

FINAL TECHNICAL REPORT: 2004

Studies of historic earthquakes in Washington and Oregon

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Studies of historic earthquakes in Washington and Oregon: Collaborative research with University of Washington, Washington and Oregon state emergency management agencies, and the USGS

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- Ludwin, R.S., C. P. Thrush, K. James, D. Buerge, C. Jonientz-Trisler, J. Rasmussen, K. Troost, A. De Los Angeles, 2005, [Serpent spirit-power stories along the Seattle Fault](#), Seis. Res. Lett. V. 76, No. 4

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03HQGR0039

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URL: <http://www.pnsn.org/CATDAT/historic.html>

Key words: Database, Earthquake Effects, Education-lay, Regional Seismic Hazards
January, 2003 - June. 30, 2004

Non-technical Summary

This proposal funded a study of historic records of earthquakes prior to 1928 in Washington and Oregon. The main objectives of this study were to estimate magnitudes and locations for historic earthquakes, search for aftershock sequences, and make information on early historic earthquakes in Washington and Oregon accessible via the web.

Investigations undertaken

Magnitude and location estimates: Large earthquakes are felt over wide areas and shaking generally falls off with distance from the earthquake. An event's magnitude and location can be estimated if the strength of shaking is known at a number of different places. For older earthquakes without instrumental measurement, shaking strength is described by the Modified Mercalli intensity (MMI) scale, which assigns values from 0 to 12 depending on severity of shaking. Larger historical earthquakes are generally reported felt at many communities, and the geographic distribution of intensities can be used as a reasonable estimate of the distribution of ground acceleration.

To determine the location and magnitude of older earthquakes, earthquakes with known locations and magnitudes are used to estimate how shaking weakens with distance. That "attenuation relation" can then be used in a large number of trials with various location/magnitude combinations. Using a trial location and magnitude, each observed intensity is compared to an intensity calculated from the trial location/magnitude. By testing many possibilities, the location/magnitude combination that best fits the observed data is determined.

Other aspects of this study: This study includes a systematic search for accounts of aftershocks for some of the larger earthquakes, and reformatting multiple catalogs and hundreds of newspaper articles (collected under previous funding and augmented under this study) for convenient viewing via internet.

Results

Intensity Assignment: Using a previously compiled database of newspaper clippings and records of weather observers, we estimated about 1,000 intensities and matched them to

geographic coordinates. For selected events with enough intensity values for location/magnitude estimation, we searched for additional newspaper accounts to expand the geographic range of the intensity estimates. In reviewing the information available for making intensity assignments, we found that only a few events had reports consistent with intensities over Modified Mercalli Intensity (MMI) V. Only six reports for MMI VII were found, and only 30 for MMI VI.

One major conclusion of this study is that no other earthquakes in the historic record of Washington or Oregon approached the magnitudes of the 1872 and 1949 earthquakes (these earthquakes have been extensively studied previously and were not included in this study).

Trial locations were attempted for larger events, but more work is needed to reconcile reports of intensities varying over short distances. This is likely the result of difficulty differentiating among the effects of MMI II-V reports, possibly also reflecting site conditions at reporting locales.

Aftershock Study: Greg Lange, an archivist, completed a search for foreshocks and aftershocks of the larger Puget Sound earthquakes, and located about 100 new accounts. The main new finding was that the 1909 northwestern Washington earthquake, previously considered to be a Benioff zone earthquake in the subducting slab, appears to have had a significant number of felt aftershocks. Felt aftershocks are uncommon in Benioff zone earthquakes. Appendix 1 is a summary of results for the earthquakes studied, and Appendix 2 is Greg Lange's report on his archival search. The larger earthquakes from Puget Sound were selected for special study. A search was made of issues of local newspapers beginning a week prior to each mainshock event and continuing for two weeks following the last apparent aftershock found in the newspaper reports.

Export of Data-Base to Web: A method for exporting the full data-base from MS Access97 to web-format was developed and the data base is available at http://www.pnsn.org/HIST_CAT/CASCAT2004/.

The event information is organized into individual event modules that can be collated into specialized catalogs organized by magnitude, location or other criteria.

A new account of the 1872 earthquake as experienced in Seattle: David Buerge, a local historian forwarded an eyewitness account of the effects of the 1872 earthquake (M 6.8, probably located near Entiat, WA) in Seattle. The source is *The Indian Journal of Rev. R. W. Summers, the first Episcopal priest in Seattle (1871-73)*, 1994, Guadalupe Translations, P.O. Box 97, Lafayette, Oregon, 97127.

Outreach materials based on Native American earthquake and tsunami stories: Development of outreach materials based on Native traditional knowledge was proposed as part of this study in cooperation with emergency managers in Washington and Oregon. The reviewing committee deemed it a lower priority and did not provide funding. However, because this work was very fruitful I pursued it, partially funded by the PNSN, partially by this grant, and partially at my own expense. Collaborative work with co-

authors including tribal members, anthropologists, archaeologists, tsunami scientists, emergency management officials, and historians resulted in two published papers that received considerable media attention. College science teachers working with Native American student populations also find this work of interest. Native Americans are under-represented in the Earth-Science community.

Video: A K-12 video, produced by Washington State Military Department, Emergency Management Division Earthquake Program, “Run to High Ground” won the WSSPC 2005 Award for Overall Excellence in Mitigation in the category of Outreach to Schools. The video features a Hoh Tribal elder, Viola Riebe, telling a traditional story from the Washington coast.

Journal Articles: Two journal articles on Native American and First Nations earthquake tsunami and landslide traditions from Cascadia were published in *Seismological Research Letters*, and widely covered in scientific and popular media.

Posters: Each paper was preceded by a poster developed for a scientific meeting. These posters are designed to appeal to a general audience, and copies have been distributed to emergency managers, teachers, and tribal groups. A third poster, incorporating observations of the 2004 Indian Ocean Tsunami with Pacific Northwest art and myth was presented at the June, 2005 NSF Tsunami Deposits workshop held at the UW.

PDFs of the three posters are available on-line at http://www.pnsn.org/HIST_CAT/Posters

Book Chapter: A chapter comparing oral traditions from Cascadia to printed material on folklore from Japan is in press for a volume on geomorphology being published by the Geological Society of London.

Indian Ocean Indigenous Knowledge: The value of traditional knowledge became apparent after the catastrophic Indian Ocean tsunami of 2004. Ancient tribal groups survived because of traditional orally-transmitted knowledge. A sidebar on indigenous tsunami stories from the Indian Ocean appeared in *Seis. Res. Lett.*, V. 72, No.2, and an extended abstract on the same topic was included in *TsuInfo Alert*, a newsletter for Emergency Managers.

Publications fully or partially supported by this grant

· Reports and Articles

- Ludwin, R.S., C. P. Thrush, K. James, D. Buerge, C. Jonientz-Trisler, J. Rasmussen, K. Troost, A. De Los Angeles, 2005, [Serpent spirit-power stories along the Seattle Fault](#), *Seis. Res. Lett.* V. 76, No. 4
- Ludwin, R.S., R. Dennis, D. Carver, A.D. McMillan, R. Losey, J. Clague, C. Jonientz-Trisler, J. Bovechop, J. Wray, K. James, 2005, [Dating the 1700 Cascadia Earthquake: Great Coastal Earthquakes in Native Stories](#), *Seis. Res. Lett.*, V. 76, No. 2, pp.140-148.

- Ludwin, R. S., G. J. Smits, D. Carver, K. James, C. Jonientz-Trisler, A.D. McMillan, R. Losey, R. Dennis, J. Rasmussen, A. De Los Angeles, D. Buerge, (in press), Folklore and Earthquakes: Native American oral traditions from Cascadia compared with written traditions from Japan, IN Geomythology, L. Piccardi and W.B. Masse, eds., Geological Society of London

· *Abstracts*

- Ludwin, R.S., K. James, C. Jonientz-Trisler, J. Pickens, M. Skaret, K. Troost, 2003, Water-serpent myths of Puget Sound Natives may refer to the A.D. 900 Seattle earthquake, GSA Geoscience Horizons, Seattle 2003, Abstracts with Programs, p. 80.
- Ludwin, R.S., 2005 (extended abstract), Indian Ocean Tsunamis in Legend, TsuInfo Alert, V. 7, No. 3.
- Ludwin, R.S. and A. Colorado, 2005, Tsunamis and Whirlpools; Representation in Art and Myth, NSF WORKSHOP ON TSUNAMI DEPOSITS, University of Washington, 12-15 JUNE 2005.

Appendix 1

Summary for significant earthquakes affecting Puget Sound

1863-1865 Victoria EQs

Sept 26, 1863, 1:30 PM Known only from Milne's catalog, which says "A rather severe shock was felt at Vancouver."

October 9, 1863, 2:53 AM Milne says: "three shocks were felt. The first two followed each other by a few seconds, and they were followed by another in 10 minutes. Bottles fell off shelves and some people ran out of doors. Br. Col.". One clipping from an Oregon paper was found, but the British Colonist article could not be located.

February 28, 1864, 7:30 PM Fort Langley area, known from a transcription of an article in the British Colonist in the WPPSS collection "felt on Thorne's Creek, three miles east of Fort Langley, ... It was accompanied by a hoarse thundering rumble, and lasted for about thirty seconds. ...So frightful was the commotion of its quick and awful rockings as to make it a moment of great suspense as to whether the beholder would be buried with the log shanty, which cracked, rolled and tottered around him."

September 4, 1864, 8:40 PM Victoria, duration 2 seconds. Known from newspaper articles in the British Colonist and the Oregon Statesman

September 26, 1864 12:45 AM Awakened many in Victoria The shaking was reported to cause considerable fright and crockery breakage at Port Townsend and Whidbey Island, and was strong enough to wake sleepers in Olympia. The newspaper from New Westminster, on the B.C. mainland, does not indicate that it was felt there. Multiple newspaper references from Washington and Oregon.

September 26, 1864, between 5 and 6 AM Another slight shock. Referred to in a British Colonist article about the preceding event.

Largest shock - October 29, 1864, 6:55 AM

October 29, 1864 Felt at both Victoria and New Westminster, B.C., with the shock being stronger in Victoria, where it was described as lasting 10 seconds (Holden's catalog gives the duration as 15 seconds and calls it the "severest shock on record."), toppling one chimney, cracking plastering all over, and throwing bottles and crockery to the floor in several shops. Henry Roeder, an early settler at Bellingham, wrote in his journal that he feared his house would fall off its foundation, although the time he reports is about 45 minutes later than times reported in Victoria. No report of the earthquake being felt was noted in a scan of weather reports from Neah Bay.

The New Westminster paper also reports that the large trees were broken on an island near Plumper Pass, probably referring to a location close to Discovery Island, about 5 km east of Victoria's Oak Bay

Subsequent reports in the British Colonist about a week later suggest a massive rockfall from Mount Baker. The April, 1895 weather records of James Swan at Neah Bay included an additional clipping from 1895 related to changes in appearance of Mount Baker since the previous year, and Swan says that he included sketches of the appearance of the mountain before and after.

Damage – Victoria, plaster, crockery, one chimney

June 12, 1865 No newspaper clippings for this event – known from catalogs only. Holden cites Fuchs, a European cataloger: "Several shocks at Victoria ...". Other catalogs echo Holden. Newspapers could be searched.

August 26, 1865 This earthquake appears to have been felt only in Victoria, and the accounts from the

Victoria papers are terse: "A sharp shock of an earthquake was felt in this city a few minutes after 9 o'clock last night." An account from Olympia asserts that plastering was cracked in this event. There are multiple newspaper sources for this event.

October 15, 1865 Known only from the report of Neah Bay weather Observer James Swan. Felt in Neah Bay, no report found in British Colonist.

June 1869 Mt. Rainier, Olympia, and Puget Sound earthquakes

Four earthquake shocks were felt in Olympia over the course of a week in June, 1869. A small shock on June 20 was followed by an event strong enough to wake nearly all sleepers on the 22, and another strong event that was even more widely felt occurred on the 27th. A smaller shock, reported only in Olympia, occurred a few hours later.

Foreshocks?

June 20, 1869, PM Felt in Olympia On Monday "Mr. R.H. Howe, the telegraph operator at Pumphrey's, sent word by wires that [the Cowlitz] river, which is noted for the particular clearness and placidity of its waters, was disturbed by some cause unknown to the people; the water becoming...very muddy throughout the entire day and remaining for some time.

June 22, 1869, 5AM an earthquake was felt strongly in Olympia, where it "terrified all who are in the least inclined to timidity...awaked from the soundest slumbers nearly all who had not yet arisen, and seriously alarmed those who were astir that hour". This earthquake was apparently also felt in Seattle.

Mainshock?

June 27, 1869, 8:00 PM an earthquake was felt in Olympia, Seattle, Astoria Oregon, Camp San Juan (on San Juan Island), and Victoria. No report of the event being felt at Portland was found. The shaking was described as severe in Astoria, and was

apparently strong enough to cause general alarm in both Seattle and Olympia although no damage was reported. Damage to vases and chinaware in a Victoria shop was reported. The earthquake was described as "slight" at Camp San Juan.

Two Olympia papers report very unusual disturbances in Puget Sound:

"Some fifteen minutes before the shock of earthquake was felt, an Indian woman who happened to be near to the residence of Mr. Jeal [near Olympia?] discovered and (sic) immense multitude of fish of all kinds known to these water, floating on the surface of the bay. She called to those in the house to see. Mr. Jeal, Mr. Ball and "Captain Harry" all went to the door and saw such a sight as none of them ever before beheld. As far as they could see the surface of the bay the water was literally covered with fish."

"Persons who were near the shores of the Sound last Sunday, when the earthquake struck, witnessed a singular spectacle. They state that the water near the shores swarmed with fish of all varieties, seemingly desirous of escaping from the deep to terra firma. Evidently, the waters were more agitated than their surface indicated; in no other way can this phenomenon be accounted for."

Damage – Broken chinaware in Victoria and Seattle

Aftershocks –

June 27, 1869. Around midnight another earthquake was reported felt in Olympia.

December 1880 – March 1881: Puget Basin Sequence

A series of earthquakes were felt in the Puget Basin beginning on Dec. 7, 1880. Multiple sources cite an event on Dec. 7 that was felt throughout central Puget Sound. This was followed on Dec. 12 by a larger event felt from Portland and Astoria, OR to Victoria B.C. Although multiple additional events were reported felt in the following weeks either in Olympia or by the Bainbridge Island weather observer, precise times were not given, and most reports appear only in a single source.

Foreshocks

Dec, 7, 1880, 5:55 PM Multiple newspaper sources, plus report of Bainbridge Island Weather observer . Felt in Seattle, Bainbridge Island, Tacoma, Puyallup, and Olympia, and Port Townsend. Persons were reported to have fled into the streets in Seattle, but no damage was reported.

Dec. 8, 1880 Morning A single newspaper article says an earthquake was reported felt at Hat Camp, W.T. The location of Hat Camp is not known. Two Islands (Hat Island: 48 31' 27"N, 122 32'48"W and Gedney Island 48 00' 44" N, 122 19' 02" W) have been known as Hat Island in the past.

Mainshock

Dec. 12 1880 8:47 PM – Main Shock Well documented in newspapers. Reported felt from Victoria to Portland and to Astoria, Oregon. It rang a church bell and the bell of a parked locomotive in Tacoma, damaged hop-kiln chimneys in Sumner, and a

chimney in Seattle. The event was reported *not* felt at Neah Bay by weather observer James G. Swan. The Spokane Times mentions the earthquake being felt in the Sound, but it was not reported to have been felt anywhere east of the Cascades.

Damage – Sumner, Hop kiln chimney; Seattle, one chimney

Aftershocks – Numerous aftershocks were reported, but dates and times proved difficult to pin down. The microfilm of Seattle PIs is missing these dates, so the likely best source is not available

Dec. 13, 1880 PM Reported in three newspapers, but none give a precise time, and the event was **not** reported by the weather observer on Bainbridge Island. The Oregonian of Dec. 15, in a report headlined Dec. 14th, says “Earthquakes are becoming monotonous in Olympia, there having been six shakes within a week, three of which occurred in the space of five hours last night. None were hard enough to cause any damage.” These accounts could possibly refer to the Dec. 12 event, but it seems likely that additional events occurred on Dec. 13.

Dec. 14, 1880 7 PM Reported only by the weather observer on Bainbridge Island

Dec. 19 Reported only by the Vancouver (WA) Independent

Dec. 20, 1880, 10:16 PM Reported only by the weather observer on Bainbridge Island

Dec. 29, 1880 11:25 PM Reported only by the weather observer on Bainbridge Island

Jan 5, 1881, 10:56 PM Reported only by the weather observer on Bainbridge Island

Jan 6, 1881, 4:20 AM Reported only by the weather observer on Bainbridge Island

Jan 7, 1881, 10:15 PM Reported only by the weather observer on Bainbridge Island

Jan 16, 1881, 11 PM Reported only by the weather observer on Bainbridge Island

Jan 30, 1881, 9:46 PM Reported only by the weather observer on Bainbridge Island

Feb 20, 1881, 12:15 AM Reported only by the weather observer on Bainbridge Island

Feb 24, 1881 10:45 PM Reported only by the weather observer on Bainbridge Island

March 14, 1881 10:30 PM Reported only by the weather observer on Bainbridge Island

April 30, 1882 (M 5.8) South Puget Sound

An earthquake occurred on April 30, 1882 at 10:48 PM local time (May 1, 6:48 GMT) and was widely felt in Oregon, Washington Territory, and southern Vancouver Island. It made a considerable impression on the populace although apart from a few broken chimney tops and window panes in Olympia, and crockery and glassware damage there and elsewhere, no damage was reported. An extended abstract and isoseismal map are published in 'R.S. Ludwin and A.I. Qamar, 1991, 1882 Earthquake Rediscovered, Washington Geology, V. 19, N. 2, pp. 12-13.' The intensity 5 and 6 contours for this earthquake appear very like those of the 1939 "Olympic" earthquake (1939 event was located at 47.4, 122.6 per EQ Hist. of US).

This similarity of isoseismal contours suggests that the two earthquakes were of similar location and magnitude. The 1939 earthquake has been considered subcrustal, probably at a depth of 40-70 km within the subducting Juan de Fuca plate; its magnitude has been estimated at 5.75-6.2.

No foreshocks were noted prior to this earthquake, in fact an April 28 report from the Puget Sound Weekly Courier, published in Olympia, comments on variable weather by saying "And thus we have had every change known under the heavens except an earthquake and cyclone in the short space of a few days."

Damage – Olympia, broken crockery, glassware and a few broken chimney tops

Aftershocks – Not prominent No significant aftershock sequence was reported for this earthquake, although one small shock was reported felt in Portland a few three small shocks on May 10 were reported felt in Portland, and on May 15 the Bainbridge Island weather observer reports an earthquake: "Not quite so severe as the first [apparently referring to the April 30 event]. Motion similar." No reports of the May 15 event were found in any of the newspapers searched.

1891 March 7 (M 5.0) Central Cascades

Information on this earthquake is described in "The Central Cascades Earthquake of March 7, 1891"; by T.E. Johnson, R.S. Ludwin, and A.I. Qamar, in Washington Geology, V. 20, N. 1, pp. 36 -37 (felt area isoseismal map included). This earthquake was misidentified in previous catalogs as being felt only at Smith Island lighthouse. In fact, the earthquake was felt from Ellensburg to Seattle and Tacoma. The apparent focus was east of Seattle in the central Cascades, close to Mt. Si, with a total felt area of approximately 36,000 square km, therefore a magnitude of 5.0 (following the method of Topozada, 1975) has been estimated. About a dozen accounts from newspapers both east and west of the Cascade Mountains and a diary entry from Monitor, Washington provide documentation for this interpretation.

Many catalogs contain an entry for an earthquake on March 8, 1890. Holden cites Plummer as his original source, but Townley and Allen correctly point out that the date given by Plummer was 1891 rather than 1890. We have attributed catalog entries for the March 8, 1890 earthquake to this March 7, 1891 earthquake.

Damage – None Reported

Aftershocks – Not prominent A search of newspapers found no reports of events that could be either foreshocks or aftershocks. However this earthquake originated in a sparsely populated area of the Cascades, and small events could have gone unnoticed.

1891 November 29 – 3:15 PM, North Puget Sound

This earthquake was reported felt in Snohomish, around Bellingham Bay, in Port Townsend, Tacoma, and Olympia, but not in Portland. Milne says that this event was felt only slightly in Victoria. Newspaper reports suggest that the shaking was most severe near Seattle. Reports of possible landslide-generated tsunamis - waves or swells - were reported in Lake Washington, and in Puget Sound both in Seattle and in Tacoma in newspapers and in "Tsunamis Affecting the West Coast of the United States, 1806-1992". The index for the Spokane Spokesman Review says "Great alarm felt by Coast people when quakes are felt in Sound region SR 8th D 2, 91 6:4', but we could not locate this article on the microfilm. The handwritten report from the Aberdeen weather observer describes this earthquake as "slight", while the report by weather observer Riley Hoskinson on Bainbridge Island tells of a "smart rocking".

Damage – None reported

Aftershocks – Not prominent A search of newspapers found scant indication of other associated shocks, although there was a report of an earthquake felt at North Bend and Snoqualmie Pass on November 24 and another report, apparently from a single individual in downtown Seattle, of feeling an earthquake around 9 AM on the morning of Nov. 29th.

1895 February 25 – 4:30 AM South Puget Sound

This earthquake is well represented in older catalogs, with the location usually given as Portland. However, newspaper descriptions suggest the event was most strongly felt in the Tacoma suburbs of Sumner, Puyallup and Steilacoom. The Oregonian reports the experience in Portland as follows: "At 4:47 o'clock in the morning a slight earthquake shock was felt, and those who were awakened, or are light sleepers, experienced the tremor. The vibrations were from north to south, and the first shock was quickly followed by two others, each about three seconds in duration. Although plainly perceptible, the shocks were not severe, and, aside from the rattling of loose window frames, and the swinging of picture frames and hanging lamps, there were no unusual indications of the presence of the seismic visitor" The Seattle Post-Intelligencer reports that people were awakened in Seattle, and that the earthquake failed to stop clocks in Tacoma. Various reports say that the earthquake was felt at Seattle, Tacoma, Sumner, Puyallup, Steilacoom, Chehalis, Centralia, Olympia, Portland, Edison (probably referring to a neighborhood of Tacoma), Oregon City and as far east as Centerville in Klickitat County. Two shocks, fifteen minutes apart, were reported at Fulton, a place name no longer used but apparently located in the western part of Lewis County. A report in the daily Astorian (cataloged separately) suggests the event may have been felt there.

Earthquake History of the U.S. (1973) gives a location estimate in the vicinity of Morton, WA, and reports this quake as being strongest at Green River Mines and the Toutle River, but the only support for this is a suggestion of F.G. Plummer, a local scientist who was operating a home-made seismometer that only faintly registered

this quake

Damage – None reported

Aftershocks – Not prominent. Although several other shocks were reported shortly before or after the quake, their felt locales were varied, widely separated, and distinct from the main shock. They do not appear to be fore- or after-shocks.

A quake was reported felt on Feb. 14th at Silver Creek in Lewis county.

At Fulton, in western Lewis County, a second shock followed 15 minutes after the main shock on Feb. 25th

The Pacific County Historical Society and Museum web site says: "February 26, 1895 earthquake hits Astoria (Daily Morning Astorian, p 4)". This may refer to an account of the Feb. 25 quake that appeared in the Astoria newspaper on the following day.

Three shocks were reported felt in Yakima the following morning, Tuesday Feb. 26th. The Feb. 25 quake was not reported felt in Yakima

1903 March 13 – 6:30 PM (M 4.9) South Puget Sound

The preferred location and magnitude of this event are from the dissertation of G.C. Rogers.

The Seattle Post Intelligencer reports this earthquake felt in Seattle, Tacoma, Olympia, and Aberdeen. In Tacoma "Houses were rocked and crockery rattled and in some cases plaster fell off the walls." In Aberdeen: "Some persons reported that clocks were stopped and dishes on the table rattled.". The Oregonian reports that in Aberdeen "houses were shaken and the inmates ran out badly frightened", and in Olympia " Buildings were shaken so that occupants ran into the streets in alarm." The earthquake was reported *not* felt in Portland, Port Townsend, Whatcom County, and Everett.

Damage –Tacoma -falling plaster

Foreshock March 13 3:30 PM A possible foreshock was reported felt only in Seattle

Aftershock - March 17 evening One possible aftershock was reported in the Tacoma Semi-Weekly News of March 17, 1903: "Tacoma was shaken by an earthquake last evening, but nothing took a tumble. The timid fold may be reassured. These faint vibrations of terra firma are harmless." This could be a late report.

1903 September 11 3:44 PM felt from Seattle to Astoria, OR

This event was well felt from Seattle to Portland and Astoria, especially on higher floors. Although there are several newspaper articles on this event, it has only been cataloged by Woodward-Clyde. Though no significant damage was reported, this event is likely magnitude 5 or slightly larger.

The Seattle Post-Intelligencer states: "An earthquake was distinctly felt in Seattle ... most perceptible in the upper stories of some of the higher buildings. Several observers on the sixth floor of the Lumber Exchange were alarmed at the vibrations in that structure... One man ... counted five very distinct vibrations and estimated that they followed each other at from one to two seconds apart. The time at which the shock first appeared was sixteen minutes before 4 o'clock, the waving undulations lasting fully ten seconds." The report from Tacoma mentions "windows and crockery jarred and tipped about."

The Portland Oregonian reports the earthquake felt in Everett, Seattle, Tacoma, Olympia, Chehalis, and Astoria, and says of Portland: "Just at 19 minutes before 4 o'clock, a tremor shook the earth. People in the high office buildings and those lying or sitting still felt it distinctly. Those walking on the street did not notice the shock... A gentle little tremor in some parts of the city, but it was strong enough to move the pictures on the wall in others. In the Meier residence at Twelfth and Clay streets, the framed pictures were seen to swing upon the walls and the building, substantial as it is, rattled all over. Here the shock lasted fully half a minute"

The earthquake was also reported felt in Astoria, Oregon and at South Bend, Menlo, and LaCenter Washington. Several sources report a time of 4:20 for strong shaking in South Bend, but this is almost certainly the same event. The date of the main shock suggested by the report in the Tacoma Semi-weekly News is unclear.

Damage – None reported

Foreshock possible -- One earlier shock, on the morning of Sept. 5, was reported felt at Castle Rock in the Seattle PI and Tacoma Daily news.

Aftershocks – None reported There appear to be no aftershocks..

1909 Jan. 11, 3:50 PM mainshock (M 6.0) felt from Port Angeles and Chilliwack to Aberdeen and Tacoma, and aftershock sequence Jan. 11-Feb. 4, San Juan Islands

January 11, 1909, 3:50 PM Times stated variously as 3:30 to 4:30 PM. Numerous newspaper sources state that it was widely felt from Port Angeles, Victoria, Vancouver and Chilliwack in the north to Tacoma and Aberdeen in the south. There were no reports of felt shaking from Olympia or Portland, and presumably the earthquake was not felt there.

Some damage occurred. The San Juan Islander, reporting from Friday Harbor, says” “Here buildings rocked enough to crack some chimneys, stop clocks, and cause some breakage of window glass, crockery, etc. In the valley, the large chimneys on P.E. Peterson's house were shaken down as were also one of the chimneys of Chas. Peterson's house at Argyle and one on Mrs. Schmidt's house of Kanaka Bay. Most of the monuments in the cemetery were moved. Here in town Dr. Wright is the only one who suffered damage worth mentioning. In his drug store a large number of bottles and medicines were thrown from the shelves and broken, and one chimney on the drug store building and one on his residence were cracked and moved horizontally so as to necessitate rebuilding them from the roofs up.

Navigators and others out on the water, whether in large or small craft report that when the first shock occurred their first thought was that their boats had struck submerged logs or unknown reefs. The captain of the Rosalie ordered the engines reversed thinking that the vessel had struck a big log or rock.”

Although it has previously been suggested (Garry Rogers, 1983) that this earthquake occurred at depth, based on a lack of reported aftershocks, It appears that at least seven aftershocks were felt in the San Juan Islands. Garry Rogers (1983) calculates the magnitude of this event to be around magnitude 6.0 and states:

" Felt reports from newspapers limit this epicentre to the San Juan Islands region where several instances of damage occurred” Felt information also clearly shows that the size of the isoseismal map is between that for the 1965 Seattle earthquake and the 1976 Gulf Islands earthquake (Figure 7). The magnitude is about 6 according to Topozada's (1975) felt area relationship."

Damage – Friday Harbor – Chimneys cracked, window glass & crockery broken, Cemetery monuments moved

Aftershocks –More than a half-dozen reported All reported aftershocks were in the San Juan Islands, particularly noted at Lopez. Blasting at several locales was also mentioned. (Waldron Island – San Juan Islander, Feb. 5, 1909, Fri., p. 8, c. 5; Bellingham – Friday Harbor Journal Feb. 11, 1909, Thurs., p. 8, c. 4, 5), though it seems unlikely to have been the cause of all the reports.

January 11, 1909, 4:50 PM Times stated variously as 4:20-4:50 PM. Felt at East Sound on Orcas Island and slightly at Lopez Island. The second tremor was reported as coming 20 minutes after first shock at East Sound (San Juan Islander January 16, 1909 p 8 col. 2) or 40 minutes later at Lopez (Friday Harbor Journal, Jan 14, 1909 p 8 col. 4)

January 11, 1909, 10 PM No mention of precise felt locales, mentioned in only one newspaper account

January 11-12, 1909, (evening), (East Sound) “During the night there was a

succession of light shocks ...” (San Juan Islander January 16, 1909 p 8 col. 1)

January 12, 1909, 12 AM No mention of precise felt locales, mentioned in only one newspaper account

January 14, 1909, PM Reported felt at Lopez . The same report says “Several [tremors] have been reported since Monday.”

January 16, 1909, 7:25 PM Reported in East Sound

January 29, 1909, 3:30 AM Reported at West Sound and Lopez (2 reports)

February 4, 1909, 1:40 AM Reported at Lopez

1913 July 19 8:15 AM Mt. Rainier

Newspaper accounts agree with the BSSA description:

"A slight earthquake on Mt. Rainier, Washington. - About 8:15 o'clock on the morning of July 29, 1913, two earthquake shocks shook Mount Rainier and were felt over an area of more than a hundred square miles. The shocks appeared to be the strongest at Lewis in Lewis County, and were noted at Elbe and Etonville, in Pierce County.

The disturbance is said to have lasted about half a minute. Ethan Allen, superintendent of the National Park, Washington, says the shocks came close together and were so violent that there could be no doubt about their being of a seismic nature. From reports received the shock had an intensity of between V and VI of the Rossi-Forel scale."

Some catalogers report that this earthquake was recorded on the seismometer at Seattle. but several newspapers say that it was not.

Damage – None Reported

Aftershocks – None Reported

1916 Nov. 21 11:30 AM, North Puget Sound

This earthquake was felt in Skagit, Whatcom and Snohomish Counties, most strongly in Mt. Vernon and Concrete. There are no reports of it being felt in Seattle or in British Columbia. Catalogs reporting this event use Silverton as a location because a weather observer there reported it, but the newspaper reports suggest that it was more strongly felt to the north. Neither damage nor aftershocks were reported. In Mount Vernon, a newspaper (the name of the paper is not known) says: "(the) water superintendent was examining the ... pumping station, 16 feet below the

surface of the ground when he felt a movement of the earth and swaying of the cellar floor, entirely uncommon to any former experience while down beneath the ground. Realizing it was a quake, he hurriedly ascended the steps. 'I never made better time climbing those steps', said the water superintendent. 'I did not wait to change gears, but went right up to the top on high.' 'It was nature's protest against the democratic administration,' said N. B. Hannay, as he hastened out of the bank to see if the quake had started his auto."

Damage – None Reported

Aftershocks – None Reported

1920 Jan. 21 11:10 PM, North Puget Sound

Felt in Chilliwack, Vancouver, Victoria, Bellingham, Anacortes, Blaine, Port Angeles, Friday Harbor, Everett, and Seattle. This earthquake broke windows and cracked walls. It is well-documented and well-cataloged. A lengthy note to the BSSA from F. Napier Denison, the seismologist at Victoria, lists damages in Bellingham and Anacortes and summarizes the effects (he reports no damage) on Vancouver Island. Intensity V (RF) reports were received from weather observers in Forks, Clallam Bay and Anacortes. The location, felt area, and magnitude given here were taken from the dissertation of Garry Rogers. The data base includes a half- dozen reports from weather observers, and quite a few newspaper articles.

The Anacortes American reports that two additional quakes (Jan 21 at 9 PM and Jan 22 at 2 AM) were recorded on the seismograph at Victoria, but not felt.

Damage – Bellingham, brick walls cracked.

Anacortes, brick walls cracked, window(s?) broken.

Victoria – Fallen plaster, broken china.

Vancouver – A few bricks fell from the tops of chimneys.

Port Ludlow – water conduit to mill shaken down.

Foreshock – Jan 21 9 PM – Not reported felt in sources examined– recorded at Victoria

Aftershocks – Jan 22 2 AM – Not reported felt in sources examined – recorded at Victoria

1926 Dec. 4 5:55 AM, North Puget Sound

This earthquake was felt from Seattle to Victoria, apparently most strongly at Anacortes, where some slight damage was reported. Townley and Allen say: "Strait of Juan de Fuca. Widely felt. Pictures fell and dishes broke at Anacortes, Skagit Co.; at Friday Harbor, San Juan Co., an explosive shock nearly threw people from their feet; at Bellingham, Flower pots were toppled over; at Port Angeles, suspended

objects rattled in regular beats, and the ground swayed and trembled twenty-five or thirty seconds. At Clallam, Ediz Hook, and Marietta, lighter intensities were reported. Intensity reports of IV came from Port Townsend, Everett, and Mount Vernon. SRC&GS". Magnitude and location from the dissertation of Dr. Garry Rogers. One possible aftershock was reported felt at Anacortes at 7:05 AM

Damage – West Sound Items shaken from tables & shelves

Anacortes: Chimneys cracked, pictures knocked down, dishes broken, windows reported broken (unconfirmed), furniture moved.

Aftershocks – One additional shock at 7:05 AM was reported in Anacortes by one newspaper.

Appendix 2

Report of Consultant Greg Lange

September 26, 1864 EVENTS

September 26, 1864 12:45 to 1:00 AM numerous sources

September 26, 1964 (Victoria) “between 5 and 6” AM (British Colonist September 27, 1964 p 3 col. 1)

October 29, 1864 (Victoria) about 6:55 AM (British Colonist October 31, 1864 p 3 col. 1 and November 3, 1864 p 3 col. 1 and November 7, 1864 p 3 col. 2)

Newspapers examined -

Puget Sound Herald (Steilacoom) - September 9, 1864 to October 24, 1864 (Issued every two weeks - complete) Note: No local news in November 7, 1864 issue

Pacific Tribune (Olympia) - September 10, 1864 to November 19, 1864 (Weekly - Missing October 29 else complete)

Washington Standard (Olympia) - September 10, 1864 to November 12, 1864 (Weekly - complete)

Statesman (Walla Walla) - September 23, 1864 to October 28, 1864 (Weekly - over half of text too light to read else complete)

Oregonian (Portland) - September 26, 1864 to October 10, 1864 (6 days a week - Oct. 1, 1864 missing else complete)

The Daily British Colonist (Victoria) - September 1, 1864 to November 11, 1864 (6 days a week - Missing November 10 else complete)

The British Columbian (New Westminster) - September 3, 1864 to November 23, 1864 (2 times per week - complete)

Statesman (Walla Walla) September 23 to October 28, 1864 (Weekly - most of text too light to read else complete)

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Seattle Gazette - September, October, November 1864 issues are too dark to read on microfilm reel.

June 20-27, 1869 EVENTS

June 20, 1869 (Olympia) “about” 4 PM (Olympia Transcript June 26, 1869 p 3 col. 1)
Other sources state in afternoon or during day.

June 21, 1869 [sic June 22] (Olympia) “a few minutes before” 5 AM (Olympia Transcript June 26, 1869 p 3 col. 1)

June 22, 1869 (Olympia) 4:30 to 5:00 AM. (Weekly Pacific Tribune June 26, 1869 p 3 col. 2) (Territorial Republican June 28, 1869 p 3 col. 1) (Morning Oregonian June 23,

1869 p 2 col 3) (Olympia Transcript June 26, 1869 p 3 col. 1)
June 23, 1869 [sic June 22] (Olympia) “about 5” AM. (Washington Standard June 26, 1869 p 2 col. 1)
June 27, 1869 8:00 to 8:05 PM numerous sources.
June 28, 1869 (Olympia) midnight (Oregonian June 29, 1869 p 2 col. 4)

Newspapers examined -

Daily British Colonist (Victoria) June 19, 1869 to July 6, 1869 (6 days a week - complete)
Daily British Columbian (Victoria) June 19, 1869 to July 3, 1869 (6 days a week - complete)
Washington Standard (Olympia) June 12, 1869 to July 31, 1869 (Weekly - complete)
Weekly Intelligencer (Seattle) June 21, 1869 to August 2, 1869 (Weekly - complete)
Morning Oregonian (Portland) June 21, 1869 to June 24, 1869 and June 28, 1869 to June 30, 1869 (6 days a week - complete)
Weekly Pacific Tribune (Olympia) June 26, 1869 to August 7, 1869 (Weekly - complete)
Port Townsend Weekly Message July 7, 1869 (Weekly - only issue, June issue missing)
Olympia Transcript June 26, 1869 and July 3, 1869 (Weekly)
Western Star (Steilacoom) July 17, 31, 1869 (only two issues)
Territorial Republican (Olympia) June 21, 1869 to July 12, 1869 (Weekly - complete)

December 7-19, 1880 EVENTS

December 7, 1880 5:55 to about 6:00 PM numerous sources
December 7 to 13, 1880 (Olympia) “six shakes within a week, three of which occurred [sic] in the space of five hours last night” (Morning Oregonian December 15, 1880 p 1 col. 5)
December 12, 1880 (Portland) about 8:00 PM “a few minutes before 8 o’clock several lively vibrations were felt ... and about an hour later quite a heavy shock was felt...” (Democratic Press December 16, 1880 p 2 col. 2)
December 12, 1880 8:00 PM, 8:30 to 8:47 PM, 9:00 PM numerous sources
December 13, 1880 (Olympia) evening “three [shakes] ... occurred [sic] in the space of five hours last night” (Morning Oregonian December 15, 1880 p 1 col. 5)
December 13, 1880 (New Tacoma) Evening (Weekly Ledger December 17, 1880)
December 19, 1880 (Vancouver, W.T.) Evening (Vancouver Independent December 23, 1880 p. 5 col. 2)

Newspapers examined -

Puget Sound Weekly Courier (Olympia) November 26, 1880 to January 7, 1881 (weekly)

- complete)

Democratic Press (Port Townsend) November 25, 1880 to December 30, 1880 (weekly - complete) Note: January 6, 1881 issue of Democratic Press missing

Puget Sound Argus (Port Townsend) November 26, 1880 to January 7, 1881 (weekly - complete)

Weekly Tacoma Ledger November 25, 1880 to February 18, 1881 (weekly - February 11, 1881 missing else complete)

Vancouver Independent (W.T.) December 2, 1880 to December 30, 1880 (weekly - complete)

Yakima Record December 4, 1880 to January 8, 1881 (weekly - January 1, 1881 missing else complete)

Oregonian (Portland) December 7, 1880 to January 4, 1881 (6 times per week - complete)

Washington Standard (Olympia) December 4 [sic 3], 1880 to January 28, 1881 (weekly - complete)

Seattle Weekly Post December 3, 1880 to January 28, 1881 (weekly - missing December 10, 24, 1880 and January 7, 1881 else complete)

Walla Walla Union December 11, 1880 to January 1, 1881 (weekly - complete)

New Northwest (Portland) December 9, 1880 to December 23, 1880 (weekly - complete)

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Statesman (Walla Walla) UW reel missing

Willamette Farmer December 1880 (issues missing/not published)

Olympia Transcript (issues missing/not published)

Seattle Daily Intelligencer (December 4, 1880 to June 8, 1881 issues missing/not published)

Weekly Intelligencer (Seattle) (issues missing/not published)

Puget Sound Dispatch (Seattle) (issues missing/not published)

Tacoma Herald (issues missing/not published)

Fair Words (Olympia) (issues missing/not published)

April 30, 1882 EVENT and week following

April 30, 1882 10:40 PM to 11:05 PM numerous accounts

May 1-6, 1882 (Olympia) "Two or three slight shocks have also been felt during the week." (Olympia Transcript May 6, 1882 p. 3 col. 1)

May 10, 1882 "Portland had three distinct shocks of an earthquake last Wednesday." (Seattle Daily Chronicle May 15, 1882 p. 3 col. 2) NOTE: Check Portland papers to verify

Newspapers examined -

Olympia Transcript - April 22, 1882 to June 3, 1882 (Weekly - complete)

Washington Standard (Olympia) - April 21, 1882 to June 2, 1882 (Weekly - complete)

Seattle Daily Chronicle - April 21, 1882 to May 22, 1882 (6 days a week - complete)
Weekly Ledger (Tacoma) - April 21, 1882; April 28, 1882; June 2, 1882 (Wkly - only available issues)
Puget Sound Weekly Courier (Olympia) - April 21, 1882 to June 2, 1882 (Weekly - complete)
Seattle Post Intelligencer - April 20, 1882 to May 20, 1882 (6 times per week - complete)
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Seattle Daily Herald (issues missing/not published)
Weekly Herald (Tacoma) (issues missing/not published)

March 7, 1891 EVENT

March 7, 1891 7:35 to 7:54 PM numerous sources

Newspapers examined -

Seattle Telegraph February 26, 1891 to April 9, 1891 (weekly - complete)
Tacoma Weekly News March 6, 1891 to March 20, 1891 (weekly - March 6, 1891 missing)
Tacoma Daily News March 9, 1891 to March 19, 1891 (6 times per week - complete)
Tacoma Morning Globe March 8, 1891 to March 13, 1891 (daily? - complete)
Tacoma Daily Ledger March 8, 1891 to March 11, 1891 (daily - complete)
Seattle Post-Intelligencer March 8, 1891 to March 17, 1891 (daily - complete)
Ellensburg Capital March 5, 1891 to April 2, 1891 (weekly - complete)
Ellensburg Localizer March 7, 1891 to March 28, 1891 (weekly - complete)
Snohomish Daily Sun March 2, 1891 to March 18, 1891 (6 times per week - complete)
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Steilacoom News UW microfilm reel missing
Buckley Banner (issues missing/not published)
Tacoma Evening Call (issues missing/not published)
Tacoma Herald (issues missing/not published)

November 24 to 29, 1891 EVENTS

November 24, 1891 (North Bend, Snoqualmie Pass) night (Seattle Telegraph November 28, 1891 p 3 col. 1)
November 29, 1891 (Seattle) "about 9" AM (Seattle Post Intelligencer November 30, 1891 p 8) NOTE: Only one witness
November 29, 1891 3:13 to 3:20, 3:35 PM numerous sources

Newspapers examined -

Sunday Herald (Tacoma) November 22, 1891 to December 6, 1891 (weekly - complete)
Tacoma Daily Ledger November 20, 1891 to November 30, 1891 (daily - complete) Note
December 1891 issues missing/not published

Tacoma Daily News November 20, 1891 to December 3, 1891 (6 times per week &
Thanksgiving on November 26, 1891 not published - complete)

Tacoma Morning Globe November 20, 1891 to December 4, 1891 (daily - complete)

Tacoma Evening Call November 20, 1891 to December 2, 1891 (6 times per week &
Thanksgiving on November 26, 1891 not published - complete)

Seattle Telegraph November 20, 1891 to December 9, 1891 (6 times per week - complete
Note: portions of December 5 too dark to read)

Ellensburg Capital November 19, 1891 to December 10, 1891 (weekly - complete)

Everett News December 11, 1891 to December 25, 1891 (weekly - complete) Note
December 4, 1891 missing

Anacortes American November 19, 1891 to December 17, 1891 (weekly - complete)

Anacortes American December 5, 7, 11, 1891 (daily - only issues)

Seattle Press Times November 21, 1891 to December 12, 1891 (6 times per week -
complete)

Seattle Post-Intelligencer December 20, 1891 to December 8, 1891 (daily - complete)

Anacortes Progress December 11, 1891 (weekly - only issue) Note December 4 & 18,
1891 missing/not published

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Snohomish Daily Sun (issues missing/not published)

Snohomish Weekly Sun (issues missing/not published)

Port Townsend Leader (issues missing/not published)

Island County Times (issues missing/not published)

Ellensburg Localizer All issues missing/not published during November and December

February 25, 1895 EVENTS

February 14, 1895 (no time) (Silver Creek, Lewis County) (see below)

February 25, 1895 4:30 to 4:50 AM numerous sources

February 25, 1895 (Fulton, east Lewis County) 4:45 AM (initial shock at 4:30 AM
“followed by a slight shock fifteen minutes later” (Chehalis Bee March 1, 1895 p 2 col.
3)

ADDITIONAL ENTRIES

Feb 14, 1895 “Silver Creek, Lewis Co.: Slight earthquake shock on the 14th.”

(Washington State Weather Service. Monthly Meteorological Report and Summary of
the Washington State Weather Service Volume 4 #8 February 1895 p. 1)

Feb 25, 1895 “An earthquake shock was quite generally noticed in Western and Central

Washington on the morning of the 25th about 4:30 o'clock." "Ashford, Pierce co: Quite a severe earthquake occurred here on the twenty fifth at 4:27 A.M." "Centerville, Klickitat Co: Feb. 25th, at half past four A.M., two earthquake shocks were felt very distinctly, one following immediately after the other. The first was stronger than the second." (Washington State Weather Service. Monthly Meteorological Report and Summary of the Washington State Weather Service Volume 4 #8 February 1895 p. 1)

Newspapers examined -

Washington Standard (Olympia) February 22, 1895 to March 8, 1895 (weekly - complete)
Chehalis Nuggett February 22, 1895 to March 8, 1895 (weekly - complete)
Chehalis Bee March 1, 1895 to March 22, 1895 (weekly - complete)
People's Advocate (Chehalis) February 22, 1895 to March 8, 1895 (weekly - complete)
Oregonian (Portland) February 18, 1895 to March 1, 1895 (daily - complete)
Seattle Post-Intelligencer February 26, 1895 to February 28, 1895 (daily - complete)
Sumner Herald (Pierce County) February 22, 1895 to March 22, 1895 (weekly - missing March 8, 22, 1895 else complete)
White River Journal (Kent) February 23, 1895 to March 9, 1895 (weekly - complete)
Aberdeen Herald February 21, 1895 to March 7, 1895 (weekly - complete)
Tacoma Herald February 16, 1895 to March 9, 1895 (weekly - complete)
Seattle Press Times February 25, 1895 to February 27, 1895 (daily - February 26, 1895 missing/not published else complete)
Palladium (Olympia) February 20, 1895 to March 20, 1895 (weekly - complete)
Snohomish County Tribune (Snohomish) March 1, 1895 to March 29, 1895 (weekly - complete)
*
Washingtonian (Hoquiam) UW microfilm reel missing

March 13 to 16, 1903 EVENTS

March 13, 1903 6:21-6:40 PM numerous sources

March 16, 1903 (Tacoma) evening (Tacoma Semi Weekly News March 17, 1903 p 4 col 2) NOTE: Need to confirm by looking at other Tacoma newspapers.

ADDITIONAL ENTRY

Mar 13, 1903 Earthquake Shocks - Centralia, Grand Mound, Olympia, Seattle (Weather Bureau, US Department of Agriculture. Washington Section of the Climate and Crop Service of the Weather Bureau (Seattle, Weather Bureau) volume 6 #10 March 1903)

Newspapers examined -

Snohomish County Tribune (Snohomish) March 6, 1903 to March 27, 1903 (weekly - complete)

Washington Standard (Olympia) March 13, 1903 to April 17, 1903 (weekly - complete)
Seattle Post-Intelligencer March 14, 1903 to March 17, 1903 (daily - complete)
Port Orchard Independent March 7, 1903 to March 21, 1903 (weekly - complete)
White River Journal (Kent) March 7, 1903 to March 21, 1903 (weekly - complete)
Kitsap County Herald (Poulsbo) March 13, 1903 to March 20, 1903 (weekly - complete)
Tacoma Semi Weekly News March 13, 1903 to March 24, 1903 (2 times per week - complete)
Willapa Harbor Pilot (South Bend) March 20, 1903 to March 27, 1903 (weekly - complete)

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Everett Herald UW microfilm copy very dark, unable to read
Index Miner (issues missing/not published)
Issaquah Independent (issues missing/not published)
Daily News Searchlight (Bremerton) (issues missing/not published)
Chehalis Bee Nugget (issues missing/not published)
Peoples Advocate (Chehalis) (issues missing/not published)
Olympia Chronicle (issues missing/not published)
Weekly Capital (Olympia) (issues missing/not published)
Spectator (Tacoma) (issues missing/not published)
Tacoma Times (issues missing/not published)
Union Record (Tacoma) (issues missing/not published)
Tacoma Daily News (issues missing/not published)

September 5 to 11, 1903 EVENTS

September 5, 1903 (Castle Rock) "morning" (Tacoma Daily News September 12, 1903 p 2 col. 4) (Seattle Post-Intelligencer p. 1 col. 4)
September 11, 1903 3:30 to 3:50, 4:20 PM numerous sources

ADDITIONAL ENTRY

Sept 11, 1903 Earthquake Shocks - La Center at 3:50 p.m., South Bend at 3:30 pm (Weather Bureau, US Department of Agriculture. Washington Section of the Climate and Crop Service of the Weather Bureau (Seattle, Weather Bureau) volume 7 #4 September 1903)

Newspapers examined -

Skamania County Pioneer (Stevenson) September 3, 1903 to September 24, 1903 (weekly - complete)
Oregonian (Portland) September 12, 1903 to September 14, 1903 (daily - complete)
Willapa Harbor Pilot (South Bend) September 11, 1903 to September 25, 1903 (weekly -

complete)
Kitsap County Herald (Poulsbo) September 11, 1903 to September 25, 1893 (weekly - complete)
Seattle Times September 12, 1903 only
Kitsap County Review (Bremerton) November 14 & 21, 1903 (weekly)
White River Journal (Kent) September 5, 1903 to September 19, 1903 (weekly - complete)
Tacoma Semi Weekly News September 8, 1903 to September 18, 1903 (twice a week - complete)
Port Orchard Independent September 12, 1903 to September 19, 1903 (weekly)
Tacoma Daily News September 11, 1903 to September 14, 1903 (6 times per week - complete)
Washington Standard (Olympia) September 11, 1903 to September 18, 1903 (weekly)
Seattle Post-Intelligencer September 12, 1903 to September 15, 1903 (daily - complete)
Buckley Banner September 11, 1903 to September 25, 1903 (weekly - Sept 18 missing else complete)
Aberdeen Herald September 14, 1903 to September 21, 1903 (2 times per week - complete)

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Weekly Chronicle (Olympia) (issues missing/not published)
Weekly Capital (Olympia) (issues missing/not published)
Tacoma Times (issues missing/not published)
Sumner Index (issues missing/not published)
Sumner Herald (issues missing/not published)
Olympia Chronicle (issues missing/not published)
Issaquah Independent (issues missing/not published)
Chehalis Bee Nugget (issues missing/not published)
Daily Spectator (Tacoma) (issues missing/not published)
People's Advocate (Chehalis) (issues missing/not published)

January 11 to February 8, 1909 EVENTS

January 11, 1909 3:30 to 4:30 PM Numerous sources

January 11, 1909 (Lopez) First tremor 4:30 PM Second tremor 20 minutes later (4:50 PM) (Friday Harbor Journal Jan 14, 1909 p 8 col. 4)

January 11, 1909 (Olga) First tremor 3:40 PM. Second tremor 40 minutes later (4:30 PM) (San Juan Islander January 16, 1909 p 8 col. 2)

January 11, 1909 (Friday Harbor) 10 PM (San Juan Islander January 16, 1909 p 1 col. 6)

January 11-12, 1909 (evening) (East Sound) "During the night there was a succession of light shocks ..." (San Juan Islander January 16, 1909 p 8 col. 1)

January 12, 1909 (Friday Harbor) 12 midnight (San Juan Islander January 16, 1909 p 1 col. 6)

January 14, 1909 (Lopez) night "distant tremor ... felt Thursday night" (Jan 14) "Several

[tremors] have been reported since Monday.” (Friday Harbor Journal Jan 21, 1909 p 8 col. 6)

January 16, 1909 (East Sound) 7:25 PM (Friday Harbor Journal Jan 21, 1909 p 8 col. 4)

January 29, 1909 (West Sound) 3 AM (Friday Harbor Journal Feb 4, 1909 p 8 col. 3)

(Lopez) 3:30 AM (Friday Harbor Journal February 4, 1909 p 8 col. 5)

February 4, 1909 (Lopez) 1:40 AM (Friday Harbor Journal February 11, 1909 p 8 col. 5)

February 8, 1909 (West Sound) Monday (Feb 8) night (Friday Harbor Journal February 11, 1909 p 8 col. 4)

ADDITIONAL ENTRIES

Jan 11, 1909 Earthquakes - Anacortes, Baker, Bellingham, Blaine, Coupeville, East Sound, Granite Falls, Olga, Olympia, Port Townsend, Vashon Island (Weather Bureau, US Department of Agriculture. Washington Section of the Climatological Service of the Weather Bureau (Portland Oregon, Weather Bureau) volume 13 #1 January 1909)

Jan 21, 1909 Earthquakes - Lakeside, Rex Creek [Chelan County] (Weather Bureau, US Department of Agriculture. Washington Section of the Climatological Service of the Weather Bureau (Portland Oregon, Weather Bureau) volume 13 #1 January 1909)

Newspapers examined -

San Juan Islander (Friday Harbor) January 7, 1909 to February 12, 1909 (weekly - Jan 30, 1909 missing else complete)

Friday Harbor Journal January 7, 1909 to March 4, 1909 (weekly - complete)

Anacortes American January 7, 1909 to February 11, 1909 (weekly - complete)

American Reville (Bellingham) January 10, 1909 to January 30, 1909 (6 times per week - complete)

Everett Herald January 11, 1909 to January 18, 1909 (6 times per week - complete)

Arlington Times January 16, 1909 to February 13, 1909 (weekly - complete)

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Island County Times (Coupeville) (issues missing/not published)

Blaine Journal (January 1909 issues missing/not published)

July 29, 1913 EVENT

July 29, 1913 (Mt Rainier) 8:15 AM (Tacoma Daily News July 29, 1913 p 1 col 1; July 30, 1913 p 2 col 4) (Tacoma Tribune July 30, 1913 p 1 col. 1) (Buckley Banner Aug 1, 1913 p 3 col 2)

Newspapers examined -

Puyallup Herald August 1, 1913 to August 15, 1913 (Weekly - complete)

Buckley Banner July 25, 1913 to August 15, 1913 (Weekly - complete)

Sumner Index July 25, 1913 to August 8, 1913 (Weekly - complete)

Washington Standard (Olympia) August 1 & 8, 1913 (Weekly)

Tacoma Daily News July 29, 30, 1913 (Daily)

Tacoma Tribune July 29, 1913 & July 30, 1913 (page 1 only)

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Lewis County Clarion (Centralia) (July-August 1913 issues missing/not published)

Tacoma Times (July-August 1913 issues missing/not published)

Tacoma Daily Ledger (July-August 1913 issues missing/not published)

Olympia Chronicle (July-August 1913 issues missing/not published)

Washington Saturday Review (July-August 1913 issues missing/not published)

Morton Mirror (issues missing/not published)

November 21, 1916 EVENT

November 21, 1916 (Everett, Anacortes) 11:30 AM numerous sources

Newspapers examined -

Arlington Times November 16, 1916 to November 30, 1916 (weekly - November 16, 1916 missing)

Concrete Herald November 18, 1916 to December 6, 1916 (weekly - complete)

Everett Herald November 21, 22, 1916 (daily)

Oak Harbor News November 24, 1916 to December 1, 1916 (weekly)

Anacortes American November 16, 1916 to December 7, 1916 (weekly - complete)

Friday Harbor Journal November 23, 30, 1916 (weekly)

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Skagit News (Mount Vernon) (issues missing/not published)

Mount Vernon Herald (issues missing/not published)

Mount Vernon Argus (issues missing/not published)

Skagit County Times (issues missing/not published)

Guemes Beachcomber (issues missing/not published)

January 23 to 24, 1920 EVENTS

January 23, 1920 (Victoria, BC) 9:00 PM Recorded on Victoria seismograph (unknown if felt by residents) (Anacortes American January 29, 1920 p 1 col. 5-6)

January 23, 1920 11:00 to 11:12 PM numerous sources

January 24, 1920 (Victoria, BC) 2:00 AM Recorded on Victoria seismograph (unknown if felt by residents) (Anacortes American January 29, 1920 p 1 col. 5-6)

Newspapers examined -

Friday Harbor Journal January 29 & February 5, 1920. Also March 1920 weather summary in March 4, 1920 issue (weekly)

Anacortes American January 22, 1920 to February 12, 1920 (weekly - complete)

February 19, 1920 page one only (rest of issue missing)

Port Townsend Weekly Leader January 29, 1920 to February 19, 1920 (weekly - complete)

Oak Harbor News January 16, 1920 (weekly - last issue)

Island County Farm Bureau News (Oak Harbor) January 23, 1920 to February 13, 1920 (weekly - complete)

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Port Angeles Daily Herald (issues missing/not published)

Mount Vernon Daily Herald (issues missing/not published)

Bellingham American (issues missing/not published)

Stanwood News (issues missing/not published)

December 4, 1926 EVENT

December 4, 1926 5:55 to 5:57 AM numerous sources

Newspapers examined -

Friday Harbor Journal December 2, 1926 to December 30, 1926 (weekly - complete)

Anacortes American December 9, 1926 to December 23, 1926 (weekly - complete)

Port Townsend Leader December 3, 1926 to December 17, 1926 (weekly - complete)

Bellingham American December 4, 1926 only issue examined

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Anacortes Daily Mercury (issues missing/not published)

Olympic Tribune (Port Angeles) (issues missing/not published)

WEATHER BUREAU

Climatological Data - Washington Section

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[US Weather Bureau statement] "Although earthquakes have little to do directly with meteorology, yet the students of geology need for their study as many observations as possible of the exact time and nature of even the slightest earthquake tremor. In order to assist in the study of this subject, the Weather Bureau has always indorsed [sic] the policy

adopted by meteorologists throughout the world of encouraging its observers to observe and record this earthquake phenomena. ... Those who have no instruments, and not even an exact timepiece, should pay especial attention to the frequency and the number of the several slight tremors that usually accompany the main shock; they should notice the apparent direction of movement of buildings and the ground at as many places as possible in the neighborhood, since the movement often varies very much on the opposite sides of a hill or valley. In describing the results of such observations, observers should omit references to their theories as to the nature and origin of an earthquake shock unless, indeed, they collect observations especially adapted to test definite theoretical hypotheses.” (Weather Bureau, US Department of Agriculture. Monthly Weather Review November, 1893 (Washington DC, Weather Bureau, 1894) p 332-333)

NOTICES OF EARTHQUAKE EVENTS IN WASHINGTON MONTHLY WEATHER SUMMARIES

Washington State Weather Service

Monthly Meteorological Report and Summary of the Washington State Weather Service (AKA - Monthly Review of the Washington State Weather Service) (Seattle, Washington)

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September 1891 to January 1896 events taken from above source

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September 16, 1891 “... a light earthquake shock occurred at Portland on the 16th and at East Sound on the 21st.” Seattle Weather Report September 1891 (Anacortes American Nov 5, 1891 p 4 col. 5)

September 21, 1891 “... a light earthquake shock occurred at Portland on the 16th and at East Sound on the 21st.” Seattle Weather Report September 1891 (Anacortes American Nov 5, 1891 p 4 col. 5)

October 2, 1891 “The earth quaked slightly at Chelan on the 2d, moving from the southeast to northwest.” State Weather Bureau [September (sic October) 1891 Monthly Report] (Anacortes American Dec 10, 1891 p 4 col. 5)

Dec 9, 1894 “Slight earthquake shock on 9th at Lakeside.” (Volume 4 # 6 December 1894 p. 1)

Feb 14, 1895 “Silver Creek, Lewis Co.: Slight earthquake shock on the 14th.” (Volume 4 #8 February 1895 p. 1)

Feb 25, 1895 “An earthquake shock was quite generally noticed in Western and Central Washington on the morning of the 25th about 4:30 o’clock.” “Ashford, Pierce co: Quite a severe earthquake occurred here on the twenty fifth at 4:27 A.M.” “Centerville, Klickitat Co: Feb. 25th, at half past four A.M., two earthquake shocks were felt very distinctly, one following immediately after the other. The first was stronger than the second.” (Volume 4 #8 February 1895 p. 1)

July 13, 1895 "At Grand Mound on the 13th a brilliant meteor was noticed in the east moving at an elevation of about 14 degrees." (Volume 5 #1 July 1895 p. 1)

Jan 3, 1896 "An earthquake was noticed on the 3d at New Whatcom, Coupeville, East Sound, and other places in the northwestern portion of the state. Mr. Jas. Theo.

Geoghegan, observer at East Sound, writes: "An earthquake shock was felt at this place on the evening of the 3d of January, 1896, at 9 minutes past 10 o'clock, lasting for about 20 seconds. It was not accompanied by any noise. The shock was preceded by a slight trembling lasting a few seconds, and about 5 seconds after this a sharp shock was felt lasting 10 or more seconds. The intensity would come in class 3, but in one case, at least, plaster was cracked and thrown down." "Mr. Lewis Mayhew, observer at New

Whatcom, writes: "On the 3d at 10 P.M. two distinct shocks of earthquake were felt; vibration from east to west, lasting 6 seconds; no damage done." (volume 5 #7 January 1896 p 1)

Feb 5, 1896 "Lapush: Earthquake shock night of 5th." (volume 5 #8 February 1896 p 1)

US Weather Bureau - Washington Section

Weather Bureau, US Department of Agriculture. Washington Section of the Climate and Crop Service of the Weather Bureau (Seattle, Weather Bureau) Issued from June 1897 to January 1906 (Volume 1 #1 to Volume 10 #1)

*

December 1897 to January 1906 events taken from above source

*

Dec 15, 16, 17, 20, 1897 "Lakeside -- Charles Johnson, Observer. A severe shock of earthquake was felt at this station on the 15th, followed by light shocks on the 16th, 17th and 20th, all occurring at 6:00 A.M. Vibration from west to east." (volume 1 #7 December 1897 p 5)

[Dec 15?, 1897] "Waterville -- R.W. Starr, Observer. Shock of earthquake sufficient to rattle the dishes in frame houses, duration from four to six seconds: direction from northwest to southeast." [Note: Date not given, assume Dec 15th] (volume 1 #7 December 1897 p 5)

Jan 11, 14, 15, 1898 "Slight earthquake shocks were felt at Lakeside on the 11th, 14th and

- 15th.” (p 4) “Lakeside - Charles Johnson, Observer. A slight shock of earthquake on the 11th, 14th and 15th; vibration from southwest to northeast.” (volume 1 #8 January 1898 p 5)
- Feb 2, 1898 “Union City -- M. Eells, Observer. ... A slight earthquake shock at Brinnon on the 2d, at about 6:30 P.M.” (volume 1 #9 February 1898 p 5)
- Feb 22, 1898 “Ellensburg -- R. Lee Barnes, Observer. Earthquake shock at 5:30 A.M. on the 22d.” (volume 1 #9 February 1898 p 5)
- May 4, 1898 “Lakeside -- Charles Johnson, Observer. Slight shock of earthquake on the 4th, vibration from west to east.” (volume 1 #12 May 1898 p 5)
- June 3, 1898 “Lakeside -- Charles Johnson, Observer. Light shock of earthquake on the 3d, vibration from west to east.” (volume 2 #1 June 1898 p 8)
- Nov 7, 1898 “An earthquake tremor was noticed as occurring on the 7th at 6:30 p.m.; it was reported by Anacortes and Olga observers.” (Not in Ludwin & Qamar 1995) (volume 2 #7 November 1898)
- Dec 26, 1898 “On the morning of the 26th and up to 8 a.m. several distinct shocks of earthquake were noted at Ellensburg.” (Not in Ludwin & Qamar 1995) (volume 2 #8 December 1898)
- Aug 6, 1899 “Earthquakes - La Center, two light shocks, about 3 p.m. on the 6th, lasting about ten seconds. Olympia, slight shock at 3:05 p.m. of the 6th; vibration from west to east, lasting about five seconds.” (volume 3 #3 August 1899)
- Dec 30, 1899 “Remarks of Voluntary Observers. Lakeside - Capt. Chas. Johnson. Two slight shocks of earthquake on the 30th.” (Not in Ludwin & Qamar 1995) (volume 3 #7 December 1899)
- Apr 23, 1900 Earthquakes - Olympia, La Center (Not in Ludwin & Qamar 1995) (volume 3 #11 December 1899)
- Feb 5, 1902 “Earthquake ... Centralia, 5th (slight)” (p 4) (volume 5 #9 February 1902)
- Feb 22, 1902 “Earthquake -- Lakeside, 22nd (slight shock)” (volume 5 #9 February 1902 p 4)
- Feb 26, 1903 “Earthquake Shocks: Lakeside, 26th, vibration from west to east. Waterville, 26th, vibration from northwest to southeast.” (volume 7 #9 February 1903 p 4)
- Mar 13, 1903 Earthquake Shocks - Centralia, Grand Mound, Olympia, Seattle (volume 6 #10 March 1903)
- Apr 24, 1903 “Meteor Fell -- La Center 24th.” (volume 6 #11 April 1903 p 4)
- Apr 26, 1903 “Sulphur Ashes: Aberdeen, sulphur ashes fell on 26th that were quite strong of sulphur.” (volume 6 #11 April 1903 p 4)
- Sept 11, 1903 Earthquake Shocks - La Center at 3:50 p.m., South Bend at 3:30 pm (volume 7 #4 September 1903)
- Oct 14, 1903 Meteors - “La Center two fine meteors fell on 14th at 9:30 and 10 pm” (volume 7 #5 October 1903)
- Mar 16, 1904 Earthquakes - Coupeville, Grand Mound, La Center, Port Townsend, Seattle, Snohomish, Cle Elum, Waterville (volume 7 #10 March 1904)

CONTINUED US Weather Bureau - Washington Section

Weather Bureau, US Department of Agriculture. Washington Section of the Climate and Crop Service of the Weather Bureau (Seattle, Weather Bureau) Issued from June 1897 to January 1906 (Volume 1 #1 to Volume 10 #1)

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Jun 10, 1904 Earthquakes - Lakeside [Chelan County] (Not in Ludwin & Qamar 1995) (volume 8 #1 June 1904)

July 27, 1904 Earthquakes - Lakeside "shock of earthquake on 27th. The vibration was from northwest of southeast." (Not in Ludwin & Qamar 1995) (volume 8 #2 July 1904)

Nov 15, 1904 Earthquake - Lakeside (Not in Ludwin & Qamar 1995) (volume 8 #6 November 1904)

July 25, 1905 Earthquakes - Rattlesnake Mountains (Not in Ludwin & Qamar 1995) (volume 9 #2 July 1905)

July 28, 1905 Earthquakes - Olga (Not in Ludwin & Qamar 1995) (volume 9 #2 July 1905)

Oct 17, 1905 Earthquake - Lakeside "A series of earthquakes occurred on the 17th; first at 6:00 p.m., second at 11:30 p.m., severe, followed at intervals of 10 to 15 minutes with three other mild shocks. Vibration from southwest to northeast." (volume 9 #5 October 1905)

Jan 2, 1906 Earthquake - Colville, Conconully, Danville, Loomis, Merritt, Republic, Twisp (volume 10 #1 January 1906)

Weather Bureau, US Department of Agriculture. Washington Section of the Climatological Service of the Weather Bureau (Portland Oregon, Weather Bureau) Issued from February 1906 to June 1909 (Volume 10 #2 to Volume 13 #6)

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August 1907 to June 1909 events taken from above source

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Aug 1, 1907 Earthquake - Lakeside (Not in Ludwin & Qamar 1995) (volume 11 #8 August 1907)

Aug 1, 1908 Earthquake -- Lakeside (Not in Ludwin & Qamar 1995) (volume 12 #8 August 1908)

Oct 27, 1908 Earthquake - Lakeside (Not in Ludwin & Qamar 1995) (volume 12 #10 October 1908)

Dec 13, 1908 Earthquake - Lakeside (Not in Ludwin & Qamar 1995) (volume 12 #12 December 1908)

Jan 11, 1909 Earthquakes - Anacortes, Baker, Bellingham, Blaine, Coupeville, East Sound, Granite Falls, Olga, Olympia, Port Townsend, Vashon Island (volume 13 #1 January 1909)

Jan 21, 1909 Earthquakes - Lakeside, Rex Creek [Chelan County] (volume 13 #1 January 1909)

May 4, 1909 Earthquake - Conconully (volume 13 #5 May 1909)

May 23, 1909 Earthquake - Lakeside (Not in Ludwin & Qamar 1995) (volume 13 #5 May 1909)

May 24, 1909 Earthquake - Lakeside (volume 13 #5 May 1909)

Jun 24, 1909 Earthquake - Lakeside (Not in Ludwin & Qamar 1995) (volume 13 #6 June 1909)

Weather Bureau, US Department of Agriculture. Climatological Service of the Weather Bureau. District No. 12. Columbia Valley (Washington DC, Weather Bureau) Issued from January 1911 to December 1913 (Volume 15 #1 to Volume 17 #12) Note this title is not given a volume and issue number

Oct 14, 1913 Earthquake - Lakeside at 4:45 am (volume 17 #10 October 1913) CHECK

Weather Bureau, US Department of Agriculture. Climatological Data - Washington Section (Seattle, Weather Bureau) January 1914 to post December 1917 (Volume 18 #1 to Volume 21 #12)

*

January 1914 to November 1917 events taken from above source

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Jan 5, 1914 Earthquakes - Baker very slight (Not in Ludwin & Qamar 1995) (volume 18 #1 January 1914)

Jan 7, 1914 Earthquakes - Lakeside (Not in Ludwin & Qamar 1995) (volume 18 #1 January 1914)

Jan 13, 1914 Earthquakes - Yale "distinct" (Not in Ludwin & Qamar 1995) (volume 18 #1 January 1914)

Jan 31, 1914 Earthquake - Lakeside (Not in Ludwin & Qamar 1995) (volume 18 #1 January 1914)

Feb 1, 1914 Earthquakes - Lakeside (volume 18 #2 February 1914)

Aug 8, 1914 Earthquake - Lakeside "there was a slight earthquake on the 8th at 2:30 am." (volume 18 #8 August 1914)

Sept 5, 1914 Sumner "There was an earthquake shock on the 5th at 1:38 am. The shock was quite distinct having a twisting motion, travelling from south to southwest. The duration was from 8 to 10 seconds." (volume 18 #9 September 1914)

Sept 23, 1914 Earthquake - Lakeside "There was a heavy earthquake shock on the 23d at 2:33 am" (Not in Ludwin & Qamar 1995) (volume 18 #9 September 1914)

July 18, 1915 Earthquakes - Lakeside (volume 19 #7 July 1914)

"August 17(?), 1915" Earthquakes - Laurier, White Bluffs [Note: publication has "?" implying event likely occurred August 18, 1915. See next entry gwl] (volume 19 #8 August 1915)

Aug 18, 1915 Earthquakes - Anacortes, Baker, Colville, Glacier, Lakeside, Omak, Winthrop, Twentyfive Mile Creek (volume 19 #8 August 1915)

Aug 18, 1915 Anacortes - "there was an earthquake shock on the 18th at about 5:58 a.m., apparently vibrating east and west." (volume 19 #8 August 1915)

Aug 18, 1915 Baker - "there were two earthquake shocks on the 18th at 6:05 a.m., of 15 seconds duration from west to east. Buildings were severely shaken." (volume 19 #8 August 1915)

Aug 18, 1915 Lakeside - "There was an earthquake shock on the 18th at 6:08 a.m., the vibrations being from southwest to northeast." (volume 19 #8 August 1915)

[Aug 18, 1915] Laurier - "On the 17th(?) an earthquake shock was felt at about 6:05 a.m." (volume 19 #8 August 1915)

Aug 18, 1915 Twentyfive Mile Creek - "On the morning of the 18th at about six o'clock, there was a rumbling and then a sharp shock and then a rumbling, coming from the northwest and passing to the southeast." (volume 19 #8 August 1915)

[Aug 18, 1915] White Bluffs - "An earthquake occurred on the 17th(?) at about 6 a.m." (volume 19 #8 August 1915)

Aug 18, 1915 Winthrop - "At 6:10 a.m., on the 18th, there were two earthquake shocks, the second being most severe. Crockery was rattled. The shocks were generally observed in the vicinity." (volume 19 #8 August 1915)

Aug 27, 1916 Earthquakes - Twentyfive Mile Creek "There was a light earthquake on the 27th at 12:20 p.m. northwest to southeast." (Not in Ludwin & Qamar 1995) (volume 20 #8 August 1915)

Jun 9, 1917 Earthquakes - La Center, Longmires Springs, Twentyfive Mile Creek (volume 21 #6 June 1917)

Jun 11, 1917 Earthquakes - Glenoma (Not in Ludwin & Qamar 1995) (volume 21 #6 June 1917)

July 24, 1917 Earthquakes - Cedar Lake (Not in Ludwin & Qamar 1995) (volume 21 #7 July 1917)

Nov 12 & 13, 1917 Earthquakes - Longmires Springs "Two earthquakes occurred; one on the 12th and severe enough to shake loose rock off the foothills." (volume 21 #11 November 1917)

EARTHQUAKE EVENTS LISTED IN Workman, Land of Trees (1997)

SOURCE: Workman, Larry J. Land of Trees: Scannings From Quinault Country, the Grays Harbor Region, and Beyond 1774-1997 (Taholah, WA: The Quinault Indian Nation, 1997)

Newspapers that were used for most of the entries include Daily World (Aberdeen), Montesano Vidette, Weekly Puget Sound Courier (Olympia), Olympic [sic?] Transcript (Olympia), Washington Standard (Olympia), North Coast News (Ocean Shores)

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November 23, 1827 "Slight shock of earthquake felt at Fort Langley"

October 1842 "St. Helens enters a violent eruptive phase that will continue intermittently for fifteen years."

November 23, 1842 "Ash from St. Helens falls to ½ inch deep at the Dalles."

February 16, 1843 "Peter H. Burnett (later governor of California) reports, 'The mountain (St. Helens) burning magnificently.'"

1854 "George Davidson, a scientist, reports 'vast rolling masses of dense smoke,' on Mt. Baker."

December 14, 1872 "Strong earthquake felt on Puget Sound." p 35

October 19, 1873 "Clouds of smoke pour from the highest peak of Mount Rainier. (Last for nearly a week)." p 35

March 27, 1884 "Quite an earthquake shock in Hoquiam was noticed about 10:00 p.m. lasting 3 seconds; no damage." p 38

- October 9, 1885 “Earthquake in Olympia.” p 40
- September 3, 1886 “Greatest earthquake to hit the United States centers on Charleston, South Carolina.” p 41
- April 22, 1887 “An earthquake shock, heavy enough in places to shake dishes from shelves, was felt in several towns in this Territory.” (Note: Index refers to this as an earthquake at Grays Harbor) p 42
- May 7, 1887 “Something like a tidal-wave struck the Quinaielt agency at midnight. Some of the Indian houses were waist deep in water, the inmates yelling in terror as they were submerged during sleep on their low sleeping places. The water receded as rapidly as it came, carrying everything portable in its exit.” p 43
- November 30, 1891 “Earthquake shock slight on [Grays? gwl] Harbor, but heaviest ever experienced in some Sound cities.” p 49
- April 18, 1906 “Bay City (San Francisco) ravage by earthquake at 5:10 a.m. and the fires that followed (the rebuilding of the city greatly stimulated logging on Grays Harbor).” p 66
- January 11, 1909 “Grays Harbor Earthquake, 4:03 p.m.” p 68
- April 16, 1910 “Halley’s Comet visible to the naked eye.” p 70
- October 11, 1911 “Earthquake in Southern California kills 700.” p 71
- September 5, 1914 “Earthquake in Olympia felt over 1,000 sq. miles.” p 74
- January 13, 1915 “50,000 die in Italian earthquake.” p 74
- April 22, 1915 “Tacoma rocked by an earthquake.” p 74
- December 24, 1920 “A small tidal wave sweeps beaches, washes 12 Sunset Beach cottages from their foundations.” p 79
- September 3, 1923 “Japanese earthquake kills 90,000.” p 82
- December 4, 1926 “Quake shakes Northwest.” p 85
- July 16, 1928 “Giant meteor lights up night sky and [Grays? gwl] Harborites hear rumble.” p 87
- March 12, 1929 “Brilliant light flashes in the sky.” p 87 (Note: Index references this as Meteor - Harbor)
- May 4, 1929 “Report of vast earth upheaval on the Queets near M. M. Kelly Ranch.” p 88
- December 31, 1931 “Tremor shakes up Puget Sound and Hood Canal.” p 91

EARTHQUAKE EVENTS LISTED IN THE FOLLOWING WEB PAGE

Pacific County Historical Society and Museum “Columbia River Chronology Historical Dates”

www.pacificcohistory.org/columbia.htm

Note: Citations are given for each entry but bibliography is not available at this time per discussion with Pacific County Historical Society.

[SW WASHINGTON EARTHQUAKES]

December 2, 1841 earthquake near Ft Vancouver Washington (Wong and Bott p 128)
December 23, 1854 tsunami recorded at Astoria (Lander p 121)
December 24, 1854 tsunami recorded at Astoria (Lander p 121)
April 3, 1868 tsunami recorded at Astoria (Lander p 122)
August 14, 1868 tsunami recorded at Astoria (Lander p 123)
August 23, 1872 teletsunami recorded at Astoria (Lander p 24, 47)
October 12, 1877 earthquake tremors felt in Astoria oscillating from east to west (Daily Astorian October 13, 1877 p 1)
December 12, 1880 2 earthquakes shocks felt (Daily Astorian [Dec?] 14, 1880 p 3; Algermissen and Harding)
April 30, 1882 Severe tremors (Daily Astorian May 2, 1882 p 3) Daily Astorian May 3, 1882 p 3 mentions that earthquake was felt in Westport and Ft Canby about 10:30 pm [on] April 30. Daily Astorian May 4, 1882 tells that 3 shocks vibrated from SW to NE on April 30.
March 27, 1884 earthquake felt in Hoquiam (Workman p 38)
November 30, 1891 slight earthquake on Grays Harbor (Workman p 49)
February 2, 1892 earthquake in Astoria (Bott and Wong p 118)
February 26, 1895 earthquake hits Astoria (Daily Morning Astorian p 4)
August 6, 1899 earthquake hits Astoria (Astoria Daily Budget August 8, 1899 p 4)
November 20, 1899 tidal wave at Shoalwater Bay (Astoria Daily Budget November 20, 1899 p 4)
September 12, 1903 quake hits city (Astoria Daily Budget p 4)
March 16, 1904 Earthquake felt along Washington Coast and in Aberdeen, Hoquiam (Lander p 59, 127 not mentioned in Astoria newspapers)
March 30, 1904 possible tsunami off Washington coast caused flooding (Lander p 19 not mentioned in Astoria newspapers)
January 11, 1909 Grays Harbor Earthquake (Workman p 68)
November 9, 1920 earthquake hits Astoria (Astoria Budget p 1)
November 29, 1920 slight earthquake hits Astoria (Astoria Budget p 1)

Possible references mentioned per Bruce Weilepp at Pacific County Historical Society
Workman Land of Trees

Appendix 3

New Account of the 1872 Entiat Earthquake, as felt in Seattle

David Buerge, a local historian forwarded an eyewitness account of the effects of the 1872 earthquake (M 6.8, probably located near Entiat, WA) in Seattle. The source is *The Indian Journal of Rev. R. W. Summers, the first Episcopal priest in Seattle (1871-73)*, 1994, Guadalupe Translations, P.O. Box 97, Lafayette, Oregon, 97127.

#113 An Earthquake: Chinese and Indian Reaction. (Ms I-72)

“An earthquake visited this town last night. I chanced to be out-of-doors at the moment, when suddenly, across the bay I heard a sound like the rumble of many freight trains rolled into one. It grew louder as it circled the shore towards me and finally struck the business part of the city and started back toward the interior. As it traveled up the hill, everything shook. The sidewalks, fences, buildings, trees all cracked and crackled like a grand discharge of Minie balls. As it touched church and church ground, the earth rolled under my feet in such waves as a carpet makes, shaken with regular motion on a greensward. Then the quaking and the earth-waves rolled on above the town and over the brow and off toward Lake Duwamish, until the terrible convulsion passed out of hearing. The giant firs and cedars lashed together back and forth and their tall trunks were reported as swaying a full fifteen feet. It was about nine o'clock. When the first sickening chill left me, I became conscious of other sounds beside the rumbling underground. Gongs were desperately beating in the Chinese quarter and strange cries of terror were their accompaniment. Drums, tin pans--anything that would resound--told of the wild excitement among the frightened Indians, whose place of abode was in the same direction. They too were crying out and long to frighten away the Demon whom they believed to be the doer of this evil. All this drumming and crying was in order to Mamook temanous, or "make magic" to charm away a threatened calamity. Both nations kept it up a long time. Indeed, as a slight shock was perceptible more than once before morning, these benighted ones were uneasy all night. Congregated in the open air, at intervals they renewed their charming and their cries to powers overhead. What a strange, almost supernatural, night they made of it, for themselves and for those who listened.”

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

Ruth S. Ludwin¹, Robert Dennis², Deborah Carver³, Alan D. McMillan⁴, Robert Losey⁵, John Clague⁶, Chris Jonientz-Trisler⁷, Janine Bowechop⁸, Jacilee Wray⁹, and Karen James¹⁰

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,

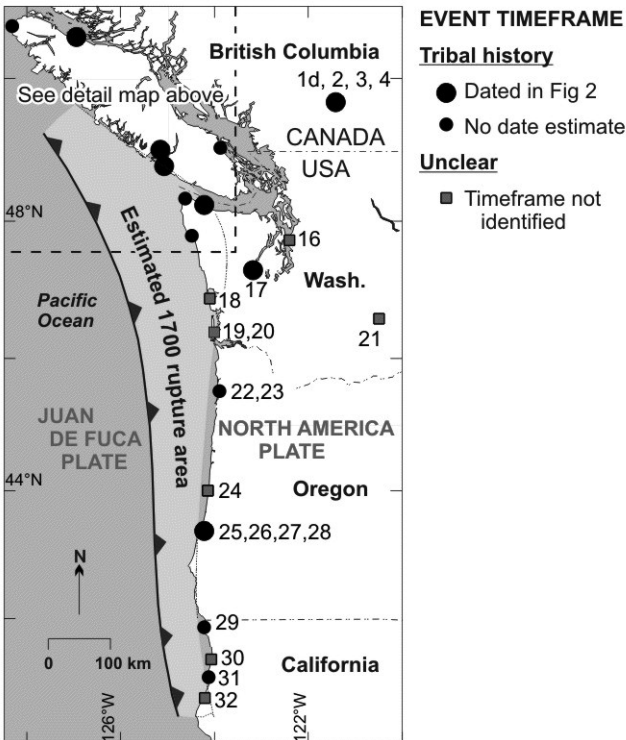
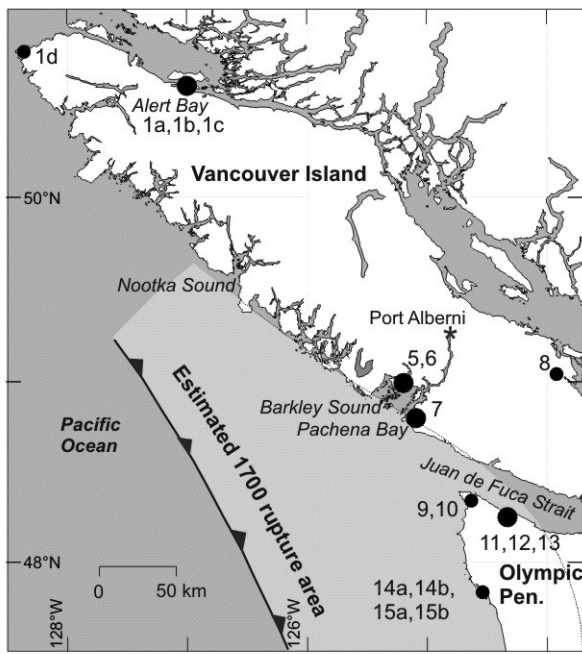
were killed when their roots were suddenly plunged into salt water. Beneath the surface of these same estuaries, soil cores revealed layered deposits showing a repeated cycle of slow uplift and rapid submergence. Preliminary age estimates based on radiocarbon dating (Nelson *et al.*, 1995) and tree-ring 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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1. Department of Earth and Space Sciences, University of Washington
 2. Huu-ay-aht First Nation
 3. Carver Geologic, Inc.
 4. Department of Anthropology, Douglas College
 5. Department of Anthropology, University of Alberta
 6. Department of Earth Sciences, Simon Fraser University
 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.

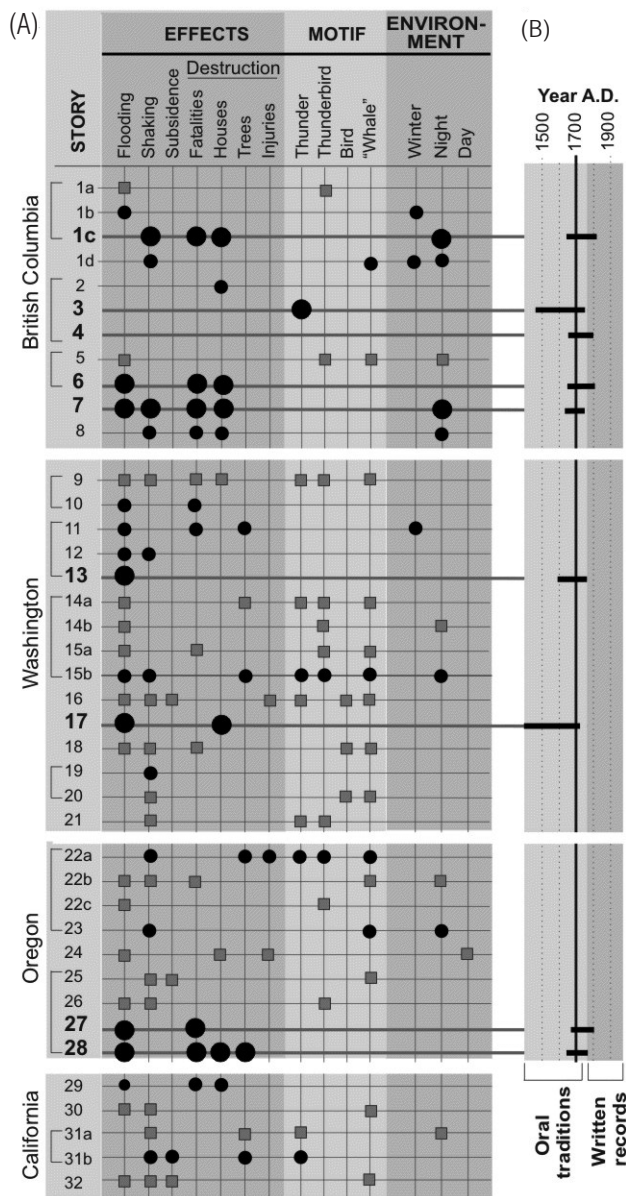
Stories vary considerably in content and style along the Cascadia coast. At the southern end, many stories explicitly mention both earthquakes and tsunamis. At the northern end, there are explicit earthquake stories and explicit flood stories, but only a few stories including both phenomena. In the middle 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,



▲ **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).

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." — *Labid 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 canoes 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.*

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 "thun-

der-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 earth-

quakes 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.

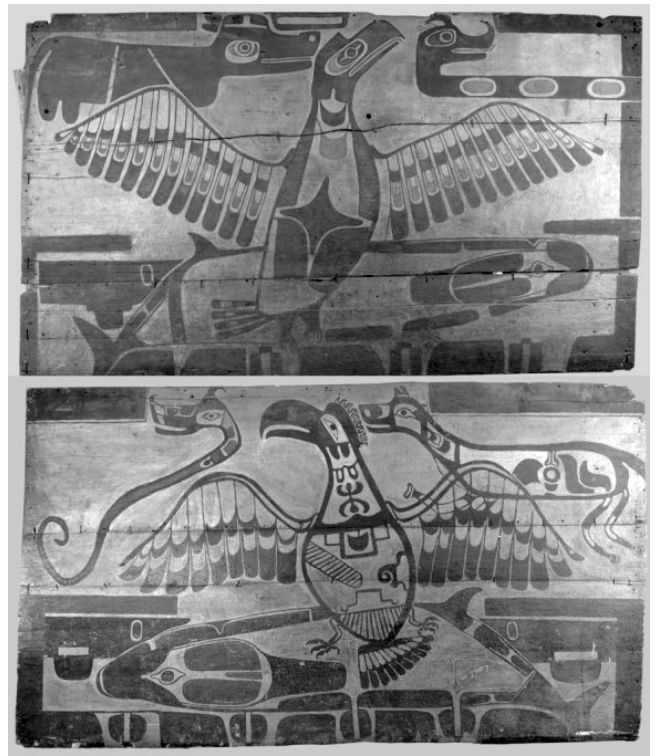
Artifacts depicting Thunderbird and Whale sites which long predate the 1700 earthquake have been recovered from coastal archaeological sites (McMillan, 2000), and native populations witnessed multiple cycles of CSZ earthquakes: Geologic evidence indicates at least seven in the last 3,500 years (Atwater 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)

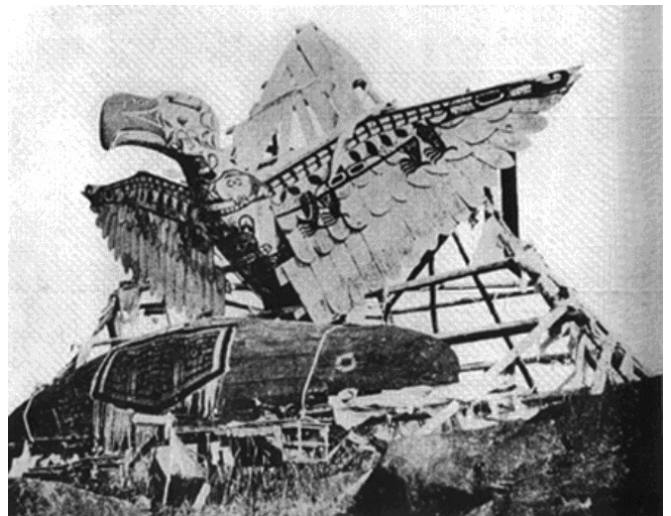
The Thunderbird/Whale motif is the central theme in carved and painted art of the outer coast and coastal fjords of Vancouver Island (Malin, 1999) (Figures 4 and 5), where broad ocean openings funnel water into narrow waterways that run far inland. Port Alberni, at the landward terminus of Barkley Sound, 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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Serpent Spirit-power Stories along the Seattle Fault

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INTRODUCTION

The Seattle Fault is a multistranded east-west-striking reverse fault cutting across Puget Sound, through downtown Seattle, and across Lake Washington. Although geophysical evidence has long indicated a substantial offset in basement rocks beneath Puget Sound (Danes *et al.*, 1965), no clear pattern of recent earthquake activity defining the fault has been observed. Geologic evidence of an earthquake around A.D. 900 (estimated magnitude 7.3) came to light in the early 1990's (Bucknam *et al.*, 1992), however, and the Seattle Fault is now recognized as a substantial hazard to the Seattle urban area.

The circa A.D. 900 earthquake caused 7 m of vertical uplift on the southern side, sent massive block landslides tumbling into Lake Washington, and created a tsunami in Puget Sound that left sand deposits on Southern Whidbey Island (Atwater and Moore, 1992).

Two archaeological sites near Seattle attest to the effects of such events on local indigenous communities. Excavations at West Point, a promontory jutting out into Puget Sound north of downtown that was used as a fish- and shellfish-processing site since at least 4,000 years before the present, show that the area dropped at least a meter during the quake. The point's marshes were flooded with saltwater and a layer of sand covered the entire site. Over time, people returned to West Point and began using it as they had before the quake (Larson and Lewarch, 1995). The earthquake also had the capacity to transform some locales permanently. At the Duwamish No. 1 archaeological site, excavations show that the quake lifted up a low, wet area that had been only a minor camping and food-processing site and turned it into a higher, drier spot that eventually became home to a major permanent settlement with several longhouses (Campbell, 1981; Blukis Onat, 1987).

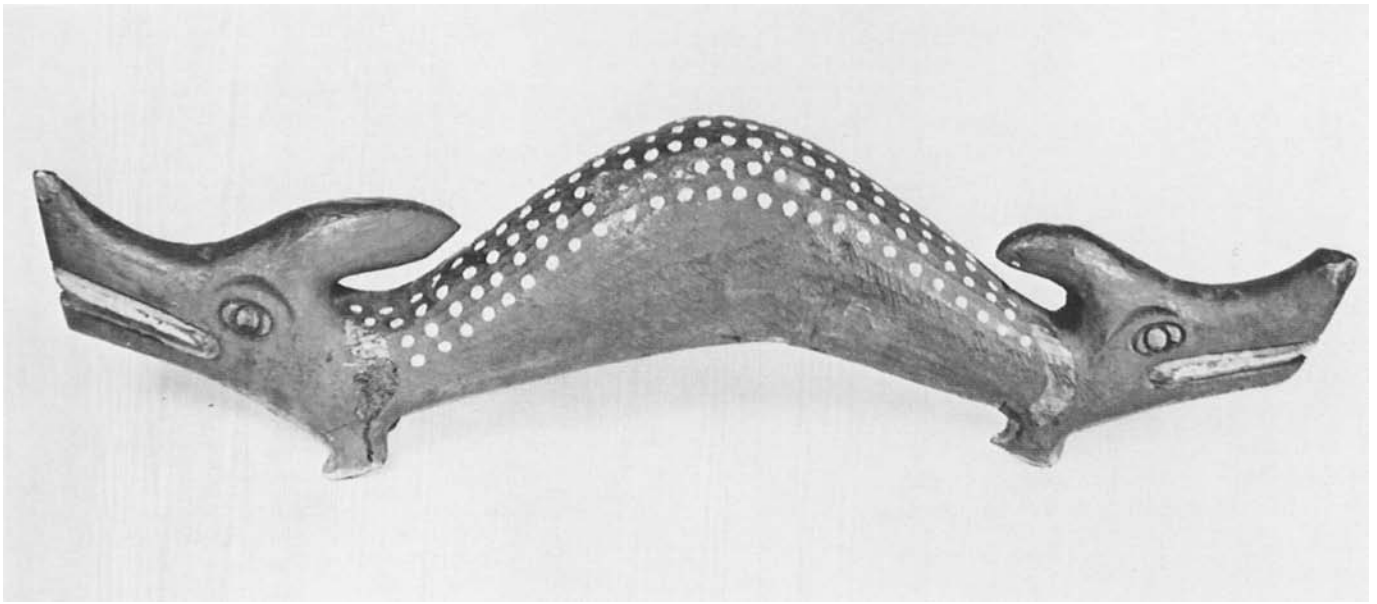
Native peoples described and commemorated geologic events in their oral traditions by using descriptive metaphors based on their cultural concepts, often ascribing earth shaking to actions of supernatural beings. In this paper we discuss stories about *ayabos*, a supernatural spirit power that natives associated with five locales along the trace of the Seattle Fault. Three of these locales are associated with landslides, and another has a description of offset consistent with the movement of the Seattle Fault.

In 1985, prior to published evidence of the A.D. 900 earthquake on the Seattle Fault, an article in the *Seattle Weekly* (Buerge, 1985) mentioned a "spirit boulder" associated with earthquakes and landslides located near the Fauntleroy ferry dock in west Seattle. The proximity of this location to the Seattle Fault invited investigation, and we discovered that the Fauntleroy spirit boulder is associated with a supernatural being called *ayabos*, which is often described in a way that could refer to earthquake effects and particularly landslides. The *ayabos* is a shape-shifter, often appearing as an enormous serpent, sometimes double-headed with blazing eyes and horns, or as a composite monster having the forequarters and head of a deer and the tail of a snake (Mohling, 1957).

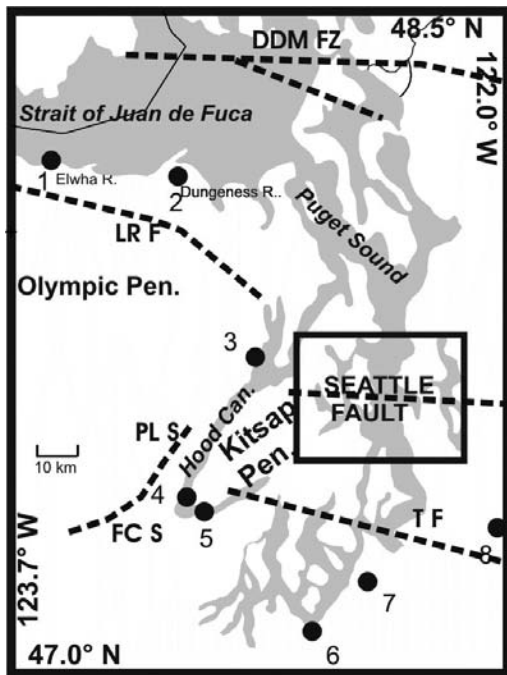
Ayabos is associated with shaking and rushes of turbid water and comes simultaneously from land and sea (Smith, unpublished notes). "At the spot where *ayabos* came to a person the very earth was torn, land slides occurred and the trees became twisted and warped. Such spots were recognizable for years afterward" (Smith, 1940). Figure 1 shows an artifact from a non-Salish tribe on the outer coast of Washington that corresponds to the description of *ayabos* and represents a vicious guardian spirit.

Stories about *ayabos* mention a number of specific locales in the central Puget Sound, along the Hood Canal, and on the Strait of Juan de Fuca as far west as the Elwha River. Thirteen *ayabos* locales are mentioned in various stories (Figures 2 and 3). While some locales are identified precisely, rather general location descriptions (*e.g.*, "Dungeness River") are given for others. *Ayabos* sites appear to coincide generally with shallow faults around the Puget Lowland, including the Little River Fault along the strait of Juan de Fuca, the Seattle and Tacoma Faults, and the Price Lake scarps (Haugerud *et al.*, 2003). Five of the *ayabos* story sites are spatially concentrated and located very close to the trace of the Seattle Fault (Figure 3). Four of the Seattle locales can be associated with land-

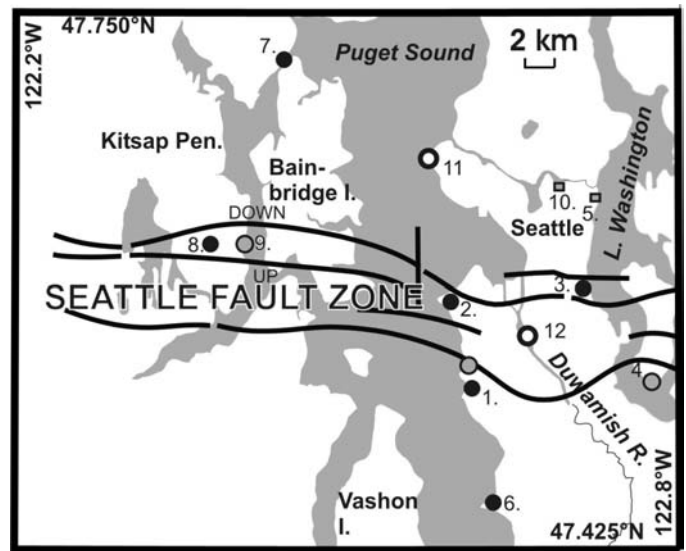
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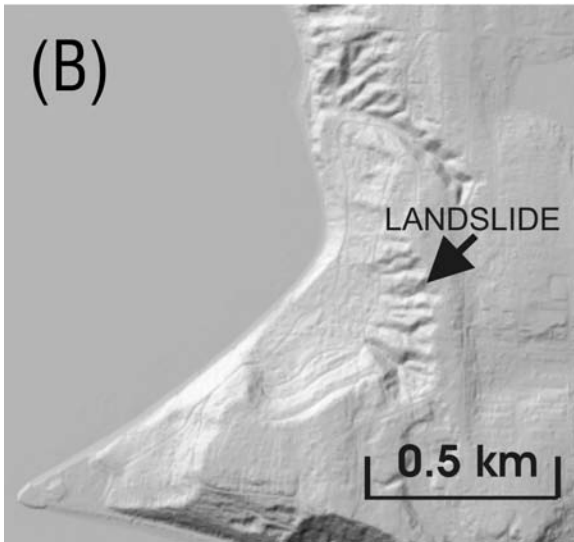
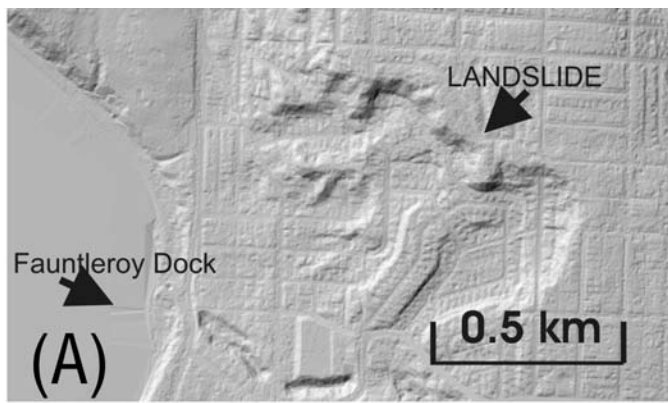
▲ **Figure 1.** A Quileute ceremonial representation of a two-headed horned serpent with legs; known as a vicious guardian spirit-power. From Powell and Jensen (1976). Courtesy American Museum of the American Indian, Smithsonian Institution, 05/8861.



▲ **Figure 2.** Puget Sound and eastern Olympic Peninsula. Boxed area indicates location of larger-scale map shown in Figure 3. Dashed lines show locations of some shallow faults (after Haugerud *et al.*, 2003): LR F: Little River Fault; T F: Tacoma Fault; DDM FZ: Darrington Devil's Mountain fault zone; PL S: Price Lake scarp; FC S: Frigid Creek scarp. Numbers indicate locales outside the Seattle Fault area associated with *a'yahos* stories: 1. Elwha River; 2. Dungeness River; 3. Dabob Bay; 4. Bald Point, also known as Ayers Point; 5. Tahuya River; 6. Medicine Creek (Nisqually Delta); 7. American Lake; 8. Black Diamond Lake (1–5 from Elmendorf, 1993; 6 and 8 from Waterman, 2001; 7 from Smith, 1940).



▲ **Figure 3.** Map showing the Seattle Fault zone, *a'yahos* story locales (black circles), other stories that have apparent connection to earth shaking or landsliding (gray circles), and archaeological sites (white circles). Locales: 1. Fauntleroy; 2. Alki Point; 3. Lake Washington *a'yahos* site; 4. South Point, Mercer Island; 5. Madison Park; 6. Three-Tree Point; 7. Agate Passage; 8. Bremerton; 9. Moore Point; 10. Portage Bay; 11. West Point; 12. Duwamish Site No. 1. LIDAR images of Fauntleroy (1) and Three-Tree Point (6) are shown in Figure 4.



▲ **Figure 4.** LIDAR images showing apparent landslides at locales said to be *a'yahos* dwelling places: (A) Fauntleroy Cove in West Seattle; (B) Three-Tree Point in Burien.

slides or reports of land-level changes that might have been caused by the A.D. 900 Seattle earthquake. Additional native stories related to shaking, landsliding, or land-level change are associated with three of these sites.

A'YAHOS STORIES ALONG THE SEATTLE FAULT

The west Seattle *a'yahos* spirit boulder mentioned by Buerge (1985) is located on the beach immediately south of Fauntleroy ferry dock, below what appears to be a very large landslide of undetermined age clearly visible in LIDAR images (Figure 4A) but not shown on existing geologic maps (the boulder location was pointed out by long-time local residents Morey Skaret and Judy Pickens; Waterman [2001] indicated a location further south, near Brace Point). Stories of *a'yahos* spirit power are told about both the Fauntleroy boulder (Waterman, 2001) and Alki Point (Smith, notes), immediately to the north and uplifted during the A.D. 900 quake. Stories about Alki Point speak of shaking, rocks exploding, and the power coming from sea and land simultaneously (Smith, notes). Williams Point, between Alki and Fauntleroy, is just

south of a creek called “Capsize” (Waterman, 2001). Places that have undergone massive transformations are often referred to as having “capsized” in Lushootseed, the indigenous language of the region (Miller, 1999).

The second place in Seattle associated with *a'yahos* is by the shore of Lake Washington. According to elders who worked with T. T. Waterman, “On the lake shore opposite the north end of Mercer Island ... an enormous supernatural monster ... lived” (Waterman, 2001). Large block landslides dated to A.D. 900 slid into Lake Washington from the southern end of Mercer Island and at Madison Park (Karlin and Abella, 1992), about 2 km south and north, respectively, of the *a'yahos* site. In addition to the massive slides of A.D. 900 that bracket this site, a close-by landslide during the 1890's is said to have damaged buildings (McDonald, 1956). It is possible that the 1890's landslide influenced the identification of this site with *a'yahos*. Landslides occur in many locations along the bluffs and steep slopes that line portions of the shores of Lake Washington and Puget Sound.

The large blocks of land that slid into Lake Washington from Mercer Island's South Point submerged intact and upright trees. As the lake rose and fell several feet during the course of the year owing to seasonal run-off in the lake basin, the trunks of these drowned trees were exposed. Native people avoided this place, which they called “stripping someone's clothes off” (Waterman, 2001), because they believed supernatural “earth beings” lived in the stumps of the drowned trees. A man who came to strip the bark off the drowned trees protruding above the lake surface reportedly became crazy, because stripping the bark from the submerged trees was thought to be like stripping the clothes off the earth beings (Waterman, 2001).

A third locale in greater Seattle is on the shore of Puget Sound, near Three-Tree Point in Burien, at a bluff where “a great snake lived inside, shoving the sand down when people disturbed him” (Waterman, 2001). James Rasmussen, of the Duwamish Tribe, identifies this snake as *a'yahos*. As at Fauntleroy, a large undated and previously unmapped apparent landslide visible in LIDAR (Figure 4B) is located there.

The fourth story comes from the Suquamish Tribe on the western side of Puget Sound. Oral traditions handed down by elders tell of the creation of Agate Passage (the waterway between the northern end of Bainbridge Island and the Kitsap Peninsula; located on the downthrown side of the Seattle Fault) following an underwater battle between a water serpent (not specifically identified as *a'yahos*) and a mythic bird, resulting in ground shaking, churning of the waters, and widening of the channel.

Long ago, when this land was new, the area we know as Agate Pass was much smaller than today. ... There lived in this ... body of water a ... Giant Serpent.

The Double Headed Eagle flew over the pass and the Giant Serpent came up very angry. The two began to fight, and the earth shook and the water

boiled ... the people began to scream and cry until it was as loud as thunder.

Then, as if the earth was going to be swallowed by the waters, they began to boil and churn. Then, the Double Headed Eagle exploded out of the water and up into the sky with the body of the Giant Serpent in its claws. The Double Headed Eagle flew back into the mountain and behind him was left the wide pass (Jefferson, 2001)

The description of the widened channel could reflect permanent ground-level change, and the sense of ground motion suggested by the story is accurate: Agate Passage is on the down-dropped northern side of the Seattle Fault. Geologic evidence suggests that the A.D. 900 earthquake produced mainly uplift on the southern side, however, with the north side down-dropped only slightly; the correspondence between the story and reality is thus approximate rather than exact. We note that some “drift” seems probable in a story that may be a thousand years old and has been preserved through extreme cultural destruction. This story, though set in an undated “long ago”, is strikingly similar to stories from the outer coast of Cascadia that use the struggle of a supernatural bird and water-beast to refer to earthquakes on the Cascadia subduction zone (Ludwin *et al.*, 2005). The “long ago” time frame suggests an origin more ancient than 1700. Another account refers to a more recent event, which might be the 1700 CSZ earthquake:

When Seattle was first settled by the white people the Indians told of a great earthquake that had occurred some fifty years before. They related that the shocks were so severe that the earth opened up in great cracks and that their little mat and slab huts were shaken to the ground and there were great landslides. The largest slide near Seattle was immediately south of West Point lighthouse. It is about a mile in extent and can be clearly seen at the present day. The lower bench of Kinnear Park slid at that time from the cliff shore, carrying giant fir trees that still stand on the slide. The Indians said that the mountains “momoked poh” (shot at each other), and roaring of the tidal waves was frightful. (*Seattle Post-Intelligencer*, Sunday, March 20, 1904, p. 1, c. 1, byline “Chelana”, probably a daughter of the Denny family)

A fifth locale, on the Kitsap Peninsula near Bremerton, is said to be another spot where shamanistic spirit-power could be acquired (Smith, notes; Waterman, 2001). Sam Wilson, born in 1861 and grandson of Chief Seattle, told Marian Smith “it comes from land and sea at same time” (Smith, notes). No obvious geologic features were noted at this site, though it is situated between several strands of the Seattle Fault. On the Puget Sound shore of Kitsap Peninsula, just east of this locale, at Moore Point near Illahee State Park, is a spot named “to have a chill” or “to feel a tremor” (Waterman, 2001). A com-

parison of earth tremors to feverish chills was made by Aristotle (Leet, 1948; Oeser, 2002), and it is possible that the natives of Puget Sound drew a similar connection.

A'YAHOS, INDIAN DOCTORING, AND CEREMONY IN SALISH CULTURE

Shaking was a central element in Puget Sound native medical practices and ceremonies, and *a'yahos*, associated with both landslides and earth shaking, was a central source of “doctor” power.

The Puget Sound lowland was home to dozens of Salish-speaking bands with two distinct, but related, languages: Lushootseed and Twana. Cultural beliefs, like language, were distinct but closely related. Throughout the region, individuals sought personal spirit powers to guide their lives and bring them luck and skill. *A'yahos* was one of the most powerful of these personal spirit powers, though it was also malevolent, dangerous, and possibly fatal to encounter (Smith, 1940). *A'yahos* “doctor” spirit power was one of only two powers (*a'yahos* and *staduk^wa*) reserved exclusively for shamans, and descriptions of both these shamanistic powers include shaking or landsliding imagery (Elmendorf, 1993; Smith, notes; Smith, 1940; Waterman, 2001). Descriptions of these powers are quite limited and vary somewhat, likely reflecting both cultural differences between groups in the area and perhaps also the shape-shifting nature of *a'yahos*.

Shamans obtained power from some of the same spirit sources as laymen, but two very powerful spirits gave power to shamans only. These were the *ʔayahus*, described by the Twana as a two-headed serpentlike being and by some Lushootseed speakers as a giant elklike creature, and the *staduk^wa* (Twana), an alligatorlike being that appeared sliding down talus slopes in the mountains. (Suttles and Lane, 1990)

Shaking was an important element in Puget Sound Salish ceremony, occurring when ritual objects filled with spirit-power became self-animated (Haeblerlin and Gunther, 1932; Miller, 1999; Elmendorf, 2001). The name of James Zackuse, a Duwamish Indian doctor who lived on Portage Bay in Seattle in the late 19th and early 20th centuries, translates to “trembling face.” Its root is *dzaku*, the Lushootseed word for earthquake (Miller and Blukas-Onat, 2004). A specific connection between ceremony and earthquake shaking was noted by Samuel Coombs, an early settler, in 1893:

During the past thirty-three years I have on many occasions endeavored to gather from the oldest and most intelligent Indians something for their earlier recollections; for instance, as to when the heaviest earthquake occurred. They said that one was said to have occurred a great many years before any white man had ever been seen here, when mam-ook tamah-na-wis was carried on by hundreds. This is the

same performance they go through when they are making medicine men, and consists of shouting, singing, beating on drums and sticks and apparently trying to make as much noise as they can. (*Seattle Post-Intelligencer*, Sunday, March 26, 1893, p. 10, c. 4, "Recollections of Samuel Coombs")

Salish earthquake stories from outside Puget Sound also draw a connection between ceremony and shaking (Boas, 1898; Hill-Tout, 1978). Other cultures regionally (Yurok, Nuu-chah-nulth, Kwakiutl) also have ceremonies related to earthquake shaking.

The strong link between shaking and spiritual power and ceremonial observances with earth shaking in Puget Sound suggests that the earthquakes memorialized in these culturally central ways were likely much more severe than the rather modest events known from the 19th and 20th centuries.

DISCUSSION

Stories of *áyahos*, a supernatural creature linked to shaking and landslides, correspond to large landslides at Fauntleroy and Three-Tree Point that are not easily observable, *i.e.*, not active in historic time and not included in previous geologic maps. The difficulty of observing these landslides in modern times lends support to the idea that the stories are based on actual eyewitness experience. The proximity of a similar *áyahos* locale on the shore of Lake Washington close to the site of A.D. 900 block landslides suggests the possibility of seismic triggering of the Fauntleroy and Three-Tree Point slides in the A.D. 900 Seattle Fault earthquake. Dating the landslides at Fauntleroy and Three-Tree Point could confirm or negate this hypothesis, though present landslide dating methods may not be adequate to provide dates.

In fact, current geologic maps do not categorize these features as landslides. USGS scientists are currently identifying landslide features in Seattle using LIDAR imagery (Schulz, 2004). Although the appearance of the feature seen in the Fauntleroy LIDAR suggests a landslide, it has not been mapped as such due to the lack of evidence of recent activity. Schulz (personal communication, 2004) suggests that the lobed appearance of this feature could result from multiple episodes of activity and notes that the shape of the feature north of Three-Tree Point is more suggestive of a single landslide episode. The rather deep erosional channels across the Three-Tree Point feature suggest that its occurrence was not recent. Definitive identification of either feature as a landslide would require trenching or excavating, which would be difficult due to extensive development in both areas.

Active landslides are extremely common in Puget Sound, including features along shorelines that are several kilometers in length, though these features were probably not active simultaneously over their whole length (Schulz, personal communication, 2004). Many hillsides and bluffs along Seattle-area waterfronts have landslide-prone geology, and LIDAR imagery has been used to identify 173 active land-

slide sites within the city (Schulz, 2004). Landslides in Puget Sound are most frequently a result of weather-related groundwater conditions, though several 20th-century earthquakes also caused landsliding (Noson *et al.*, 1988; Highland, 2003). Shaking in the Puget Basin from the A.D. 900 earthquake would have been very much stronger than any shaking experienced in modern times.

Additional stories from along Hood Canal and the Strait of Juan de Fuca, either about *áyahos* or describing changes in topography (Costello, 1896; Elmendorf and Kroeber, 1992, #28, #29, #57), can be used to develop additional testable hypotheses that offer the possibility of clarifying landscape features and unifying the geologic record with local human recall of landscape-damaging events.

CONCLUSIONS

Stories about a dangerous serpent power (*áyahos*) that lives in the ground often speak of shaking and earth disturbances, and are concentrated in Puget Sound in the vicinity of the Seattle Fault. One *áyahos* site is close to a landslide dated to the A.D. 900 Seattle Fault earthquake, and two others are linked to large-scale but currently inactive landslides near the Seattle Fault. These ancient, place-specific stories have a powerful effect on the human imagination. The profound respect in which *áyahos* was held by the natives of Puget Sound for perhaps a thousand years may help contemporary Puget Sound residents grasp the severity of the earthquake effects experienced by c. A.D. 900 Puget Sound residents, and grapple with the hazard issues that the Seattle Fault continues to present. Geologic knowledge of the earthquake history of Puget Sound and Cascadia helps us interpret the meaning of these native stories, and the traditional knowledge from the region may hold additional clues to past events as yet unidentified. ☒

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