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# Dating the 1700 Cascadia Earthquake: Great Coastal Earthquakes in Native Stories

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## INTRODUCTION

Although scientific recognition of the earthquake hazard presented by the Cascadia subduction zone (CSZ) is relatively recent, native peoples have lived on the Cascadia coast for thousands of years, transferring knowledge from generation to generation through storytelling. This paper considers the ways in which information on coastal earthquakes is presented in native traditions and estimates the date of the most recent event from them.

The primary plate-boundary fault of the CSZ separates the oceanic Juan de Fuca Plate from the continental North America Plate (Figure 1). It lies about 80 km offshore and extends roughly parallel to the coast from the middle of Vancouver Island to northern California. Although recognized as early as the mid-1960's, the CSZ was initially assumed to be incapable of producing great megathrust earthquakes. It is seismically quiet, and no sizable earthquake has occurred on it since European settlement began.

As the theory of plate tectonics matured, studies of subduction zones worldwide identified characteristics associated with megathrust earthquakes. These earthquakes are most common in areas where hot, young, buoyant crust is rapidly subducted (Heaton and Kanamori, 1984).

Although the rate of subduction in Cascadia is relatively slow, the subducted crust is among the youngest and hottest anywhere. Field investigations soon located geological evidence of abrupt land-level changes characteristic of megathrust earthquakes in "ghost forests" of dead cedar trees in coastal estuaries in Washington and Oregon (Nelson *et al.*, 1995). The cedars, originally above the limit of the tides, were killed when their roots were suddenly plunged into salt water. Beneath the surface of these same estuaries, soil cores revealed layered deposits showing a repeated cycle of slow uplift and rapid submergence. Preliminary age estimates based on radiocarbon dating (Nelson *et al.*, 1995) and tree-ring studies (Yamaguchi *et al.*, 1989) suggested that the most recent earthquake happened about 300 years ago. The exact date and approximate time of the most recent CSZ earthquake, 9 PM on 26 January 1700, were determined from Japanese historic records of a tsunami arriving with no reports of associated shaking (Satake *et al.*, 1996). The year was confirmed through close study of tree-ring patterns of ghost cedar roots (Yamaguchi *et al.*, 1997). The magnitude estimate of 9.0 implies rupture along the entire length of the CSZ (Satake *et al.*, 2003). Figure 1 shows the geographic extent of the likely rupture area.

## TRADITIONS FROM CASCADIA

At the time of initial European contact, Cascadia native groups spoke more than a dozen distinct languages (Thompson and Kinkade, 1990) and lived in a complex social landscape with both similarities and differences between groups. Collection and recording of native stories began in the 1860's, more than 350 years after the first European contacts in North America, almost 100 years after initial contact in Cascadia, and nearly 50 years after European settlement began. As a result, as much as 95% of native oral traditions may have been lost (Jacobs, 1962), and available recorded examples may not be a representative sampling of the original material. Storyteller, transcriber, and language and cultural issues all affect the story that ends up in print. Nonetheless, versions of oral traditions are preserved in hundreds of sources, and numerous stories describe shaking or marine flooding. Artifacts, dances, songs, ceremonies, and personal and place names supplement the range of information available for study. We are deeply indebted to the many informants who shared their stories and allowed them to be preserved in written form.

Figure 1 shows source locations for 40 native stories from 32 independent sources. These stories represent less than a third of the known stories that refer to shaking or marine

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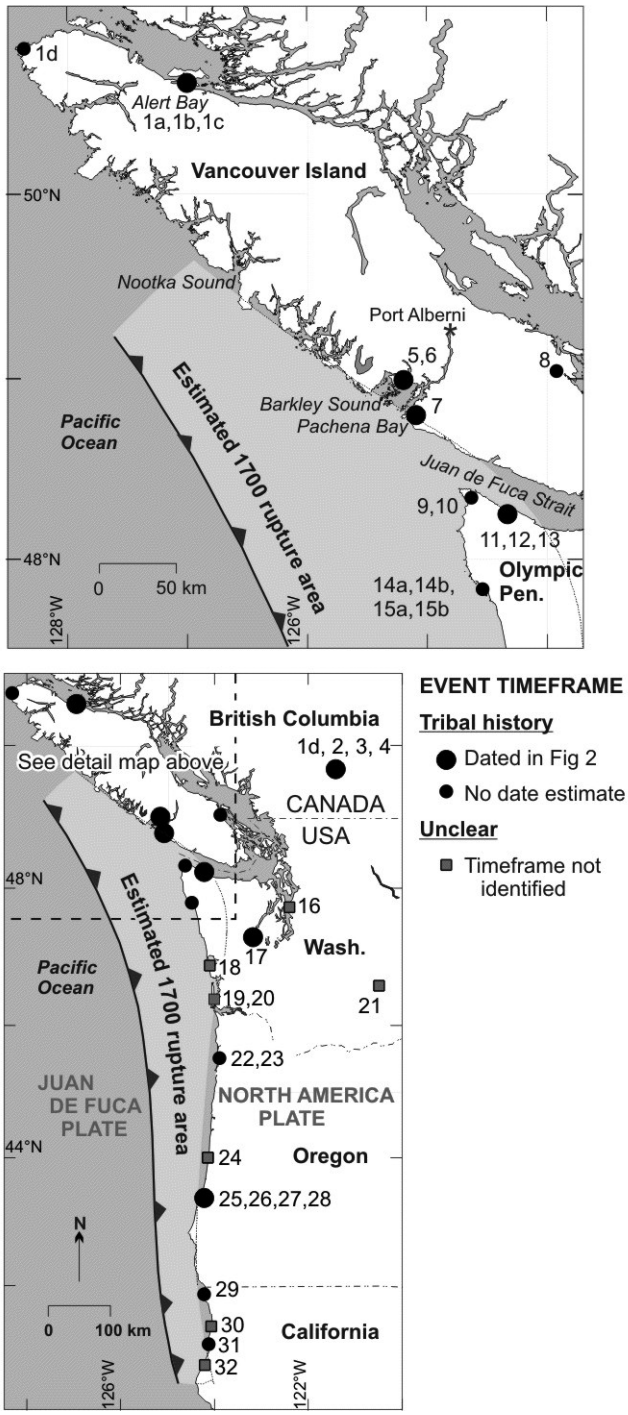
7. FEMA Region X
8. Makah Museum and Cultural Center
9. Olympic National Park
10. Bainbridge Island, Washington




▲ **Figure 1.** Story-source location map. Estimated 1700 rupture from Wang *et al.* (2003).

flooding and were selected on the basis of clarity, descriptions of phenomena notable in megathrust earthquakes, and geographic distribution. Some of these stories have been discussed in earlier studies (Heaton and Snavely, 1985; Clague, 1995; Carver and Carver, 1996; Minor and Grant, 1996; Hutchinson and McMillan, 1997; Losey, 2002; McMillan and Hutchinson, 2002). Figure 2 tabulates story elements and gives date estimates.

Stories referenced in Figures 1 and 2A have been broadly grouped into three time categories: stories from which dates can be estimated, stories that are clearly historical but impossible to date, and apparently mythic stories without any clear timeframes. Historical stories cannot be distinguished from myth by style or content alone, however (story ref. 23, p. ix), and stories that appear to be mythological may be based on historical events. Stories designated as historical in the source texts are identified as historical in Figures 1 and 2A.

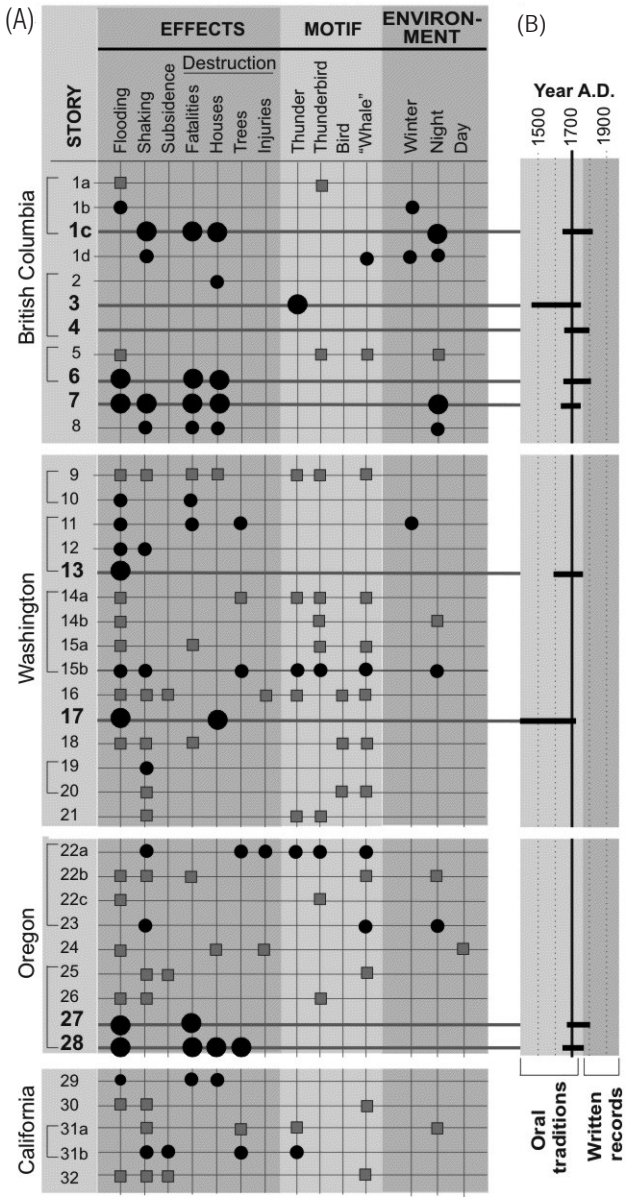
Stories vary considerably in content and style along the Cascadia coast. At the southern end, many stories explicitly mention both earthquakes and tsunami. At the northern end, there are explicit earthquake stories and explicit flood stories, but only a few stories including both phenomena. In the middle portion of the CSZ, along the coast of Oregon and Washington, direct mention of earthquakes is rare and stories of marine floods are common. The differences likely result from differences in the collection and preservation of stories, and may also reflect differences in native cultures and lifestyles along the Cascadia coast or variations in earthquake effects.

## HISTORICAL TRADITIONS

Nine stories (1c, 3, 4, 6, 7, 13, 17, 27, and 28) have information sufficient for estimating a date range for an event associated with shaking and/or flooding (two stories with both, three with shaking only, and four with flooding only). Two stories tell of a grandparent who saw a survivor of the flood, one of a great-grandparent who survived it. The stories were told between 1860 and 1964. Figure 2 tabulates the accounts and gives estimated date ranges. Date range minima and maxima are 1400 and 1825. All estimates span the interval between 1690 and 1715, and the average value of the midpoints of the date ranges is 1690. Discarding the earliest and latest midpoints yields an average midpoint date of 1701. This is remarkably consistent with the 1700 date of the most recent CSZ earthquake.

The date estimates based solely on descriptions of floods could possibly be reports of teletsunamis (*i.e.*, tsunamis arriving from distant earthquakes). Alaskan and South American earthquakes produced notable tsunamis on the Cascadia coast in the 20th century (Lander *et al.*, 1993). Although the history of Alaskan earthquakes around 1700 is not known, tsunamis from South American earthquakes were recorded in Japan in 1730, 1751, and 1780 (Watanabe, 1998). Japanese earthquakes have not produced significant tsunamis in Cascadia since at least 1806 (Lander *et al.*, 1993), but locally generated tsunamis damaged the Japanese coast in 1611, 1707, and 1771(Watanabe, 1998).

Stories that can be dated are mostly straightforward descriptions of flooding and/or shaking. The exceptions are two stories that date the origin of the Swai'xwe mask and costume (stories 3 and 4, Figure 3). The Swai'xwe represents earth shaking in a northern Vancouver Island ritual (Boas, 1897), where its mythic origin (story 1d) tells of a mask obtained at night in the winter ceremonial house of Red Cod,




## Estimated Date Range and Basis for Estimate

**1650–1825 (1c).** "This is not a myth … my tale is seven generations old … there was a great earthquake and all the houses of the Kwakiutl collapsed." — *La'bid in 1930.*

**1456–1756 (3).** "The masked dance … originated with a man … who lived about 12 generations ago." — *Unidentified informant in 1936.*

**1670–1795 (4).** "… the mask was first obtained five generations before her own …" — *Mrs. Robert Joe, age >80 in 1950.*

**1655–1814 (6).** "The tide … rushed up at a fearful speed. … The Clayoquot who thus became chief was the great-grandfather of Hy-yu-penuel, the present chief of the Sheshaht …" — *Unidentified informant in 1860.*

**1640–1740 (7).** "These are stories from my grandfather's father (born c. 1800) about events that took place four generations before his time … over 200 years ago" "… the land shook … a big wave smashed into the beach." — *Chief Louis Nookmis, age 84 in 1964.*

**1600–1775 (13).** "One old man says that his grandfather saw the man who was saved from the flood." — *Unidentified informant c. 1875.*

**1400–1715 (17).** "… eight or nine generations from my grandfather there was a flood." — *Frank Allen, age 60 in 1940.*

**1690–1805 (27).** "My grandfather saw one of the old women (survivors) who had been left alive. She had been hung up on a tree, and the limbs of that tree were too high up. So she took her pack line and tied it to a limb, and then when she wanted to go down by means of that, she fell, she was just a girl when she fell from it. Her back was broken from it (she had a humpback thereafter). That is what she told about the raised water." — *Annie Miner Petersen, age 73 in 1913.*

**1657–1777 (28).** "… there was a big flood shortly before the white man's time, … a huge tidal wave that struck the Oregon Coast not too far back in time … the ocean rose up and huge waves swept and surged across the land. Trees were uprooted and villages were swept away. Indians said they tied their canoes to the top of the trees, and some canoes were torn loose and swept away … After the tidal wave, the Indians told of tree tops filled with limbs and trash and of finding strange canues in the woods. The Indians said the big flood and tidal wave tore up the land and changed the rivers. Nobody knows how many Indians died. — *Beverly Ward, recounting stories told to her around 1930 by Susan Ned, born in 1842.*

▲ **Figure 2.** (A) Tabulation of story elements: effects, figurative motifs, and environmental settings. Brackets by story numbers group stories from common geographic locales. Symbols are as in Figure 1. The "Whale" motif is enclosed in quotes to cover a variety of sea monsters appearing in the stories. (B) Date range estimates and quotes used to calculate them. Date range estimates used the following assumptions: A "generation" is no fewer than 15 and no more than 40 years, events before age 5 are not remembered, the maximum lifespan is 100 years, flood survivors were "old" when seen, and an "old" person is at least 40.

where rumbling sounds and earth shaking are caused by fish thrashing about on the floor. Additional sources identify the Swai'xwe as historical and place its geographic origin near the town of Hope (Codere, 1948; Lévi-Strauss, 1979; Carlson *et al.*, 2001) on the British Columbian mainland. The Swai'xwe is considered earthquake-related over its entire geographic range (Lévi-Strauss, 1979), although the shaking element is not prominent in mainland stories. The Swai'xwe is also mentioned in connection with thunder and whirlwind (American Museum of Natural History Catalog, Item 16.1/1871) (story ref. 3 and story 2).

Two of the stories that can be dated include both flooding and shaking elements. The clearest and most complete (story 7) is from the outer coast of Vancouver Island, recorded by Chief Louis Nookmis following the 1964 Alaskan earthquake. It describes a nighttime earthquake quickly followed by a tsunami that destroyed the Pachena Bay people.

> They had practically no way or time to try to save themselves. I think it was at nighttime that the land shook. … I think a big wave smashed into the beach. The Pachena Bay people were lost. … But they who lived at Ma:lts'a:s, "House-Up-Against-

▲ **Figure 3.** Swai'xwe mask from mainland British Columbia, associated with shaking effects, whirlwinds, and thunder (American Museum of Natural History, Item 16.1/1871).

> Hill" the wave did not reach because they were on high ground. … Because of that they came out alive. They did not drift out to sea with the others. (Arima *et al.*, 1991)

The published translation cited above (Arima *et al.*, 1991) is slightly garbled and not clear enough to make a date estimate from. Co-author Robert Dennis, Chief Councillor of the Huu-ay-aht First Nation and grandson of Chief Louis Nookmis, working with a new translation of the recordings, has discovered that the original recording did include information that makes it possible to estimate a date for the earthquake and tsunami, placing it between 1640 and 1740. This new information comes from a comprehensive transcription and translation of the 1964 recordings currently being undertaken by the Huu-ay-aht First Nation.

The second story with both flooding and shaking is from the northern margin of the Olympic Peninsula in northwestern Washington and combines information from three independent sources (stories 11–13) to yield a tale indicating winter flooding accompanied by strong shaking.

The stories above are supplemented by a datable story of nighttime shaking from the northern end of Vancouver Island and a tradition that cannot be dated but vividly describes strong nighttime shaking, from a group on the inner coast of southern Vancouver Island (story 8):

> In the days before the white man there was a great earthquake. It began about the middle of one night … threw down … houses and brought great masses of rock down from the mountains. One village was completely buried beneath a landslide. It was a very terrible experience; the people could neither stand nor sit for the extreme motion of the earth.

The remaining stories that can be dated describe saltwater flooding events. Archaeological evidence indicates that some native villages on the British Columbia, Washington, and Oregon coasts were subsided, flooded by tsunamis, and abandoned following the 1700 earthquake and tsunami (Cole *et al.*, 1996; Minor and Grant, 1996; Hutchinson and McMillan, 1997; Losey, 2002), supporting the possibility that flooding stories may reflect this event.

## THUNDERBIRD AND WHALE

### Supernatural Symbols to Describe Events Out of the Human Scale

Throughout Cascadia, earth shaking and/or tsunamilike effects are frequently described in stories about the acts and personalities of supernatural beings, often in the guise of animals. Many stories from western Vancouver Island and northern Washington tell of a struggle between Thunderbird

and Whale, and throughout Cascadia stories about these figures frequently include explicit mention or visual imagery suggesting shaking and/or tsunamilike effects.

Thunderbird and Whale are beings of supernatural size and power. A story from Vancouver Island says that all creation rests on the back of a mammoth whale, and that Thunderbird causes thunder by moving even a feather and carries a large lake on his back from which water pours in thunderstorms (Carmichael, 1922). Shaking and ocean surges can be inferred from the story of Thunderbird driving his talons deeply into Whale's back, and Whale diving and dragging the struggling Thunderbird to the bottom of the ocean (other versions have Thunderbird conquering Whale).

Story 15b, from the northern Olympic Peninsula, includes a side comment that explicitly links earthquake- and tsunamilike effects to the struggle and suggests an historical context:

> My father [father of the medicine man who related this story to the writer] also told me that following the killing of this destroyer … there was a great storm and hail and flashes of lightning in the darkened, blackened sky and a great and crashing "thunder-noise" everywhere. He further stated that there were also a shaking, jumping up and trembling of the earth beneath, and a rolling up of the great waters.

Stories 5, 9, 14a and b, and 15a further tie the story of a supernatural battle to the flood. Shaking is implied by imagery: Thunderbird lifts the massive Whale into the air and drops him on the land surface. The flood description in story 15a is strikingly similar to that in story 10, which places the event a "long time ago … but not at a very remote period."

The struggle between Thunderbird and Whale is unique to the Cascadia coast and appears in stories from Vancouver Island to northern Oregon. From central Oregon south, thunder or whale figures appear individually in stories describing earthquake or tsunami themes. The central figures are variously identified as Thunder, Thunderbird, or bird and Whale, fish, or sea monster. In northern California, one tribe has an "Earthquake" figure with "Thunder" as his companion. Stories from Puget Sound and eastern Washington also use these motifs in conjunction with descriptions of earthquake effects. Story 16, describing a battle between a double-headed eagle and a water-monster, is told about the creation

## Indian Ocean Tsunamis in Legend

The struggle between the worlds above and below is not unique to Cascadia. Similar stories are found elsewhere, and the disastrous tsunami damage around the Indian Ocean brings a new understanding of the local deluge legends in this part of the world. Although we are not very familiar with the literature of this area, the stories below seem to reflect recent events.

Ancient stories from Sumatra say that the Earth rests on the horns of a monster described as a serpent with the horns of a cow (Frazer, 1918). At the beginning of time, the surface of the Earth was primeval ocean where this great serpent swam or lay. The daughter of the highest deity (who dwelt in the heavens and had birds as servants) came down from the upper realm and spread a handful of earth to form the world. The serpent, however, disliked the weight upon his head, and, turning over, caused this newly made world to be engulfed by the sea (Dixon, 1916). To aid his daughter, the deity let a mountain fall from heaven. From this mountain sprang all the rest of the habitable Earth, and the people of the Earth were born from his daughter (Frazer, 1918).

From that time forward, there has been a constant struggle between the serpent and the deity of the upper realm: the monster always trying to rid himself of his burden, and the deity always endeavoring to prevent him from so doing. This is the cause of the frequent earthquakes that shake the world in general and the island of Sumatra in particular. At last, when the monster proved obstreperous, the deity sent his son to tie the serpent. Even fettered, the monster continued to shake his head, so that earthquakes have not ceased to happen. He will go on shaking himself till he snaps his fetters. Then the earth will again sink into the sea (Frazer, 1918).

Ancient stories from Sri Lanka tell of a brilliant civilization that catastrophically sank beneath the waters. Another story tells of a *Patala* ("Sunken") *Lanka*, a Lanka far "underground" where a mighty king's powerful older brother slumbers in repose until the king descends to waken the sleeping giant and enlist his support in a mythical war being waged upon the surface of Lanka (Harrigan, 1989).

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of Agate Pass, a Puget Sound waterway far from the outer coast but adjacent to the Seattle Fault, where a magnitude 7.4 earthquake caused a Puget Sound tsunami (Moore and Mohrig, 1994) about 1,100 years ago (Bucknam *et al.*, 1992). Although none of the Thunderbird/Whale stories are datable, a few have vaguely historical timeframes.

In addition to describing earthquake effects, Thunderbird and/or Whale stories have a general association with landscape-forming events, such as glacial moraines (story 15b), icefalls (story 14 ref., p. 320), and landslides (Barbeau and Melvin, 1943), and Thunderbird also appears in stories about thunder, lightning, and rain. Thunderbird and Whale stories are part of a systematic oral tradition that used symbolism and mnemonic keys to condense and present information in a format that could be remembered and retold for generations.

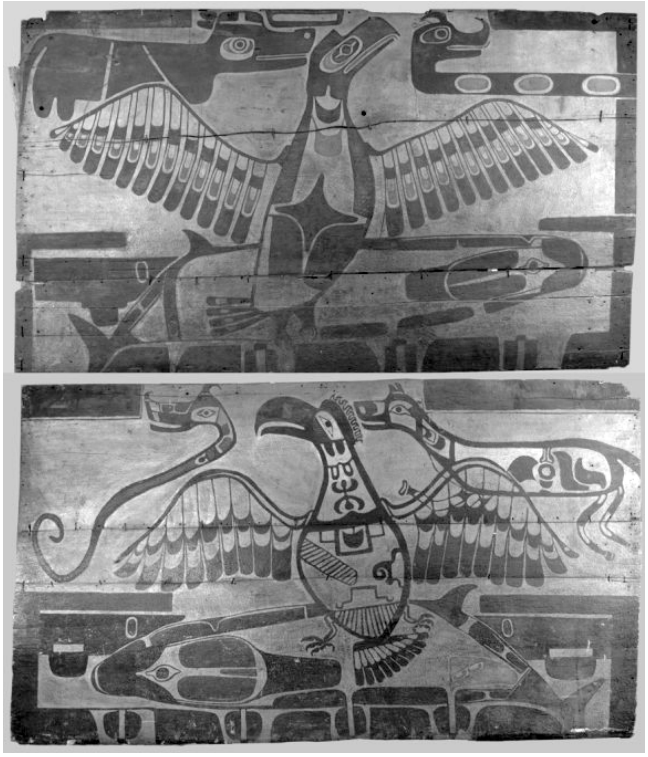
Artifacts depicting Thunderbird and Whale sites which long predate the 1700 earthquake have been recovered from coastal archaeological sites (McMillan, 2000), and native populations witnessed multiple cycles of CSZ earthquakes: Geologic evidence indicates at least seven in the last 3,500 years (Atwater and Hemphill-Haley, 1997). Knowledge of a repeating earthquake cycle may be implied in a story where Thunderbird becomes a man and sends his Thunderbird costume back to the sky, saying:

> You will not keep on thundering, only sometimes you will sound when my later generations will go [die]. You will speak once at a time when those who will change places with me will go [die]. (story ref. 1, p. 65)

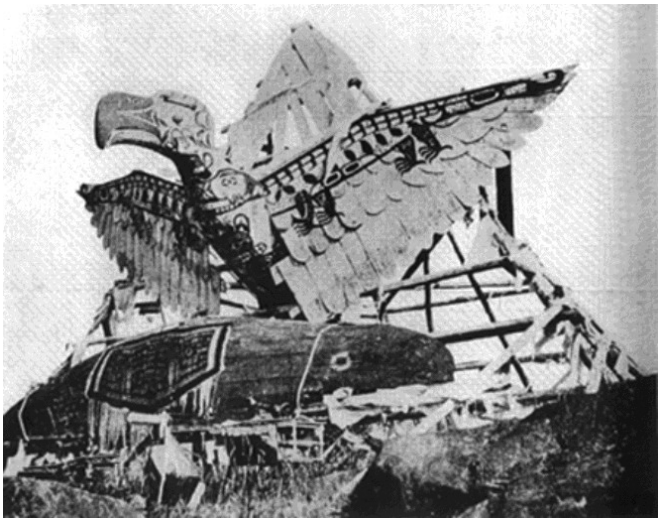
The Thunderbird/Whale motif is the central theme in carved and painted art of the outer coast and coastal fjords of Vancouver Island (Malin, 1999) (Figures 4 and 5), where broad ocean openings funnel water into narrow waterways that run far inland. Port Alberni, at the landward terminus of Barkley Sound, 40 km from the ocean, experienced tsunami runup about six times larger than did sites on the open coast following the 1964 Alaska earthquake (NOAA, 1964). Tsunami deposits from both the 1964 and 1700 earthquakes have been documented in Port Alberni and other fjordlike inlets on Vancouver Island (Clague *et al.*, 2000). Alert Bay, between the northern end of Vancouver Island and the mainland, also has prominent Thunderbird and Whale artwork (Figure 6) and story themes linking Thunderbird and flooding (story 1a), and placing flooding at the time of the winter ceremonial (story 1b).

## CONCLUSIONS

Cascadia subduction zone earthquakes are remembered in native stories, art, ceremonies, and names. Date estimates from native historical traditions place an earthquake around 1700, consistent with radiocarbon and tree-ring dating and written Japanese records. Timeless, durable, and ancient imagery describes earthquake and tsunami effects and sug-



▲ **Figure 4.** Two interior ceremonial screens from Port Alberni, dating from the late 19th century. The screens depict the thunderbird, accompanied by the lighting serpent and wolf, carrying the whale in its talons (American Museum of Natural History; Item 16.1/ 1892 AB). The screens are said to commemorate a "chief's encounter with the supernatural while checking his sockeye traps at Sproat Falls" (Kirk, 1986). Sproat Falls is just above the modeled extent of the 1700 tsunami (Clague *et al.*, 2000).



▲ **Figure 5.** Nootka Sound Memorial, erected 1902–1903 to honor a Chief Maquinna, who died in 1902. Thunderbird and Whale are shown as similar in size to the most prominent peak in the area, Conuma Peak (represented by the conical form in the background, originally covered by canvas [Drucker, 1955]). Photograph by C.H. French, Royal British Columbia Museum PN11478-A.

▲ **Figure 6.** Alert Bay: Thunderbird and Whale painted on the front of the house of Chief Tlah go glas. Photo taken by Richard Maynard, 1873. Print available from Vancouver Museum, 231.

gests awareness of repetitive cycles of world-altering events, while common symbols and imagery along the length of Cascadia suggest commonly experienced events.

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