

Indigenous Knowledge Research Report Northwest Vancouver Island Tsunami Risk Assessment

Prepared by Indigenous Engagement Research Associate, Jaquelyne LaFlamme
&
Indigenous Community Liaison, Pieter Romer



Executive Summary

This report seeks to amplify the importance of “making space at the table for everyone” in disaster risk reduction and risk management. More specifically, this report highlights how Indigenous knowledge from communities living at the forefront of tsunami risk on the northwest coast of Vancouver Island for millennia, have fostered disaster resilience which is critical for understanding current and future risk and mitigation. The Indigenous communities within the study area include; the Mowachaht-Muchalaht First Nations, the Ka:yu:'k't'h' and Che:k'tles7et'h' First Nations, the Nuchatlaht First Nation, the Ehattesaht-Chinehkint First Nations, and Quatsino First Nation (Figure 1). Using a framework of two-eyed seeing, where different ways of knowing are used simultaneously for the benefit of all instead of one being incorporated into the other, this tsunami risk assessment utilizes Indigenous knowledge and modern risk assessment tools such as Digital Elevation Models (DEMs) to create a robust risk assessment (Reid., et al. 2020). The Indigenous communities within the study area have multigenerational shared experience connecting to the land, coping with environmental change, and surviving natural disasters. Through both research and interviews conducted between September 2020 and March 2021 with elders and community members, the authors of this report collected multiple stories, teachings, and oral histories of past tsunamis including but not limited to the 1700 and 1964 tsunamis.

Introduction

The northwest coast of Vancouver Island is exposed to tsunami hazards from both local sources such as the Cascadia subduction zone, and more distant sources such as the Aleutian Islands in Alaska (Clague et al., 2000). The Cascadia Subduction Zone (CSZ) is a 1100 km long megathrust fault that stretches from Northern Vancouver Island to northern California (Pacific Northwest Seismic Network, [PNSN] n.d). The North American Plate and the Juan de Fuca plate meet at the CSZ where the Juan de Fuca plate moves towards and “subducts” below the North American Plate (PNSN, n.d). Over time the movement of plates at subduction zones create a build-up of stress as the plates try and move past each other but become locked by friction (PNSN, n.d). There is a transition zone directly below this locked section where the plates are able to move a few cm every few months, but over time the locked section will eventually exceed the fault’s frictional strength and the plates will slip past each other causing a “megathrust” earthquake (PNSN, n.d). The last megathrust earthquake to happen at the CSZ occurred in 1700 A.D and was one of the world’s largest earthquakes (PNSN, n.d). The 1700 tsunami caused incredible shaking and a massive tsunami that swept across the west coast of Vancouver Island and propagated across the Pacific Ocean (Clague et al., 2000). Events like this are not isolated, but happen every few hundred years at the CSZ (PNSN, n.d). Vancouver Island was also struck by a large tsunami in 1964 that was caused by a distant earthquake in Alaska, not by a CSZ earthquake (Clague et al., 2000). Some of the most vulnerable areas to tsunami hazards caused by both kinds of earthquakes are the inlets and fjords on the outer coast of Vancouver Island, as the waves can become amplified and therefore quite devastating (Clague et al., 2000). Tsunami hazard history in the Pacific Northwest has been well understood through analysis of sediment cores in marshes and lakes in both British Columbia and Washington, and passed on through oral histories and knowledge by Indigenous communities (Clague et al., 2000; Hutchinson & McMillan, 1996).

This report is part of a project to quantify and understand the tsunami inundation risk in communities on the northwest coast of Vancouver Island using both modern risk assessment tools such as DEMs and local knowledge. The study and project were conducted in partnership between Ocean Networks Canada (ONC), the Strathcona Regional District (SRD), and Northwest Hydraulic Consultants (NHC). Local communities play a critical role in this study as those who have lived at the forefront of natural disasters possess valuable local knowledge. There are five First Nations communities within the study area of this project (see Figure 1) who have inhabited their territories for millennia, and have long term knowledge of tsunami disaster risk within their territories. Community members and Elders from these First Nations were interviewed about their first-hand experiences with the 1964 tsunami, and about any oral histories related to tsunamis in their territories.

The Sendai Framework for disaster risk reduction calls for a “more people centered preventative approach to disaster risk”, encouraging different groups to work more closely together and create opportunities for collaboration (UNISDR, 2015). Historically Indigenous voices have been left out of disaster risk management in favour of Western risk management systems (Ali., et al. 2021). Having thousands of years of observations on their land embedded in their stories, oral histories, and teachings is advantageous in the context of risk management, disaster resilience and is invaluable to this study. They have cultivated techniques and understanding to prepare for and manage risk of all types of disasters specific to their region through generations of story sharing

and maintaining their value systems (Dicken, 2018). The experiences and stories of those living, working and stewarding on the coast of Vancouver Island, will amplify the capacity for understanding and ground truth tsunami risk on the northwest coast of Vancouver Island.

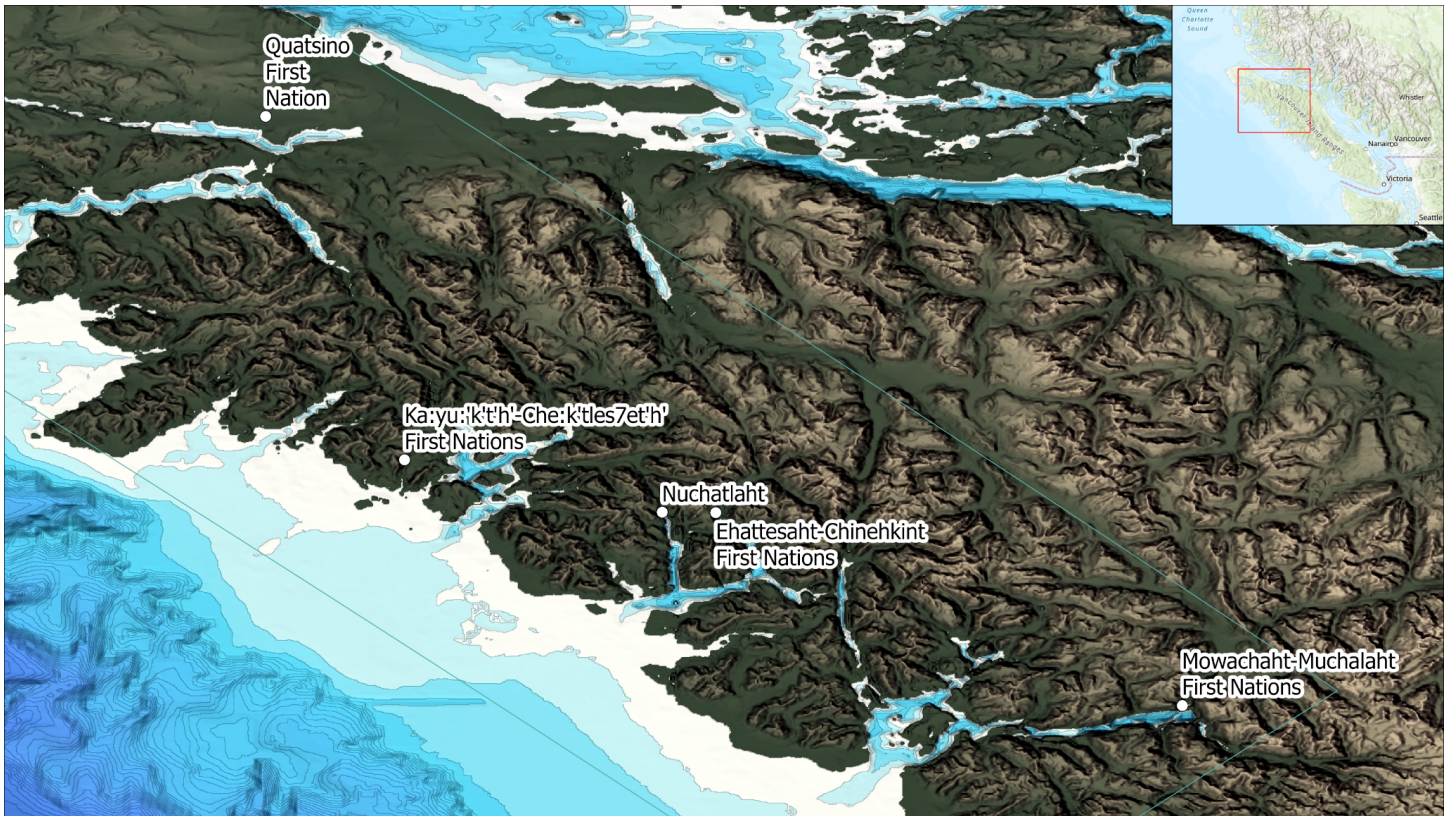


Figure 1: Map showcasing the study area (30m grid polygon used for the DEM models) and locations of the five First Nations communities participating in and contributing to the northwest coast tsunami risk assessment.

The concept of “two-eyed seeing” speaks to moving beyond the narrative of “incorporating Indigenous knowledge into western science” and instead making space for both ways of knowing to exist simultaneously for the benefit of all (Reid., et al. 2020). This project is a unique opportunity to showcase the resiliency of using “knowledge coexistence” for disaster management and risk assessment. The International Panel on Climate Change (IPCC) states that “Indigenous people’s holistic view of community and environment are a major resource for adapting to climate change, but these have not been used consistently in existing adaptation efforts. Integrating such forms of knowledge with existing practices increases the effectiveness of adaptation” (IPCC, 2014). Utilizing the resiliency already built into Indigenous knowledge systems along with innovative disaster planning technologies such as DEM modelling, we anticipate a more robust risk assessment than if either methodology were used independently.

The following are stories, knowledge, and oral histories shared with us by knowledge holders from the Nuu-chah-nulth and Kwakwaka'wakw territories of Vancouver Island. They range from tsunami and earthquake legend stories, to oral histories of the 1700 and other historical tsunamis, to first hand experiences of the 1964 tsunami. Together, they highlight the depth of disaster risk understanding from the nations within the study area.

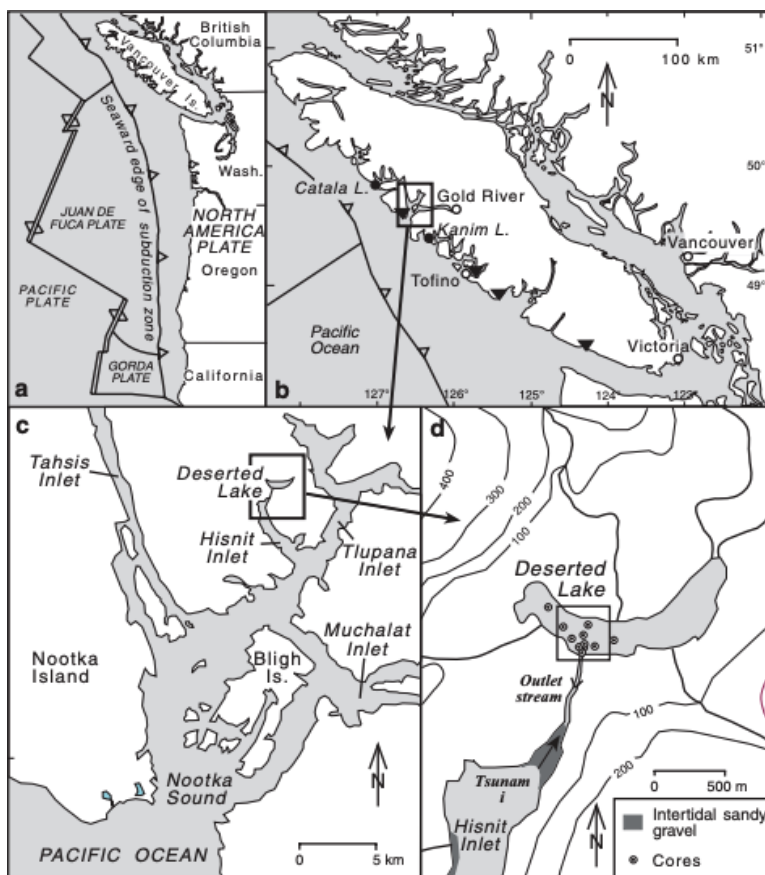
Related Scientific Studies

The following section gives examples of scientific research providing evidence of the historical presence and extent of tsunamis within the study area. This is not a comprehensive literature review but is meant to showcase relevant studies to the knowledge being shared with us.

Village Abandonments

Through radiocarbon dating of hearths and other cultural features, Hutchinson & McMillan (1996) create a timeline of village abandonment cycles following earthquake and tsunami events in the Nootka Sound (within our study area), Barkley Sound, and Olympic Areas regions that span millennia. Out of the three regions sampled, the Nootka region was most impacted by earthquakes and tsunamis. Hutchinson & McMillan infer that the most damage occurred in this region because of all the narrow inlets and sounds where tsunami waves can be amplified. Yuquot in the Nootka region (within our study area) has been occupied for at least the last 5000 years. Through radiocarbon dating of four different cultural zones in a shell midden in Yuquot, Hutchinson & McMillan identified a period of low human activity 2800 to 2400 cal yr B.P and 1600-1400 cal yr B.P coinciding with different earthquake and tsunami events. There is also stratigraphic evidence of abandonment of Yuquot following the 1700 tsunami. "In general, the probability distribution of radiocarbon ages, cultural boundaries and phases of low shell accumulation in the midden are all consistent with the hypothesis that Yuquot site history was strongly influenced by great earthquake events" (Hutchinson & McMillan, 1996).

Deserted Lake



Deserted lake is at the head of the Hismit Inlet in Nootka Sound separated from the ocean by a bedrock and gravel barrier (See Figure 2) (Hutchinson, et al., 2000). The lake is about 40 ha and surrounded by mountains that reach up to 1000 m (Hutchinson, et al., 2000). In a 3 m core taken from deserted lake three different layers of sand were found in the sediment profile (Hutchinson, et al., 2000). The sand and microfossil assemblages of these layers were consistent with deposition from tsunamis. Radiocarbon dating puts the tsunamis generated from plate-boundary earthquakes at the Cascadia subduction zone at 2600, 1600, and 300 years ago (Hutchinson, et al., 2000). Deserted lake gives concrete scientific evidence of how far reaching tsunamis can be within the study area.

Figure 2: Location of deserted lake and study area from Hutchinson, et al., 2000.

Indigenous Resilience: Legends, Stories & Oral Histories

The following section includes Indigenous legends, stories and oral histories about tsunamis and earthquakes, collected both through interviews conducted with elders from communities within our study area (Figure 1) in October of 2020, and through research of external sources.

Earthquake foot is a rendition of a Mowachaht-Muchalaht story about a young man named Yahlua and the cave-dwelling mountain dwarves who live in the mountains by Yuquot (Friendly Cove). This rendition was told by renowned artist and knowledge holder A-Nii-Sa-Put (Tim Paul) (Shake Up interview, 2020).

“A man was going through the mountains in Yuquot (Friendly Cove) and stumbled across the home of two dwarves. They were very happy and outgoing. They greeted him with every respect and invited him into their home. They invited the man to perform, to dance and sing around their great drum in the house. This went on all day and all night until the man tired and stumbled into that drum. It was then that he became afflicted with an earthquake foot, and every time he took a step, tremors occurred. The whole world began to shake and quake. This is a family cultural teaching that is a true history from Friendly Cove” (Shake Up interview, 2020).



Figure 3: Vectorized image of a silkscreen print done in 1977, “Earthquake Foot”, created by artist A-nii-sa-put (Tim Paul). Tim Paul grew up in Ehatessaht on the west coast of Vancouver Island. The print depicts the moment that Yahlua tires and kicks the drum and becomes afflicted with the disease earthquake foot, as one of the dwarves looks on.

The following information is from the Museum of Anthropology’s project “Shake Up: preserving what we value”, referenced at the end of this document, and from personal communications with Tim Paul. Tim speaks to the importance of understanding how humans are related to nature, and those in nature are relatives. He says earthquakes are a relative, just like people, to remind people who they are in the world, and what small beings we are in the scheme of the universe. He also references the importance of learning from history, knowledge and culture. Tim relates that, “what we know is what we get from living with aunts and uncles”. He understands earthquake and tsunami risk by understanding the stories and experiences of history and then passing on these teachings through his carvings.

Tim learned from his Grandmother how to survive. He gently reminds his nieces and nephews that he “comes from the University of Ester Brown, lest they forget their history, teachings and culture.” This theme is relevant for this study as we respect the Indigenous knowledge and experience as well as tsunami science. Tim describes that there are people in the community called [Nache – Natcha] who are the foreseers. The ones that can see what’s coming, why it’s coming and what it’s about. He notes that the ones who can see, are the ones that make preparations. Our study team represents one sense of people that can ‘foresee’ what is coming, as do the people who add their input to the study. For Tim’s personal and family connections with three earthquake events, they consider the earthquake as the 11th relative of his family of 10. This reminds him of our place in this world and a very small part of this universe, “like pets to nature”.

Earthquakes live on the side of the mountain. If a hunter/seeker comes upon the house, two dwarves will come out to entice you to stay. They will smile and invite you into their home by singing, dancing and drumming until you can't resist. You join in the song and dance until you tire and stumble onto a drum and become inflicted with earthquake foot disease. You want to go home but every time you step you make more earthquakes. You eventually make it home, but you don't live long. Story Moral: Do not be enticed with smiles or you may leave with something that you don't want. Tim Paul also explains that historically there were people in the community that would be able to sense when an earthquake and the following flood (tsunami) would occur. In preparation for the incoming floods the community would make miles and miles of cedar rope to tie their canoes to their land. He describes his family history and how they are the survivors of the last three great earthquake and tsunami events. The first one covered the entire mountain tops, the second the mountain tops were showing, and the third came halfway up the mountains.

Although earthquake foot is the only legend directly from our study area (See Figure 1), there are other relevant legend stories from the Hupacasath First Nation (near Port Alberni) and from the Quileute and Hoh people in Washington State.

Sproat Lake Petroglyphs: As told by Brandy Lauder



Brandy Lauder from the Hupacasath First Nation describes in the oral story of K'aka'win, which means "something on its back" in Nuuchahnulth referring to an orca's dorsal fin, who was carried into Sproat lake by a tsunami many years ago (Musée de la civilisation, 2019). K'aka'win is said to have lived a month in the lake before it was killed (Musée de la civilisation, 2019). There are petroglyphs carved into a rock at Sproat lake created by the Kleh-koot-aht peoples (Kleh-koot-aht are one of the amalgamated tribes that comprise the Hupacasath First Nation) (Images on Stone, n.d). To give this story perspective, Sproat lake is more than 4 km away from the ocean (head of Alberni Inlet would be the closest) (Images on Stone, n.d). The story of K'aka'win exemplifies the magnitude of waves historically witnessed by coastal communities.

Figure 4: Petroglyphs located at Sproat Lake depicting K'aka'win and the contents of its stomach, photo by Lucianne Marshall.

Whale and Thunderbird Legend

There are many Indigenous stories of Whale and Thunderbird fighting and causing great shaking (Finkbeiner, 2015). The Quileute and Hoh people near La Push in Washington State, describe how Thunderbird and Whale had a terrible fight, making the mountains shake and uprooting trees (Tales from Hoh and Quileute, n.d). Thunderbird then lifted Whale up into the sky, and then dropped Whale into the ocean causing a great wave. There is another story of Thunderbird being very angry, and he caused the sea to rise (Tales from Hoh and Quileute, n.d). When the water began to cover the land, the Quileute got into their boats. The water rose for four days until it covered the mountain tops. The Quileute had no way to direct themselves and could see no land. After four days the water receded but people were scattered everywhere. Only some were able to find their way back to Quileute.

1700 Tsunami Oral History: As told by Ray Williams

In October of 2020 Pieter Romer, Indigenous Community Liaison, spoke with Ray Williams about his knowledge of the effects of the 1700 tsunami near Yuquot.

"In 1700 the tsunami washed pebbles into their lake at Yuquot because there is about 300 feet between the Ocean and the lake. The last scientist that came said 300 years ago. Ghost Lagoon was wiped by a slide similar to the Ozette Lake in Washington. Ghost

Lagoon is situated [further up the inlet from Yuqout] on the left-hand side going into Klapanna inlet. They always believed there were spirits in that lagoon. Nobody goes there. One time their lighthouse keeper went there and camped out at the lagoon. When he came back he said that is a weird place to be as they hear funny sounds and people. They got scared but didn't leave."

Pachena Bay People: As told by Chief Louie Nookmiis

"It is said no one ever knew what happened. I think a big wave smashed into the beach. The Pachena Bay people were lost... But on their part who lived at maalcaas 'House Up Against Hill', the wave did not reach because they were on high ground right against a cliff. Because of that they came out alive. They did not drift out to sea along with the others" (Chief Louie Nookmiis: oral account of Pachena Bay Tsunami). Although Pachena Bay is outside of the study area for this project, it is geographically relevant and an example of the devastation caused by tsunamis on the west coast of Vancouver Island.

1964 Tsunami: First Hand Experiences

The following section is a collection of first-hand experiences of the 1964 tsunami, from both interviews conducted in the 2020/2021 winter season, and from external sources. "At 5:36 p.m. on March 27, 1964, a massive earthquake struck Alaska. According to the U.S. Geological Survey, the earthquake registered 9.2 on the Richter scale and lasted four and-a-half minutes. This makes it the most powerful recorded earthquake in U.S. history, and the second most powerful earthquake ever recorded in the world. The U.S. Geological Survey said the tsunami in Valdez Inlet, Alaska, was 67 metres high (220 feet). In Crescent City, California, the wave was 6.1 metres (20 feet) high, which wiped out the downtown and killed 12 people. Overall, 139 people were killed in the earthquake and tsunami. But no one was killed in British Columbia, although the tsunami caused lots of damage" (Mackie, 2014). The following is a summary of the events that took place at Hot Springs Cove which lies northwest of Flores Island near Tofino.

Hot Springs Cove

"Residents of Hot Springs Cove were settling in for the night as their generator, which supplied electricity to the entire community, was shut off at 11:00 p.m. as was the usual practice. With no power for lights people scrambled to high ground by the light of the full moon as rising water lifted houses off their foundations. Some were forced to swim with their babies on the bitterly cold March night. Of the 18 homes on the shores of Hot Springs Cove, only two were not destroyed. Amazingly, despite the lack of warning and given the magnitude of destruction, no lives were lost in Hot Springs Cove that night. The community was eventually relocated to higher ground on the north side of the cove. To this day, survivors take any tsunami warning seriously and they move to higher ground and wait it out" (August, 2012). Although Hot Springs Cove is out of the study area for this project, it is still geographically relevant as it sits on the west coast of Vancouver Island.



"For most, memories are vague and details are sometimes lost but all remember the fear and panic as each helped one another reach safety" (August, 2012).

Figure 5: *The earthquake threat in southwestern British Columbia: A Geologic Perspective*, the village of Hot Springs Cove, shortly after the tsunami of the great Alaska earthquake of March 1964. Photo by Charles Ford.

Interviews

The following are summaries of interviews conducted in the fall of 2020 and the beginning of 2021 with Mowachaht/Muchalaht, Nuchatlaht, Ehattesaht, and Kyuquot community members who experienced the 1964 tsunami, by Indigenous Community Liaison, Pieter Romer and Indigenous Engagement Research Associate, Jaquelynne LaFlamme.

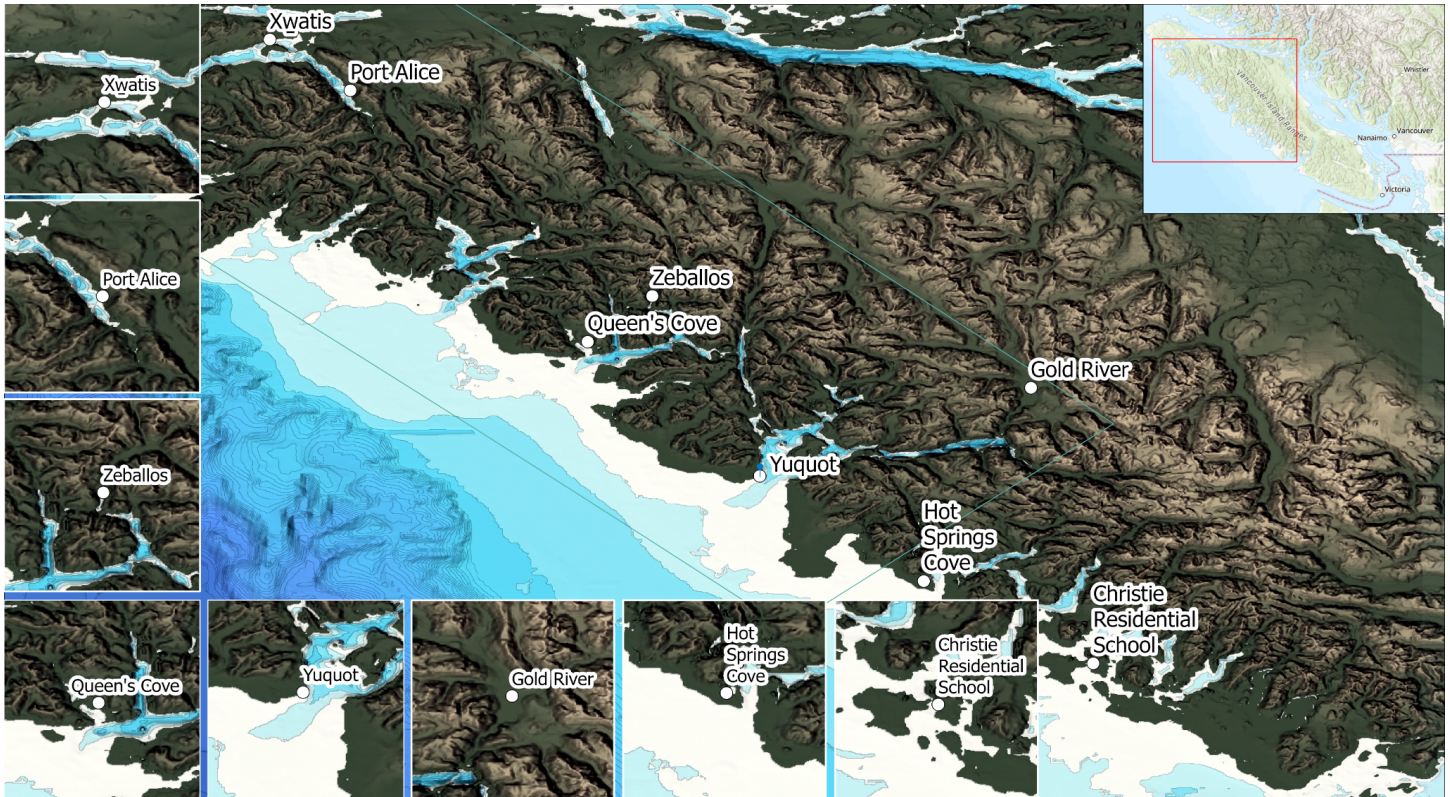


Figure 6: Map showcasing the locations where the interviewees were when they experienced the 1964 tsunami.

Harold Amos (Ehattesaht): Harold is originally from Hot Springs Cove (Figure 6) but now resides in Gold River. Harold said he was in Hot Springs Cove and remembers that it was a sunny day. There was no warning of the incoming waves, but there were luckily no human casualties. He was 9 or 10 at the time. He recalls all the birds and animals went up the mountain and it became very quiet right before the tsunami came. The tide receded down to the eelgrass. The second wave came up around 30 feet and was followed by four consecutive waves. All of the anchored boats were moved around. The houses became swamped and the 10 to 12 foot waves pushed them back 40-60 feet and flooded all the living rooms. When the tide first dropped one young boy went down to the beach and his father had to quickly run down and pick him up before the returning water washed him away. The tides eventually went back to normal. Many people ended up moving to Port Alberni after the event and unfortunately a lot of the community was broken up. Harold says the tsunami changed a lot of lives in one short week. Harold ended up moving to Queen's Cove and then to Esperanza.

"The wave was about 10 or 12 feet, it pushed back the houses 40-60 feet" ---Harold Amos

Georgina Amos (Ehattesaht): Georgina is originally from Zeballos and resides now in Gold River (Figure 6). Georgia was living in Zeballos at the time the tsunami hit. She recalls the community hall was lifted up by the wave. The wave came up 10-12 feet. She was 16 years old at the time. She recalls not noticing the wave until after church, and the ramp outside was at an opposite angle. She waited around for a bit as the wave came in and out three times. The water rose very fast. She got into a skiff with her sisters and they noticed all the ground fish had come up including Red Snappers, Rock Cod, and Long Johns. They were so excited to collect all the fish they did not think that there may be other waves coming up, as they had never experienced anything like it previously.

"There was fish everywhere" ---Georgina Amos

Victor Amos (Ehattesah): Victor was attending Christie Residential School (Figure 6) on Meares Island near Tofino at the time the waves hit. He was sleeping, but remembers seeing the large canoes pushed halfway up the hill in the morning.

Tim Paul (Ehattesah): Tim Paul's Father is from *Hesquiaht* and his mother is *Nuchatlaht*. He grew up in the Nuchatlaht community in Queen's Cove (Figure 6) at the top of Esperanza Inlet. Tim Paul is now 80 and lives in Port Alberni. Nuchatlaht doesn't have any elders left. They all passed away in the last 3 years. During the 1964 tsunami Tim Paul was at Christie Residential School in bed and didn't see anything. In the morning he saw the "Ave Marie" skiff pushed up on the shore. He heard during the 1964 tsunami that in Hot Springs Cove that there were people still in the house when it floated out toward sea.

"The tsunami bypassed some areas...Queen's Cove is right on the beach but they were not affected in any devastating way." --- Tim Paul

Ray Williams (Mowachaht/Muchalaht): Ray is now 80 years old. During the 1964 Tsunami, Ray was working as a logger in Gold River and Yuquot. The waves bypassed Yuquot and shot up the inlet towards Tahsis. The bunkhouses, which were on 4-foot spruce logs, got engulfed in water in Gold River. He was 14 at the time.

"The bunkhouses got engulfed in water" --- Ray Williams

Aloyius Vincent (Kyuquot): Aloyius was 20 years old in 1964 and working at a logging camp in Amai inlet near Kyuquot. He said the tsunami came at about 10 PM after they had turned off the generator. They heard noises at the door and when they opened the door the ocean came rushing in. Everyone ran out of the bunkhouses and up the nearest hill before the second wave hit. The second wave wiped everything out. It was very dark and difficult to see and it was the most scared he had ever been in his life.

"The river was going up instead of down" --- Aloyius Vincent

Fran Wallas (Quatsino): Fran was living in Xwatis (Old Quatsino) during the 1964 tsunami. The elders in the community knew that a tsunami was coming and instructed everyone to be ready. Fran and her family went to bed fully dressed in case they had to run to higher ground, and had food and supplies packed and ready. The wave never came, but she said that the community was ready.

"The elders knew where to go, and had a place for everyone to meet if the wave came" --- Fran Wallas

Chief Tom Nelson (Quatsino): Tom was loading a boat at the time the 1964 tsunami hit. The lines got tight and broke a few things off the dock. His friend had a cabin near Port Alice which had been moved 200 feet from its original location. He said his father's boat broke loose from where it was moored, and was lifted up by the wave and landed on a piling putting a hole in the hull. There was damage to other boats and infrastructure like docks in Port Alice, but nobody was hurt from what he remembers. Tom would have been around 18 when the tsunami hit Port Alice.

"His cabin went 200 feet from where it was sitting - we brought 45 gallon drums up there and skidded it back to where it was before" --- Chief Tom Nelson

Archie Little (Nuchatlaht): Those of us from Friendly Cove, Ehatahsah, Nuchatlaht, Kyuquot stayed at Christie Residential School for 10 months of the year and never got to come home for Christmas or Easter because of the weather and distance. We were there when the tsunami hit in 64. There is a beautiful sand beach at Christie and the tide came up 100 feet. It cleaned the beach right off, taking all the logs and trees with it. My friend was standing on a log when it came up, and he got taken out when the wave came in. We had to go out in a canoe to get him because he couldn't get back.

“Even though we haven’t had much experience, home (Nuchatlaht) was okay from what I heard. People came together for support, and to make sure everyone was accounted for, but there wasn’t any damage. But we still need to manage and be fully prepared for what can happen” --- Archie Little

Use of Indigenous Knowledge

The knowledge shared with us during interviews and stories collected through research illuminate the resilience of Indigenous communities in the face of some of the most catastrophic natural disasters to occur in the world. This project is meant to be of benefit to the communities that are within the study area, therefore results should be based on the actual needs that have been shared with us. To ensure that the results are tailored to the local context, representatives from each Indigenous community have been involved at all current stages of the project including all advisory group meetings. Their ideas, guidance, and needs have informed the DEM modelling and will be included in the next phases of the study which includes a vulnerability assessment, evacuation procedure recommendations, a community resilience assessment and a documentary. The final products of this project will have been informed by both a local Indigenous understanding and from a western science perspective.

Conclusion

Indigenous communities have learned to mitigate and deal with hazards in their territories over millennia, and know best their own vulnerabilities and capacity to respond to hazards (Trogrlić et al., 2021). Stories like earthquake foot and Whale & Thunderbird are evidence that these communities have been preparing their future generations for natural disasters that will inevitably occur in their territories. To fully grasp the insight of these stories it is critical to make space for an Indigenous worldview within this study. Indigenous knowledge is not just information to be extracted, but an entire knowledge system built from thousands of years of experiences on the land. Heshookish tsa’walk (Nuu-chah-nulth), which means ‘everything is one’ or ‘everything is connected’ is an example of the values embedded within the Nuu-chah-nulth worldview (Dicken, 2018). Tied to both physical and metaphysical realities, heshookish tas’walk is a fundamental concept that reminds Nuu-chah-nulth people that all life is connected and nothing exists in isolation (Dicken, 2018). Maintaining oral histories like the loss of the Pachena Bay people has taught communities about the importance of keeping their homes back from the shoreline. Both Tim Paul and Fran Wallas spoke about listening to elders and those in the community that knew a tsunami was coming, which likely saved many lives.

In many ways, Indigenous communities are currently living through acute and long-term disasters. With the detrimental loss of population caused by disease from early settlers in the 1700-1800s, to the impacts of the Indian Act and residential schools on communities, colonization is a human-caused disaster (Dicken, 2018). The fact that the stories collected here have survived shows the immense resiliency within these communities. Indigenous knowledge is not static and continues to evolve with a changing environment and continued challenges (Trogrlić et al., 2021). The first-hand accounts of the 1964 tsunami and oral histories of villages lost in the 1700 tsunami are good reminders and lessons of the vulnerability of coastal communities to the natural elements, and will greatly inform this study. The fact that there were no casualties during the 1964 tsunami showcases the resilience and preparedness of these communities. Understanding risk from a local, Indigenous, and science-based perspective adds strength to current disaster risk management and models international and national preparedness guidelines (UNISDR, 2015). The lessons learned from the Indigenous knowledge holders within the study area and beyond are vital to conducting a strong risk assessment and more effective risk management strategies.

Acknowledgements

Traditional knowledge faces multiple compounding threats. It is important to note that even during the time of this project, two knowledge holders, one in Yuquot and the other in Ka:yu:'k't'h'/Che:k'tles7et'h, passed away before we were able to speak with them. We extend our condolences to the families and communities who have lost these important knowledge holders. Any information, stories, interviews and research that is collected during this project will be given back to each participant. We are grateful for all the knowledge and stories that were shared with us from elders and community members. Their knowledge and deep connection to their territories is very apparent. We extend our deepest gratitude to everyone who took the time to speak with us, especially during these challenging times of the global COVID-19 pandemic.

Interviews

Quatsino First Nation

- Fran Wallas (February 19, 2021)
- Chief Tom Nelson (February 22, 2021)

Ka:yu:'k't'h' and Che:k'tles7et'h' First Nations

- Aloyius Vincent (Jan 28, 2021)

Nuchatlaht

- Archie Little (March 4, 2021)
- Tim Paul (December 16, 2020)

Ehattesaht-Chinehkint

- Georgina Amos (October 22, 2020)
- Harold Amos (October 22, 2020)
- Victor Amos (October 22, 2020)

Mowachaht/Muchalaht First Nation

- Ray Williams (October 22, 2020)

References

- Ali, T., Buergelt, P. T., Paton, D., Smith, J. A., Maypilama, E. L., Yungirrija, D., ... & Gundjarranbuy, R. (2021). Facilitating sustainable disaster risk reduction in Indigenous communities: reviving Indigenous worldviews, knowledge, and practices through two-way partnering. *International journal of environmental research and public health*, 18(3), 855.
- August, D. (2012, October 30). Hesquiaht Community hit by Tidal Wave shares memories 40 years later. *Ha-Shilth-Sa* <https://hashilthsa.com/news/2012-10-30/hesquiaht-community-hit-tidal-wave-share-memories-40-years-later>
- Clague, J. J., Bobrowsky, P. T., & Hutchinson, I. (2000). A review of geological records of large tsunamis at Vancouver Island, British Columbia, and implications for hazard. *Quaternary Science Reviews*, 19(9), 849-863.
- Finkbeiner, A. (2015). The great quake and great drowning. <https://www.hakaimagazine.com/features/great-quake-and-great-drowning/>
- Hutchinson, I., Guilbault, J.J., Clague, J.J., & Bobrowsky, P.T. (2000). Tsunamis and tectonic deformation at the northern Cascadia margin: a 3000-year record from Deserted Lake, Vancouver Island, British Columbia, Canada. *The Holocene*, 10(4), 429-439.
- Hutchinson, I., McMillan, A.D. (1996) Archaeological evidence for village abandonment associated with late Holocene earthquakes at the northern Cascadia subduction zone.
- Images on Stone (n.d). <https://imagesdanslapierre.mcq.org/en/explore/kakawin/>
- International Panel on Climate Change. (2014) Climate change 2014 synthesis report.
- Mackie, J. (2014). This week in history: Huge earthquake set off a tsunami that devastated Port Alberni. *Vancouver Sun*. <https://vancouver.sun.com/News/Metro/huge-earthquake-set-off-a-tsunami-that-devastated-port-alberni>
- Musée de la civilisation, (2019, January 31). Brandy Lauder and the Hupacasath First Nation, K'aka'win, images on stone. Youtube. <https://www.youtube.com/watch?v=B9ETs9pusDU>
- Pacific Northwest Seismic Network (n.d). Cascadia Subduction Zone. <https://pnsn.org/outreach/earthquakesources/csz>
- Reid, A. J., Eckert, L. E., Lane, J. F., Young, N., Hinch, S. G., Darimont, C. T., ... & Marshall, A. (2020). "Two-Eyed Seeing": An Indigenous framework to transform fisheries research and management. *Fish and Fisheries*.
- Museum of Anthropology, UBC. (2020). Chief Louie Nookmiis: Oral account of Pachena Bay Tsunami <http://www2.moa.ubc.ca/shakeupipad/>
- Museum of Anthropology, UBC. (2020). Shake up expert interview: A-nii-sa-put (Tim Paul), Hesquiaht Artist. Youtube. Retrieved from <https://www.youtube.com/watch?v=6s9psOexPeU>
- Tales from Hoh and Quileute (n.d). <https://pnsn.org/outreach/native-american-stories/thunderbird-and-whale/thunderbird-and-whale-stories/tales-from-the-hoh-and-quileute>
- Troglič, R. Š., Duncan, M., Wright, G., van den Homberg, M., Adeloje, A., Mwale, F., & McQuistan, C. (2021). External stakeholders' attitudes towards and engagement with local knowledge in disaster risk reduction: are we only paying lip service?. *International Journal of Disaster Risk Reduction*, 58, 102196.

UNISDR (United Nations International Strategy for Disaster Reduction). (2015). Sendai framework for disaster risk reduction 2015–2030. Geneva: UNISDR.