to understand their own misconceptions and differences between their preferences and those of the public. For example, results revealed that emergency managers and the public have divergent concerns related to disaster risk, with emergency managers being more concerned about natural threats, while the general public is more concerned about human-made intentional threats. Further, emergency manager's perceptions of the general public's perceptions of seismic hazard were much lower than the public's perceptions actually were. This suggests that n that emergency managers should not only be conducting analysis of the public's needs and knowledge to deliver information to the general public, but they should also be connecting with the public in their jurisdiction to explore these topics and to get an understanding of what their thoughts, perceptions and priorities are in order to improve public safety and support community resilience.

REFERENCES

Adger, W. N. (2006). Vulnerability. Global Environmental Change, 16(3), 268–281. http://doi.org/10.1016/j.gloenvcha.2006.02.006

Ahmed, H., Naik, G., Willoughby, H., & Edwards, A. G. K. (2012). Communicating risk. BMJ (Clinical Research Ed.), 344(June), 1–7. http://doi.org/10.1136/bmj.e3996

Alexander, D. (2011). Glossary. In Encyclopedia of Disaster Relief (pp. 807–819). SAGE Publications, Inc. Retrieved from http://knowledge.sagepub.com.ezproxy.library.uvic.ca/view/disasterrelief/SAGE.xml

BC Stats. (2012). Socio-economic profile Regional District 17 - Capital demographic profile, 1–11. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/Profiles.aspx

BC Stats. (2012). Socio-economic profile Regional District 19 - Cowichan Valley demographic profile, 1–11. Retrieved from http://www.bcstats.gov.bc.ca/StatisticsBySubject/SocialStatistics/SocioEconomicProfilesIndices/Profiles.aspx

Beck, U. (1992). Risk Society: Towards a new modernity. (M. Ritter, Ed.). London: SAGE Publications, Inc.

Bosher, L. (2008). Hazards and the built environment: Attaining built-in resilience. Routledge, Taylor & Francis Group.

Burton, I., Kates, R. W., & White, G. F. (1968). The human ecology of extreme geophysical events. Natural Hazard Center Collection, 1, 1–33.

Cascadia Region Earthquake Workgroup. (2013). Cascadia Subduction Zone earthquakes: A magnitude 9.0 earthquake scenario. Retrieved from http://www.crew.org/products-programs/cascadia-subduction-zone-earthquakes-magnitude-90-earthquake-scenario

City of Victoria. (2012). Census information. Retrieved November 9, 2016, from http://www.victoria.ca/EN/main/residents/about/census.html

Clague, J. J. (2002). The earthquake threat in southwestern British Columbia : A geologic perspective. Natural Hazards, 26, 7–34.

Coppola, D. P. (2011). Introduction to international disaster management (Third). Boston: Butterworth-Heinemann.

Coppola, D. P., & Maloney, E. K. (2009). Communicating emergency preparedness strategies for creating a disaster resilient public. Boca Raton: Auerbach Publications.

Cruikshank, K. M., & Peterson, C. D. (2017). Late stage interseismic strain interval, Cascadia Subduction Zone margin, USA and Canada. Open Journal of Earthquake Research, 6(1), 1–34. http://doi.org/10.4236/ojer.2017.61001

Cutter, S. L. (1996). Vulnerability to environmental hazards. Progress in Human Geography, 20(4), 529–539. http://doi.org/10.1177/030913259602000407

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. Global Environmental Change, 18(4), 598–606. http://doi.org/10.1016/j.gloenvcha.2008.07.013

Drabek, T. E., & Evans, J. (2007). Sociology, disasters and emergency management: History, contributions and future agenda. In Disciplines, Disasters and Emergency Management: The Convergence and Divergence of Concepts, Issues and Trends in the Research Literature (pp. 1–34). Charles C Thomas Publisher.

Emergency Management BC. (2016). PreparedBC: Know the risks. Retrieved September 22, 2016, from http://www2.gov.bc.ca/gov/content/safety/emergency-preparedness-response-recovery/preparedbc/know-the-risks

Etkin, D., Haque, E., Bellisario, L., & Burton, I. (2004). An assessment of natural hazards and disasters in Canada: A report for decision-makers and practitioners.

Fritz, C. E. (1961). Disasters. In R. K. Merton & R. A. Nisbet (Eds.), Contemporary Social Problems (pp. 651–694). New York: Harcourt.

Gao, D., Wang, K., Davis, E. E., Insua, T. L., & He, J. (2017). Thermal state of the Explorer segment of the Cascadia subduction zone: Implications for seismic and tsunami hazards. Geochemistry, Geophysics, Geosystems, 18, 1–11. http://doi.org/10.1002/2017GC006838.Received

Gierlach, E., Belsher, B. E., & Beutler, L. E. (2010). Cross-cultural differences in risk perceptions of disasters. Risk Analysis : An Official Publication of the Society for Risk Analysis, 30(10), 1539–49. http://doi.org/10.1111/j.1539-6924.2010.01451.x

Government of Canada. (2016). Get prepared. Retrieved February 9, 2017, from https://www.getprepared.gc.ca/index-en.aspx

Hager, M. (2015, December 30). Earthquake with 4.7 magnitude felt throughout B.C.'s South Coast. The Globe and Mail. Vancouver. Retrieved from https://www.theglobeandmail.com/news/national/bc-struck-by-moderate-earthquake/article27956563/

Ho, M.-C., Shaw, D., Lin, S., & Chiu, Y.-C. (2008). How do disaster characteristics influence risk perception? Risk Analysis: An Official Publication of the Society for Risk Analysis, 28(3), 635–43. http://doi.org/10.1111/j.1539-6924.2008.01040.x

Hyndman, R. D., & Rogers, G. C. (2010). Great earthquakes on Canada's West Coast: A review. Canadian Journal of Earth Sciences, 47(5), 801–820. http://doi.org/10.1139/E10-003

Insurance Bureau of Canada. (2013). Study of impact and the insurance and economic cost of a major earthquake in British Columbia and Ontario/Québec. Boston, MA.

Jackson, E. L. (1981). Response to earthquake hazard: The West Coast of North America. Environment and Behavior, 13(4), 387–416. http://doi.org/0803973233

Joffe, H., Rossetto, T., Solberg, C., & O'Connor, C. (2013). A study of people living in three highly seismic areas. Earthquake Spectra, 29(2), 367–397. http://doi.org/10.1193/1.4000138

Johnston, D., & Paton, D. (2001). Disasters and communities: Vulnerability, resilience and preparedness. Disaster Prevention and Management, 10(4), 270–277.

Kaplan, S., & Garrick, B. J. (1981). On the quantitative definition of risk. Risk Analysis, 1(1), 11–27. http://doi.org/10.1111/j.1539-6924.1981.tb01350.x

Kates, R. W. (1976). Experiencing the environment as hazard. In S. Wapner, S. Cohen, & B. Kaplan (Eds.), Experiencing the Environment (pp. 133–156). Plenum Press.

Keller, J. (2016, February 17). The B.C. budget. The Globe and Mail. Victoria, BC.

Kung, Y. W., & Chen, S. H. (2012). Perception of earthquake risk in Taiwan: Effects of gender and past earthquake experience. Risk Analysis, 32(9), 1535–1546. http://doi.org/10.1111/j.1539-6924.2011.01760.x

Lara, A., Garcia, X., Bucci, F., & Ribas, A. (2016). What do people think about the flood risk? An experience with the residents of Talcahuano city, Chile. Natural Hazards, 85(3), 1–19. http://doi.org/10.1007/s11069-016-2644-y

Levac, J., Toal-Sullivan, D., & O'Sullivan, T. L. (2012). Household emergency preparedness: A literature review. Journal of Community Health, 37(3), 725–733. http://doi.org/10.1007/s10900-011-9488-x

McClure, J., Johnston, D., Henrich, L., Milfont, T. L., & Becker, J. (2014). When a hazard occurs where it is not expected: Risk judgments about different regions after the Christchurch earthquakes. Natural Hazards, 75, 635–652. http://doi.org/10.1007/s11069-014-1338-6

Mileti, D. S. (1999). Disasters by design: A reassessment of natural hazards in the United States. Washington, D.C.: Joseph Henry Press.

Mileti, D. S., & Fitzpatrick, C. (1992). The causal sequence of risk communication in the Parkfield earthquake prediction experiment. Risk Analysis, 12(3), 393–400. http://doi.org/10.1111/j.1539-6924.1992.tb00691.x

Morell, K. D., Regalla, C., Leonard, L. J., Amos, C., & Levson, V. (2017). Quaternary rupture of a crustal fault beneath Victoria, British Columbia, Canada. GSA Today, 27. http://doi.org/10.1130/GSATG291A.1

Munroe, M., Pennisi, L., & Mileti, D. (2004). Social science to improve fuels management: A synthesis of research relevant to communicating with homeowners about fuels management. Retrieved from http://www.nrs.fs.fed.us/pubs/gtr/gtr_nc267.pdf

Nakayachi, K., Yokoyama, H. M., & Oki, S. (2014). Public anxiety after the 2011 Tohoku earthquake: Fluctuations in hazard perception after catastrophe. Journal of Risk Research, (February 2015), 1–14. http://doi.org/10.1080/13669877.2013.875936

Natural Resources Canada. (2013). Seismic zones in Western Canada. Retrieved March 5, 2015, from http://www.earthquakescanada.nrcan.gc.ca/zones/westcan-eng.php#Cascadia

Natural Resources Canada. (2016a). Glossary of seismological terms. Retrieved September 22, 2016, from http://www.earthquakescanada.nrcan.gc.ca/info-gen/glossa-en.php

Natural Resources Canada. (2016b). Natural hazards. Retrieved September 22, 2016, from https://www.nrcan.gc.ca/hazards/natural-hazards

Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: Contributions of a resilience framework. Annual Review of Environment and Resources, 32, 395–419. http://doi.org/10.1146/annurev.energy.32.051807.090348

Nigg, J. M. (1982). Communication under conditions of uncertainty: Understanding earthquake forecasting. Journal of Communication, 32, 27–36.

Office of the Auditor General of British Columbia. (2014). Catastrophic earthquake preparedness.

Renteria, H. (2014). British Columbia earthquake preparedness consultation report.

Rogers, G. C. (1988). An assessment of the megathrust earthquake potential of the Cascadia Subduction Zone. Canadian Journal of Earth Sciences, 25(6), 844–852.

Rothman, A. J., & Salovey, P. (1997). Shaping perceptions to motivate healthy behavior: The role of message framing. Psychological Bulletin, 121(1), 3–19. http://doi.org/10.1037//0033-2909.121.1.3

Rufat, S. (2012). Spectroscopy of urban vulnerability. Annals of the Association of American Geographers, 103(January 2012), 120822115533006. http://doi.org/10.1080/00045608.2012.702485

Sandman, P. (2003). Obvious or suspected, here or elsewhere, now or then: Paradigms of emergency events. Emegency Risk Communication CDCynergy.

Sandman, P., & Lanard, J. (2004). Crisis communications: Guidelines for action.

Schulz, K. (2015, July). The really big one. The New Yorker. Retrieved from http://www.newyorker.com/magazine/2015/07/20/the-really-big-one

Seemann, M. (2012). A disaster risk management approach to seismic risk on Vancouver Island, British Columbia. University of Victoria.

Seemann, M., Onur, T., & Cassidy, J. F. (2008). Seismic hazard resulting from aftershock activity following a Cascadia Subduction Earthquake. 14th World Conference on Earthquake Engineering (14WCEE).

Seemann, M., Onur, T., & Cloutier-Fisher, D. (2011). Earthquake shaking probabilities for communities on Vancouver Island, British Columbia, Canada. Natural Hazards, 58(3), 1253–1273. http://doi.org/10.1007/s11069-011-9727-6

Shreve, C., Fordham, M., Anson, S., Watson, H., Hagen, K., Wadhwa, K., … Karanci, N. (2014). Report on risk perception and preparedness.

Slovic, P. (1987). Perception of Risk. Science, 236(4799), 280–285.

Slovic, P. (2012). The perception gap: Radiation and risk. Bulletin of the Atomic Scientists, 68(3), 67–75. http://doi.org/10.1177/0096340212444870

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1979). Rating the Risks. Environment, 21(3), 14–39.

Stevens, M. R., & Hanschka, S. (2014). Multilevel governance of flood hazards: Municipal flood bylaws in British Columbia, Canada. Natural Hazards Review, 15(February), 74–87. http://doi.org/10.1061/(ASCE)NH.1527-6996.0000116.

Stueck, W. (2016, January 22). Worried residents head to court over drinking water concerns in Shawnigan Lake. The Globe and Mail. Victoria, BC. Retrieved from https://www.theglobeandmail.com/news/british-columbia/worried-residents-head-to-court-over-drinking-water-concerns-shawnigan-lake/article28359674/

The United Nations Office for Disaster Risk Reduction. (2009). Terminology. Retrieved December 30, 2016, from https://www.unisdr.org/we/inform/terminology

Thompson, J. (2011). Cascadia's fault (First). Toronto, Ontario: HarperCollins Publishers Ltd.

Tierney, K. J. (2014). Hazards and disasters. In M. Sasaki, J. Goldstone, E. Zimmermann, & S. K. Sanderson (Eds.), Concise Encyclopedia of Comparitive Sociology (pp. 427–436). Leiden: Koninklijke Brill NV.

Tierney, K. J., Lindell, M. K., & Perry, R. W. (2001). Facing the unexpected. Washington, D.C.: Joseph Henry Press.

United States Geological Survey. (2016). Earthquake glossary. Retrieved February 24, 2017, from https://earthquake.usgs.gov/learn/glossary/

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox--implications for governance and communication of natural hazards. Risk Analysis : An Official Publication of the Society for Risk Analysis, 33(6), 1049–1065. http://doi.org/10.1111/j.1539-6924.2012.01942.x

Wells, R. E., Blakely, R. J., Wech, A. G., & Mccrory, P. A. (2017). Cascadia Subduction tremor muted by crustal faults. Geology, 45(6), 4–7. http://doi.org/10.1130/G38835.1

Wisner, B., Blaikie, P., Cannon, T., & Davis, I. (2003). At risk: Natural hazards, people's vulnerability and disasters (Second). London and New York: Routledge, Taylor & Francis Group.

Wood, M. M., Mileti, D. S., Kano, M., Kelley, M. M., Regan, R., & Bourque, L. B. (2012). Communicating actionable risk for terrorism and other hazards. Risk Analysis, 32(4), 601–615. http://doi.org/10.1111/j.1539-6924.2011.01645.x

Zhang, Q. B., & Hebda, R. J. (2005). Abrupt climate change and variability in the past four millennia of the southern Vancouver Island, Canada. Geophysical Research Letters, 32(16), 1–4. http://doi.org/10.1029/2005GL022913

APPENDICES

Appendix A: Questionnaire Tool: General Public (Group 1)

Thank you for taking the time to participate. I will read the survey questions and ask that you choose the best multiple-choice answer or explain your answer concisely. Again, your participation in this survey is voluntary and all answers are anonymous and confidential. This survey consists of three short sections, but first I'll ask a little about you…

Section A – Participant Data – I'll start with 6 brief questions about you and your principal residence.

1. Age:

☐ **18-24** ☐ **25-34** ☐ **35-44** ☐ **45-54** ☐ **55-64** ☐ **65 or older**

2. Gender:

☐ **Male** ☐ **Female**

3. a) What is your highest level of education?

☐ **Less than high school diploma** ☐ **High school diploma** ☐ **Some post-secondary**

☐ **Post-secondary degree** ☐ **Graduate degree**

Optional b) Do you mind sharing your household income bracket?

☐ **Less than $30,000** ☐ **$30,000 – $60,000** ☐ **$70,000 or greater** ☐ **Prefer not to disclose**

4. a) What municipality do you live in? _____

b) Is your home located in an urban or rural location?

☐ **Urban** ☐ **Rural** ☐ **Not sure**

c) What is the name of your community? _____

Optional definition: According to Statistics Canada (2011), "Urban" is widely understood as a concentration of population at a high density, i.e. a large population in a small space (quantitatively, at least 1,000 people at a density of 400 or more people per square kilometre); "Rural" is the opposite – where population is not concentrated, but dispersed at a low density. For example, the municipality of Sooke (population 11,435 with a land area of 56.72 square km) is considered rural, whereas Victoria (population 78,057 with a land area of 19.68 square km) is considered urban.

5. How long have you lived on Vancouver Island? _____

6. a) What best describes your principal residence?

☐ **Single-family house** ☐ **Multi-family house** ☐ **Apartment building/Condo**

☐ **Mobile home** ☐ **Townhouse** ☐ **Other: _____**

b) How long have you lived in your current residence?

☐ **Less than 1 year** ☐ **1-5 years** ☐ **5-10 years** ☐ **10 years or more**

7. Do you rent or own your home?

☐ **Rent** ☐ **Own** ☐ **Live with relatives** ☐ **Reside cost-free**

Now to the Survey…

Section B – Risks - this first section asks 5 quick questions about your opinion of risks and your community.

8. What do you think are the most significant **risks** to your community? *(Risk part of the equation)*

_____

Typically, when we think of risks we identify two sources: Natural or Manmade. **Natural hazards** have their origins in the natural environment, such as a landslide, flooding, earthquakes, hurricanes, tidal surge, *etc*. Manmade can either be accidental or intentional hazards. **Unintentional hazards** are "accidents" such as gas leaks, vehicle accidents, hazardous material spills, structural collapses, *etc*. **Intentional hazards** are malicious acts such as shootings, sabotage, arson, *etc.*

9. Given these descriptions of different types of hazards, what do you see as possible natural, unintentional and intentional hazards in your community:

a) **Natural hazards**: _____

b) **Unintentional hazards**: _____

c) **Intentional hazards**: _____

In the next two questions, I'll ask you to consider first what you think are the most **likely** hazards to occur, and then secondly, the most **consequential** hazards should they occur.

10. First, what do you think may be the **most likely hazards (likelihood)** to affect your community (*3*)?

_____

11. Second, what hazards do you think may have the **greatest consequences** on your community (*3*)?

_____

12. Now that you've reflected on a range of potential hazards in your community, how often they occur, and their possible consequences, what do you consider to be the **most significant risks** threatening your community? *(Back to risk – assessing differences between 8 and 12)*

_____

Section C – Seismic risk - this second section asks 6 questions about your perception and awareness of earthquake and tsunami hazards.

13. Earthquake and tsunami perception *Refer to map.*

a) Using this map of Vancouver Island, which areas do you think are exposed to earthquake threats?

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5** ☐ **6** ☐ **7** ☐ **None** ☐ **All**

b) Is your community at risk from earthquakes? ☐ **Yes** ☐ **No** ☐ **Not sure**

c) Do you think Vancouver Island is exposed to tsunami threats? ☐ **Yes** ☐ **No** ☐ **Partially**

d) **If yes, ask:* Using this map of Vancouver Island, what areas would you consider to be at risk from a tsunami? ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5** ☐ **6** ☐ **7** ☐ **None** ☐ **All**

14. Hazard/likelihood perception

a) In your community, what do you think are the chances (in percentage terms) that an earthquake strong enough to crack windows will happen in the next **10 years**?

_____

b) Next **25 years**? _____

15. *Earthquake knowledge:* What have been your primary sources of obtaining knowledge about earthquakes? I will read you some options, you may select more than one and/or provide your own.

☐ **School system** ☐ **Seminars/workshops** ☐ **Print Media** ☐ **Radio**

☐ **Social Media** ☐ **Television** ☐ **Government/Emergency Websites**

☐ **Other education** _____ ☐ **Other** _____

16. *Personal Earthquake Knowledge questions: expectations of amount of shaking and damage.*

a) If an earthquake occurred that was strong enough to crack windows in your community, but did no greater damage, how long would you expect the shaking to last?

☐ **< 30 seconds** ☐ **30 sec-1 minute** ☐ **1-3 minutes** ☐ **>3 minutes** ☐ **Not sure**

b) After this earthquake, would you expect a tsunami to be generated?

☐ **Yes, a tsunami is certain** ☐ **Yes, a tsunami is likely**

☐ **No, a tsunami is not likely** ☐ **No, a tsunami will not occur** ☐ **Not sure**

c) For how long after this earthquake would you expect to feel aftershocks?

☐ **< 1 day** ☐ **1-6 days** ☐ **1 month** ☐ **1 year** ☐ **>1 year**

17. *Personal earthquake preparedness questions.*

a) What should individuals do in the event that shaking starts? _____

b) Does your household have a plan to connect or meet at a 'safe location' following an earthquake?

☐ **Yes** ☐ **No** ☐ **Not sure**

c) Does your school/workplace have an earthquake plan in place?

☐ **Yes** ☐ **No** ☐ **Not sure**

d) Is your hot water tank strapped to a wall (so as not to topple)? ☐ **Yes** ☐ **No** ☐ **Not sure**

e) Have you secured any large items in your house to the walls like bookcases, large appliances?

☐ **Yes** ☐ **No** ☐ **Not sure** **Details:**

_____

f) Do you have an earthquake/emergency kit at home? ☐ **Yes** ☐ **No** ☐ **Partially** ☐ **Not sure**

Any Details:

_____

g) Do you have earthquake insurance? ☐ **Yes** ☐ **No** ☐ **Not sure**

h) What other precautions, if any, have you taken to prepare yourself/your family for an earthquake?

_____

18. *Earthquake communication:* In order to better inform people about earthquake risk, we'd like to know:

a) Which way of presenting the "likelihood " of an earthquake occurring is most meaningful to you?

Refer to chart. _____

b) What form of media/communication do you think would have the greatest impact on informing you about hazards?

☐ **Formal education** ☐ **Community workshops** ☐ **Print advertisements**

☐ **TV/Radio Advertisements** ☐ **Media stories** ☐ **Social Media** ☐

Other:_____

Section D – Mitigating Damage – ***this third section asks 3 questions about what you consider acceptable building practices.***

19. On a scale of 1-5, how strongly do you feel that each of the following eight structures must be built to seismic design standards? **(1= weakly agree; 5=strongly agree)**

1) **Single-family or multi-family residential homes (e.g. duplexes)** _____
2) **Walk-up residential apartments (2-4 floors)** _____
3) **High rise residential apartments** _____
4) **Commercial/Retail structures (e.g. shopping malls, sports facilities)** _____
5) **Bridges, tunnels, and overpasses** _____
6) **Rail, sea and air terminals** _____
7) **On-shore oil and gas pipelines** _____
8) **Off-shore oil and gas pipelines** _____

20. a) When should existing buildings be required to be retrofitted? _____

b) Should retrofitting be triggered by a failure to meet a certain percent of the current building code requirements? ☐ **Yes** ☐ **No** *If yes, go to 20c*

c) If yes, what percentage is appropriate?

☐ **50%** ☐ **60%** ☐ **70%** ☐ **80%** ☐ **Other:** _____

21. Once a building retrofit is triggered:

a) Do you feel building retrofits, or upgrades, should meet100% of the seismic design requirements of the current building code? ☐ **Yes** ☐ **No** *If no, go to 21b.*

b) If no, to what percentage of the current code requirements should they be designed to?

☐ **50%** ☐ **60%** ☐ **70%** ☐ **80%** ☐ **Other: _____**

Section E – Survey experience – Now I'll ask you a few questions about your experience taking this survey if you have time.

22. Upon completion of this survey did your perception of earthquakes and other natural disasters:

☐ **Increase** ☐ **Decrease** ☐ **Stay the same**

**Optional definition of perception: While awareness is having some sense of knowledge that an event may exist, perception, for the purpose of this study, is the preliminary inference you make based on that awareness that qualify whether you feel you are at risk from that event. It can be explained as your intuitive interpretation of information* (Lee et al., 2015; Sullivan, 2009).

23. Did you learn anything from the questions brought up in this survey?

☐ **Yes** ☐ **No** ☐ **Maybe**

24. What information in the survey did you find most useful?

_____

25. Was anything addressed in this survey that you may want to know more about?

_____

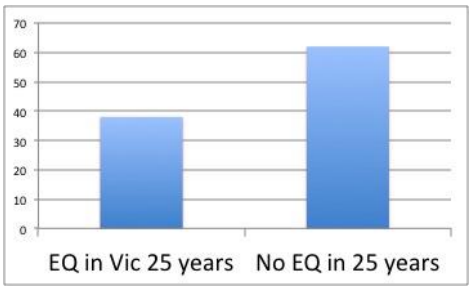
Thank you for completing the survey! If you'd like more to be informed of the results or if you'd like to receive further information on disaster preparedness, please leave me your name and contact information. Results will not be available for a few months but I am happy to share them when they are.

Do you have any questions?

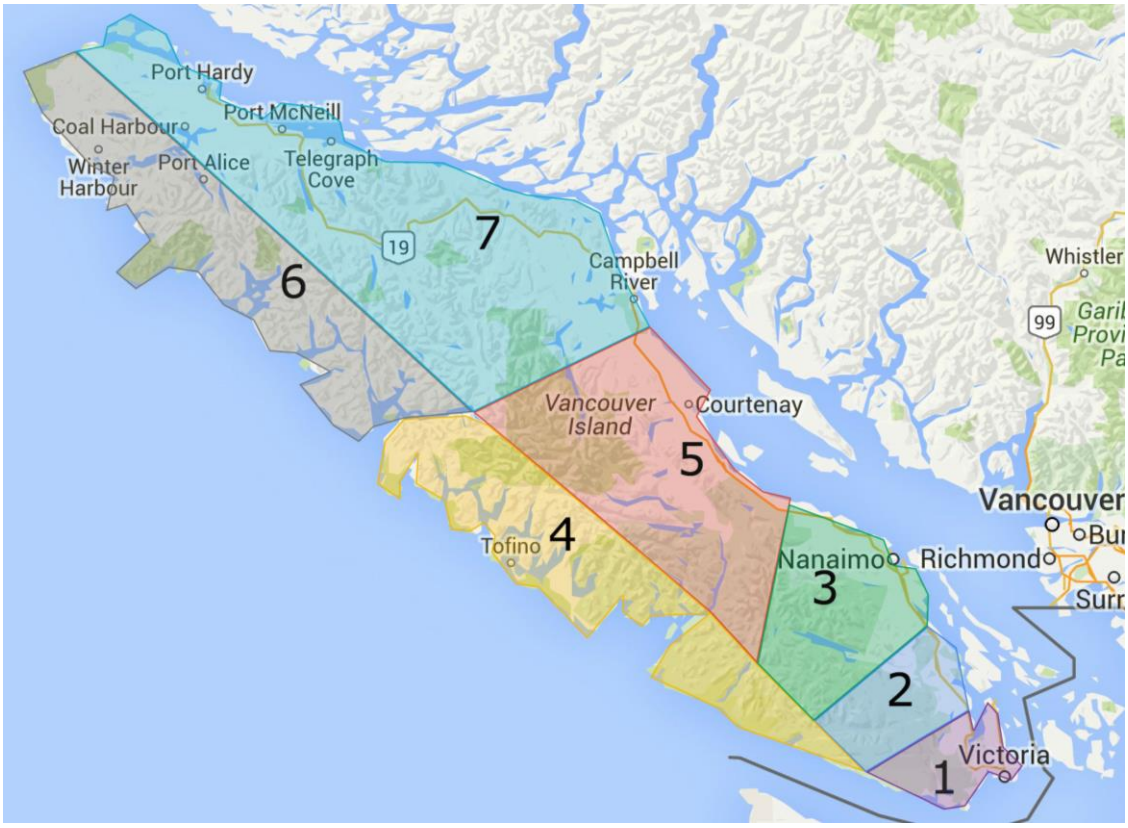
18. Earthquake communication: In order to educate you on earthquake preparedness:

a) Which way of presenting the "likelihood " of an earthquake occurring is most meaningful to you?

The probability of an earthquake strong enough to crack windows occurring in Victoria in the next 25 years is:

A) **38%**	B) **4/10**	C) **Four in ten chance**
D)  	E)  	F) **Other:** **_____**

13. Earthquake and tsunami perception



Appendix B: Questionnaire Tool: Emergency Management Professionals (Group 2)

Thank you for taking the time to participate. I will read the survey questions and ask that you choose the best multiple-choice answer or explain your answer concisely. Again, Your participation in this survey is voluntary and all answers are anonymous and confidential. This survey consists of three short sections, but first I'll ask a little about you.

For reference, in this survey I will ask you your opinion of how the people in your professional jurisdiction perceive risk, as well as yourself. Therefore, when I refer to your "jurisdiction," I am referring to the jurisdiction you work with, and when I refer to your "community" I am referring to the community you live in. If you need any clarification, just ask.

Section A – Participant Data – I'll start with 6 brief questions about you and your principal residence.

1. Age:

☐ **18-24** ☐ **25-34** ☐ **35-44** ☐ **45-54** ☐ **55-64** ☐ **65 or older**

2. Gender:

☐ **Male** ☐ **Female**

3. a) What is your highest level of education?

☐ **Less than high school diploma** ☐ **High school diploma** ☐ **Some post-secondary**

☐ **Post-secondary degree** ☐ **Graduate degree**

Optional b) Do you mind sharing your household income bracket?

☐ **Less than $30,000** ☐ **$30,000 – $60,000** ☐ **$70,000 or greater** ☐ **Prefer not to disclose**

4. a) What municipality do you live in? _____

b) Is your home located in an urban or rural location?

☐ **Urban** ☐ **Rural** ☐ **Not sure**

c) What is the name of your community? _____

Optional definition: According to Statistics Canada (2011), "Urban" is widely understood as a concentration of population at a high density, i.e. a large population in a small space (quantitatively, at least 1,000 people at a density of 400 or more people per square kilometre); "Rural" is the opposite – where population is not concentrated, but dispersed at a low density. For example, the municipality of

Sooke (population 11,435 with a land area of 56.72 square km) is considered rural, whereas Victoria (population 78,057 with a land area of 19.68 square km) is considered urban.

5. How long have you lived on Vancouver Island? _____

6. a) What best describes your principal residence?

☐ **Single-family house** ☐ **Multi-family house** ☐ **Apartment building/Condo**
☐ **Mobile home** ☐ **Townhouse** ☐ **Other: _____**

b) How long have you lived in your current residence?

☐ **Less than 1 year** ☐ **1-5 years** ☐ **5-10 years** ☐ **10 years or more**

7. Do you rent or own your home?

☐ **Rent** ☐ **Own** ☐ **Live with relatives** ☐ **Reside cost-free**

Considering the makeup of the jurisdiction you serve,

i. Approximately what percentage of the population is: **< 19 ____; 19 – 65 _____; > 65 _____**

ii. Approximately what percentage of the population's highest educational level is:

High school education _____; Post-secondary education (Undergrad/Cert/Dipl) _____; Graduate level (Masters/MD/PhD) education_____

iii. What is the approximate average household income: _____

Section B – Risk - ***this first section asks your opinion on 5 quick questions about risk in the community in which you live.***

8. What do you think are the most significant **risks** to the community you live in? *(Risk part of the eq.)*

_____

Typically, when we think of risks we identify two sources: Natural or Manmade. **Natural hazards** have their origins in the natural environment, such as a landslide, flooding, earthquakes, hurricanes, tidal surge, *etc*. Manmade hazards can either be accidental or intentional. **Unintentional hazards** are "accidents" such as gas leaks, vehicle accidents, hazardous material spills, structural collapses, *etc*.; **Intentional hazards** are malicious acts such as shootings, sabotage, arson, *etc.*

9. Given these descriptions of different types of hazards, what do you see as possible natural, unintentional, and intentional hazards in your community:

a) **Natural hazards**: _____

b) **Unintentional hazards**: _____

c) **Intentional hazards**: _____

In the next two questions, I'll ask you to consider first what you think are the most **likely** hazards to occur, and then secondly, the most **consequential** hazards should they occur.

10. First, what do you think may be the **most likely hazards (likelihood)** to affect your community (*3*)?

_____

11. Second, what hazards do you think may have the **greatest consequences** on your community (*3*)?

_____

12. Now that you've reflected on a range of potential hazards, how often they occur, and their possible consequences, what do you consider to be the **most significant risks** threatening your community? *(Back to risk – assessing differences between 8 and 12)*

---

iv. What do you think individuals in the jurisdiction you serve identify as the most significant

risks:_____

Section C – Earthquakes - *this second section asks 7 questions about your perception and awareness of earthquake and tsunami hazards.*

13. Earthquake and tsunami perception *Refer to map.*

a) Using this map of Vancouver Island, which areas do you think are exposed to earthquake threats?

☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5** ☐ **6** ☐ **7** ☐ **None** ☐ **All**

b) Is the community in which you live at risk from earthquakes? ☐ **Yes** ☐ **No** ☐ **Not sure**

v. Is the jurisdiction that you serve at risk from earthquakes?

☐ **Yes** ☐ **No** ☐ **Not sure**

vi. What percentage of your jurisdiction do you think would say yes to 13c? _____

c) Do you think Vancouver Island is exposed to tsunami threats? ☐ **Yes** ☐ **No** ☐ **Partially**

d) **If yes, ask:* Using this map of Vancouver Island, what areas would you consider to be at risk from a tsunami? ☐ **1** ☐ **2** ☐ **3** ☐ **4** ☐ **5** ☐ **6** ☐ **7** ☐ **None** ☐ **All**

14. Hazard/likelihood perception

c) In your community, what do you think are the chances (in percentage terms) that an earthquake strong enough to crack windows will happen in the next **10 years**?

_____

d) Next **25 years**? _____

How would you expect residents in your jurisdiction to respond to these questions:

vii. In your community, what do you think are the chances that an earthquake strong enough to crack windows will happen in the next **10 years**? _____

viii. Next **25 years**? _____

15. *Earthquake knowledge:* What have been your primary sources of obtaining knowledge about earthquakes? I will read you some options, you may select more than one and/or provide your own.

☐ **School system** ☐ **Seminars/workshops** ☐ **Print Media** ☐ **Radio**

☐ **Social Media** ☐ **Television** ☐ **Government/Emergency Websites**

☐ **Other education** _____ ☐ **Other** _____

ix. Where do you think people in your jurisdiction primarily obtain their knowledge of earthquakes? _____

16. *Personal Earthquake Knowledge questions: expectations of amount of shaking and damage.*

a) If an earthquake occurred that was strong enough to crack windows in your community, but did no greater damage, how long would you expect the shaking to last?

☐ **< 30 seconds** ☐ **30 sec-1 minute** ☐ **1-3 minutes** ☐ **>3 minutes** ☐ **Not sure**

b) After this earthquake, would you expect a tsunami to be generated?

☐ **Yes, a tsunami is certain** ☐ **Yes, a tsunami is likely**

☐ **No, a tsunami is not likely** ☐ **No, a tsunami will not occur** ☐ **Not sure**

c) How long would you expect to feel aftershocks following this earthquake?

☐ **< 1 day** ☐ **1-6 days** ☐ **1 month** ☐ **1 year** ☐ **>1 year**

17. *Personal earthquake preparedness questions.*

a) What should individuals do in the event that shaking starts? _____

b) Does your household have a plan to connect or meet up a 'safe location' following an earthquake?

☐ **Yes** ☐ **No** ☐ **Not sure**

x. What percentage of your jurisdiction do you think has a household plan set up? _____

c) Does your workplace have an earthquake plan in place?

☐ **Yes** ☐ **No** ☐ **Not sure**

xi. What percentage of your jurisdiction do you believe have plans set up:

At work: _____**;** At school: _____

d) Is your home hot water tank strapped to the wall (so as not to topple)? ☐ **Yes** ☐ **No** ☐ **Not sure**

e) Have you secured any large items in your house to the walls like bookcases, large appliances?

☐ **Yes** ☐ **No** ☐ **Not sure** **Details:**

_____

f) Do you have an earthquake/emergency kit at home? ☐ **Yes** ☐ **No** ☐ **Partially** ☐ **Not sure**

Any Details:

_____

xii. What percentage of your jurisdiction do you think have taken at least some household mitigations like these (*e.g.* strapping large appliances, creating a kit):_____

g) Do you have earthquake insurance? ☐ **Yes** ☐ **No** ☐ **Not sure**

xiii. What percentage of your jurisdiction do you think has earthquake insurance? _____

h) What other precautions, if any, have you taken to prepare yourself/your family for an earthquake?

_____

18. *Earthquake communication:* In order to better inform people about earthquake risk, we'd like to know:

a) Which way of presenting the "likelihood " of an earthquake occurring is most meaningful to you?

Refer to chart. _____

b) What form of media/communication do you think would have the greatest impact on informing you about hazards?

☐ **Formal education** ☐ **Community workshops** ☐ **Print advertisements**

☐ **TV/Radio Advertisements** ☐ **Media stories** ☐ **Social Media** ☐

Other:_____

xiv. What form of media/communication do you think would have the greatest impact on informing residents in your jurisdiction about hazards?

☐ **Formal education** ☐ **Community workshops** ☐ **Print advertisements**

☐ **TV/Radio Advertisements** ☐ **Media stories** ☐ **Social Media** ☐

Other:_____

Section D – Mitigating Damage – ***this third section asks 3 questions about what you consider acceptable building practices.***

19. On a scale of 1-5, how strongly do you feel that each of the following eight structure types must be built to seismic design standards? **(1= weakly agree; 5=strongly agree)**

9) Single-family or multi-family residential homes (e.g. duplexes) _____

10) Walk-up residential apartments (2-4 floors) _____

11) High rise residential apartments _____

12) Commercial/Retail structures (e.g. shopping malls, sports facilities) _____

13) Bridges, tunnels, and overpasses _____

14) Rail, sea and air terminals _____

15) On-shore oil and gas pipelines _____

16) Off-shore oil and gas pipelines _____

xv. What percentage of residents in your jurisdiction do you think feel all of these structures should be seismically designed?

_____

20. a) When should existing buildings be required to be retrofitted? _____

b) Should retrofitting be triggered by a failure to meet a certain percent of the current building code requirements? ☐ **Yes** ☐ **No** *If yes, go to 20c*

c) If yes, what percentage is appropriate?

☐ **50%** ☐ **60%** ☐ **70%** ☐ **80%** ☐ **Other: _____**

21. Once a building retrofit is triggered:

a) Do you feel building retrofits, or upgrades, should meet 100% of the seismic design requirements of the current building code? ☐ **Yes** ☐ **No** *If no, go to 21b.*

b) If no, to what percentage of the current code requirements should they be designed to?

☐ **50%** ☐ **60%** ☐ **70%** ☐ **80%** ☐ **Other: _____**

Section E – Survey experience – Now I'll ask you a few questions about your experience taking this survey if you have time.

22. Upon completion of this survey did your perception of earthquakes and other natural disasters:

☐ **Increase** ☐ **Decrease** ☐ **Stay the same**

**Optional definition of perception: While awareness is having some sense of knowledge that an event may exist, perception, for the purpose of this study, is the preliminary inference you make based on that awareness that qualify whether you feel you are at risk from that event. It can be explained as your intuitive interpretation of information* (Lee et al., 2015; Sullivan, 2009).

23. Did you learn anything from the questions brought up in this survey?

☐ **Yes** ☐ **No** ☐ **Maybe**

24. What information did you find most useful?

_____

25. Was anything addressed in this survey that you may want to know more about?

_____

Thank you for completing the survey! If you'd like more to be informed of the results or if you'd like to receive further information on disaster preparedness, please leave me your name and contact information.

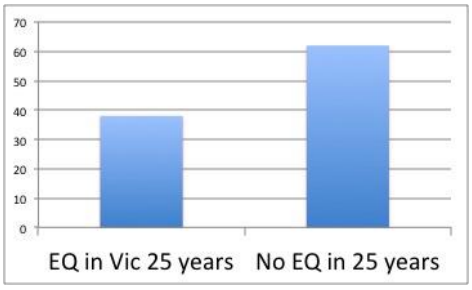
Results will not be available for a few months but I am happy to share them when they are.

Do you have any questions?

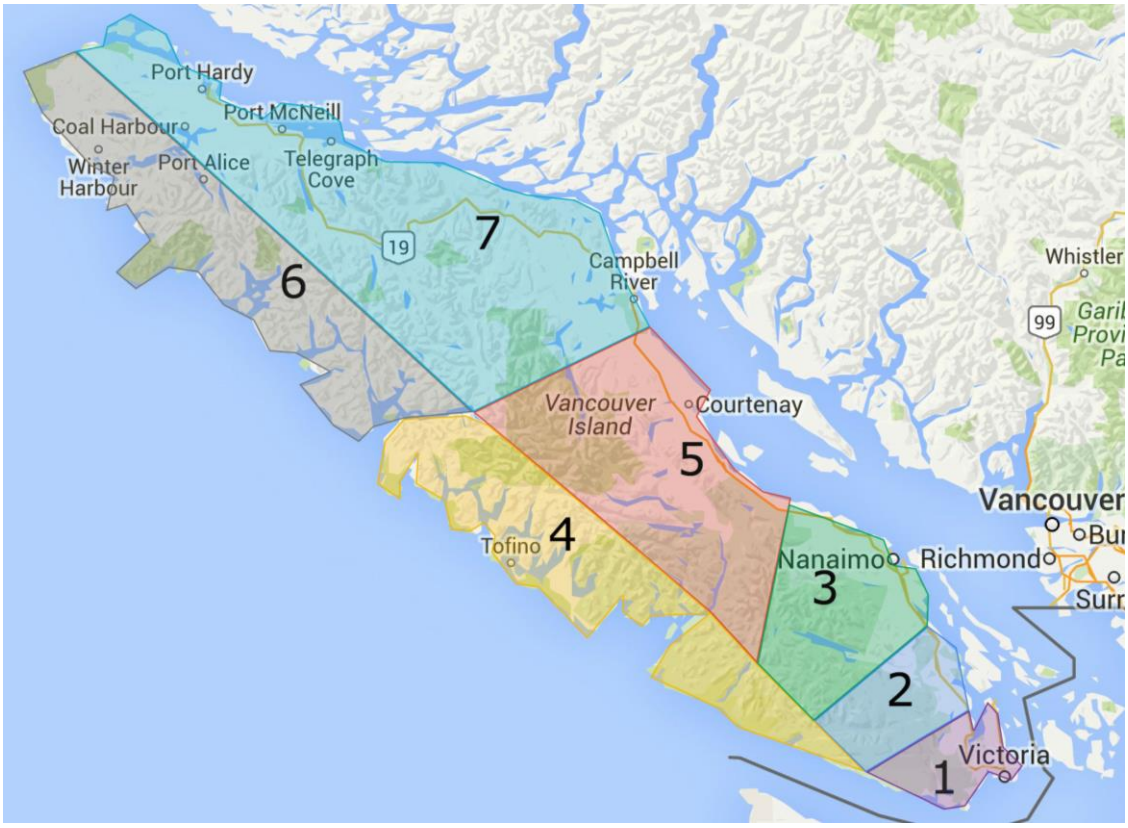
18. Earthquake communication: In order to educate you on earthquake preparedness:

a) Which way of presenting the "likelihood " of an earthquake occurring is most meaningful to you?

The probability of an earthquake strong enough to crack windows occurring in Victoria in the next 25 years is:

A) **38%**	B) **4/10**	C) **Four in ten chance**
D)  	E)  	F) **Other:** **_____**

13. Earthquake and tsunami perception



Appendix C: Schedule of Sampling and Locations for General Public Group

Municipality	Location	Date
Saanich	Gordon Head Recreation Centre	Tuesday, January 12 2016 Thursday, January 14 2016 Friday, February 19 2016
Esquimalt	Esquimalt Recreation Centre	Thursday, January 21 2016 Monday, January 25 2016 Monday, February 1 2016
Saanich	Saanich Centennial Library	Thursday, February 5 2016 Thursday, February 18 2016
Saanich	Nellie McClung Library	Thursday, February 25 2016
Victoria	Central Branch Library	Thursday, March 3 2016
Duncan	Island Savings Centre	Friday, March 4 2016 Monday, March 14 2016
Duncan	Vancouver Island University Cowichan Campus	Monday, April 11 2016 Friday, April 22 2017
Shawnigan Lake	Kerry Park Recreation Centre	Saturday, May 7 2016 Satuday, May 14 2016

Appendix D: Comprehensive List of Hazards Identified by Respondents

Beneath each heading is a more comprehensive list of the unique hazards provided that fell within each category.

Crime and Violence	Environmental	Psychosocial	Individual hazards provided
Assault	Air pollution	Emotional impacts of disaster	None/not sure
Auto theft	Climate change (or Global Warming)	Interpersonal issues	Arson
Bullying	Intentional toxic dumping	Mental health	Drought
Breaking and entering	Litter	Peer pressure	Earthquakes
Drugs	Environmental impacts		Fire
Drug trafficking	Loss of habitat (wildlife)		Flooding
Crime	Low glacial melt		Food Security
Kidnapping	Pesticides		Wildfire/forest fire
Open crime cases	Water pollution		Power outages
Robbery	Water contamination		Tsunami
Safety	Water supply		Landslide
Security	Wildlife		
Sexual assault			
Shooting			
Theft			
Vandalism			
Walking in the dark			
Youth violence			

Economic	Other Natural Disaster	Gas leaks, Hazmat & Industry	Social Welfare
Housing prices	Hurricane	Industrial hazard/accident	Lack of social welfare
Insurance rates	Monsoon	Gas leaks	Poverty
Government overspending	Other natural disaster	Hazardous material release	Unemployment
Economic	Tornado	Radiation	
Politicians			

Apathy, Lack of knowledge	Health	War & Terrorism	Motor Vehicle Incident
Lack of education/training	Illness	Nuclear war	Driving under the influence
Lack of awareness	Pandemics	Terrorism	Motor vehicle accidents
Lack of preparedness/planning		Weapons	Traffic
Apathy			

Severe Weather	**Other**
Rain	Chemical trails (from aircraft)
Severe Weather	Construction
Snowstorm	Death of community member
Wind	Infrastructure
	Lack of access (to medical resources, *etc.*)
	Debris blocking transportation
	GMOs
	Compost
	Aging population
	Falling trees
	Location of Development
	Loss of community
	Overpopulation
	Overconsumption
	Response time
	Structure failure
	Transportation
	Urban expansion
	Tourism

Appendix E: Letters of Consent

General Public Consent Form

University of Victoria

Participant Consent Form

Hazard Perceptions on Vancouver Island, BC, Canada

You are invited to participate in a study entitled *Hazard Perceptions on Vancouver Island, BC, Canada.* My name is Brittany Schina and I am a Master of Arts student in the Department of Geography at the University of Victoria. This research is being conducted under the co-supervision of Dr. Denise Cloutier, Associate Professor in the Department of Geography and Dr. Mark Seemann, Adjunct Professor in the Department of Geography.

Benefits and Objectives of Research

The results of this research will provide a baseline to understand hazard perceptions and how residents of Vancouver Island understand their risk from hazards. This research will attempt to understand the relationship between perceptions of hazard risk and preparedness and mitigation. Perceptions will be compared to scientific estimations of hazard risk in order to identify where discrepancies exist between perceptions and estimations.

Voluntary Participation

You are being asked to participate in this study because you are a resident of Vancouver Island. If you consent to voluntarily participate in this research, participation will include answering a brief survey, which should take no more than 10 minutes to complete. All responses will remain secured, confidential and anonymous. After five years all data will be destroyed. If you decide to participate, you may withdraw at any time without any consequences or any explanation.

Risks

There are no anticipated risks to you by participating in this research. If you experience stress or anxiety regarding the subject content, I can provide you with educational information on the subject following the questionnaire and will direct you to further counseling resources if you wish.

Results

The results of this research will be contained in a publicly accessible thesis, which can be obtained by contacting the University of Victoria. If you wish to be informed of the results you can provide me your email address.

If you have any further questions or concerns regarding the research, would like to learn more about disaster preparedness, or would like to access the findings of this survey, please feel free to contact myself or my supervisors.

[Contact information removed]

You may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca, protocol number: 15-152).

By completing the survey, **YOUR FREE AND INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Please retain a copy of this letter for your reference.

University of Victoria

Participant Consent Form

Hazard Perceptions on Vancouver Island, BC, Canada

You are invited to participate in a study entitled *Hazard Perceptions on Vancouver Island, BC, Canada.* My name is Brittany Schina and I am a Master of Arts student in the Department of Geography at the University of Victoria. This research is being conducted under the co-supervision of Dr. Denise Cloutier, Associate Professor in the Department of Geography and Dr. Mark Seemann, Adjunct Professor in the Department of Geography. This research is in no way affiliated with Emergency Management BC or influenced by my position of employment at EMBC.

Benefits and Objectives of Research

The results of this research will provide a baseline to understand hazard perceptions and how residents of Vancouver Island understand their risk from hazards. This research will attempt to understand the relationship between perceptions of hazard risk and preparedness and mitigation. Perceptions will be compared to scientific estimations of hazard risk in order to identify where discrepancies exist between perceptions and estimations.

Voluntary Participation

You are being asked to participate in this study because you are a resident of Vancouver Island and because of your knowledge and involvement in emergency management. If you consent to voluntarily participate in this research, participation will include answering a brief survey, which should take no more than 20 minutes to complete. All responses will remain secured, confidential and anonymous in their final form. After five years all data will be destroyed. If you decide to participate, you may withdraw at any time without any consequences or any explanation.

Risks

There are no anticipated risks to you by participating in this research.

Results

The results of this research will be contained in a publicly accessible thesis, which can be obtained by contacting the University of Victoria. If you wish to be informed of the results you can provide me your email address and I will send a summary at the end of the study. If you have any further questions or concerns regarding the research, would like to learn more about disaster preparedness, or would like to access the findings of this survey, please feel free to contact myself or my supervisors.

[Contact information removed]

You may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca, protocol number: 15-152).

By completing the survey, **YOUR FREE AND INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Please retain a copy of this letter for your reference.