

The Oregon Department of Geology and Mineral Industries (DOGAMI) has been identifying and mapping the tsunami hazards along the Pacific Northwest coast since 1980. DOGAMI manages the National Tsunami Hazard Mitigation Program, which has been administered by the National Oceanic and Atmospheric Administration (NOAA). The program's goal was to reduce the risk to life and property from tsunamis by providing information to help communities understand their vulnerability and develop mitigation strategies. This paper describes the results of a project funded by the U.S. Geological Survey (USGS) to map the potential for tsunamis along the Oregon coast. The project was part of a larger effort to assess the tsunami hazard along the entire Oregon coast, from the mouth of the Columbia River to the border with California. The project involved a series of field studies, including reconnaissance surveys, detailed mapping, and modeling. The results of the project are presented in this paper, which includes maps of the potential tsunami hazard along the Oregon coast, as well as a discussion of the implications for coastal planning and management.

CSZ Frequency. Comprehensive research of the offshore geological record indicates that at least 19 major ruptures of the full length of the CSZ have occurred off the Oregon coast over the past 10,000 years (Figure 3). All 19 of these full-rupture CSZ events were likely magnitude 8.9 to 9.2 earthquakes (Witter and others, 2011). The most recent CSZ event happened approximately 300 years ago on January 26, 1700. Sand deposits carried onshore and left by the 1700 event have been found 12 miles inland, older tsunامي sand deposits have also been discovered in estuaries 6 miles inland. As shown in Figure 3, the range in time between these 19 events varies from 110 to 1,150 years, with a median time interval of 400 years. In 2008 the United States Geological Survey (USGS) released the results of a study announcing that the probability of a magnitude 8.9 CSZ earthquake occurring over the next 30 years is 10% and that such earthquakes occur every about 500 years (WGC&P 2008).

CSZ Model Specifications: The sizes of the earthquake and its resultant tsunami are primarily driven by the amount and geometry of the slip that takes place when the North American plate slams westward over the Juan de Fuca Plate during a CSZ event. DGSAMI has modeled a wide range of earthquake and tsunami sizes that take into account different fault geometries that could amplify the amount of seafloor displacement and increase tsunami inundation. Seismic geophysical profiles show that there may be a steep play fault running nearly parallel to the CSZ but closer to the Oregon coastline (Figure 1). The effect of this play fault moving during a full-rupture CSZ event would be an increase in the amount of vertical displacement of the Pacific Ocean.

A cross-sectional diagram of the Juan de Fuca Plate subducting beneath the North American Plate. The Pacific Plate is shown to the west, with an arrow indicating its movement towards the Juan de Fuca Plate. The Juan de Fuca Plate is shown moving eastward and subducting under the North American Plate. The subducting plate is labeled 'Juan de Fuca Plate' and the overriding plate is labeled 'NORTH AMERICAN PLATE'. The boundary between them is labeled 'Juan de Fuca Plate' and 'Juan de Fuca Plate'. The subducting plate is shown dipping into the mantle, with a 'Locked Zone' indicated. The overriding plate is shown with a 'Nugget' and a 'Nugget'.

Figure 1: This block diagram depicts the tectonic setting of the region. See Figure 2 for the sequence of events that occur during a Cascadia Subduction Zone megathrust earthquake and tsunami.

Figure 2: The North American Plate rides over the descending Juan de Fuca Plate at a rate of approximately 1.5 inches per year.

A: The North American Plate is shown sliding over the Juan de Fuca Plate at the Juan de Fuca Fault. The Pacific Ocean is to the west, and the North American continent is to the east.

B: Because the two plates are stuck in place at the "locked zone," strain builds up over time and the North American Plate bulges up.

C: Eventually the locked zone ruptures and causes a great earthquake. The sudden slip of the two plates displaces Pacific Ocean water upward and creates

D: A tsunami wave traveling away from the rupture site.

E: A large amount of ocean water is displaced, creating a tsunami wave.

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Figure 3: This chart depicts the timing, frequency, and magnitude of the last 19 great Cascadia Subduction Zone events over the past 10,000 years. The most recent event occurred on January 26, 1700. The 1700 event is considered to be a "medium sized" event. The data used to create this chart came from research that examined the many submarine landslides, known as "turbidites," that are triggered only by these great earthquakes (Witter and others, 2011). The loose correlation is "the bigger the turbidite, the bigger the earthquake."

Entire Map Area				Unincorporated Areas	
Total Buildings			563		563
Buildings within Tsunami Zones*					
	Small		52		52
	Medium		70		70
	Large		75		75
	Extra Large		157		157
	Extra Extra Large		172		172
Percent of Buildings within Tsunami Zones					
	Small				9.2%
	Medium				12.4%
	Large				13.3%
	Extra Large				27.9%
	Extra Extra Large				30.6%

*Building counts shown are based on polygon centroids and are cumulative within the map area

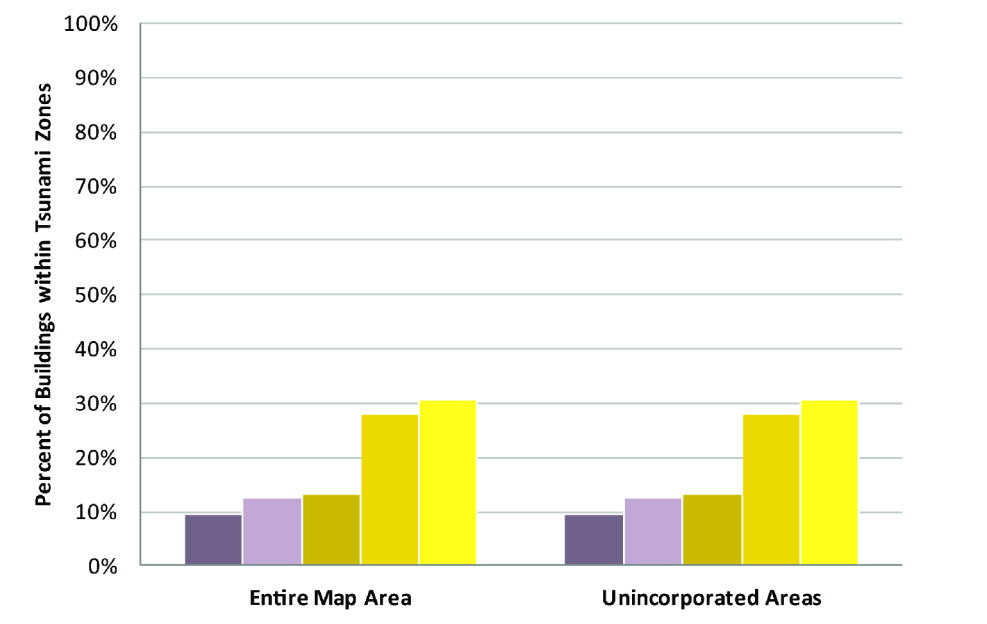


Figure 4: The table and chart show the number of buildings inundated for each "tsunami T-shirt scenario" for cities and unincorporated portions of the map.

The graph displays the change in water level (elevation in feet) over time (hours) for five tsunami scenarios at the simulated gauge station shown on the map. The y-axis represents Elevation, feet (NAVD83), ranging from -20.0 to 100.0. The x-axis represents Time since Earthquake (hours), ranging from 0.0 to 8.0. The legend identifies the scenarios: XXL (yellow), XL (green), L (blue), M (purple), and S (dark purple). A blue box with a white 'S' indicates the location of Coos Bay Mouth (Station 1). A white circle with a black outline indicates the end of simulated gauge station data at approximately 4.5 hours.

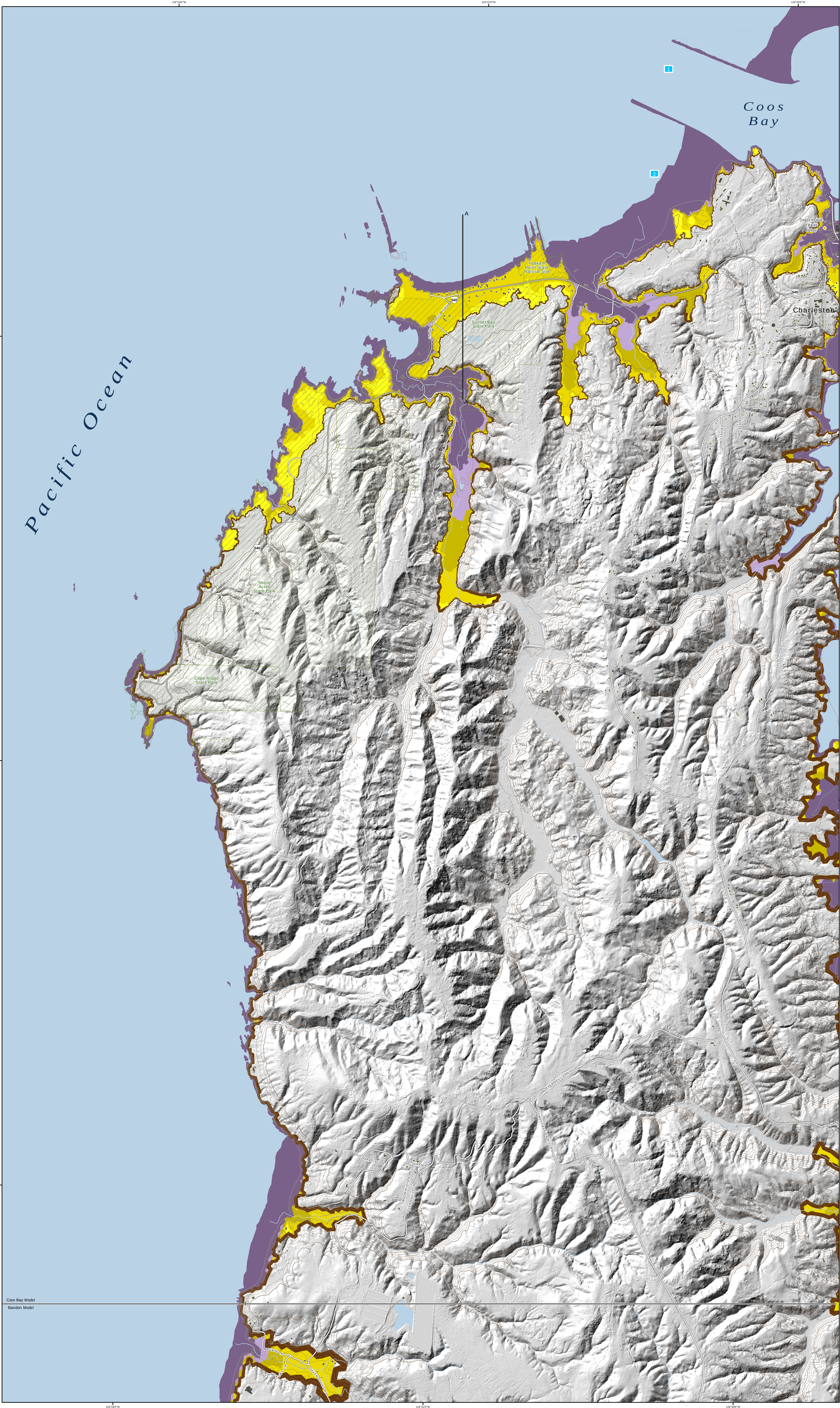
Time since Earthquake (hours)	XXL (feet)	XL (feet)	L (feet)	M (feet)	S (feet)
0.0	0.0	0.0	0.0	0.0	0.0
0.5	85.0	40.0	20.0	10.0	5.0
1.0	40.0	20.0	10.0	5.0	2.0
2.0	10.0	10.0	5.0	2.0	1.0
3.0	45.0	20.0	10.0	5.0	2.0
4.0	35.0	20.0	10.0	5.0	2.0
4.5	30.0	20.0	10.0	5.0	2.0
5.0	35.0	20.0	10.0	5.0	2.0
6.0	30.0	20.0	10.0	5.0	2.0
7.0	25.0	20.0	10.0	5.0	2.0
8.0	25.0	20.0	10.0	5.0	2.0

Figure 5: This chart depicts the tsunami waves as they arrive at the selected reference point (simulated gauge station). It shows the change in wave heights for all five tsunami scenarios over an 8-hour period. The starting water elevation (0.0 hour) takes into account the local land subsidence or uplift caused by the earthquake. Wave heights vary through time, and the first wave will not necessarily be the largest as waves interfere and reflect off local topography and bathymetry.

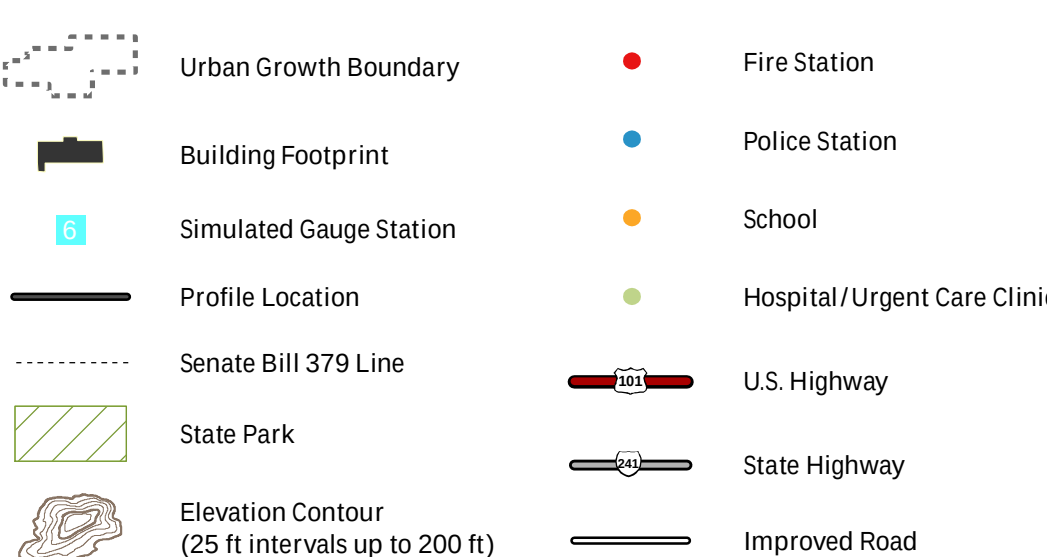
Figure 1 is a cross-sectional profile of the Charleston area, showing elevation (feet NAD83) versus distance along the profile (miles). The profile is labeled **A** and **A'**. The y-axis represents Elevation (feet NAD83) from 0 to 200. The x-axis represents Distance along Profile, miles, from 0 to 1.0. The profile shows the Pacific Ocean, various geological layers (L, M, S), and tsunami scenarios (XXL, XL). Key features include the Charleston Harbor, the Charleston River, and the Charleston Bridge. The profile is labeled **A** and **A'**.

Figure 6: This profile depicts the expected maximum tsunami wave elevation for the five "tsunami T-shirt scenarios" along line A-A. The tsunami scenarios are modeled to occur at high tide and to account for local subsidence or uplift of the ground surface.

2012



Earthquake Size		Average Slip Range (ft)	Maximum Range
	XXL	59 to 72	118 to 144
	XL	56 to 72	115 to 144
	L	36 to 49	72 to 115
	M	23 to 30	46 to 60
	S	13 to 16	30 to 36
	XXL Wet/Dry Zone		



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Coos Bay
Curry

OREGON

Coos-01 Lakeside West
Coos-02 Lakeside East
Coos-03 Sawaders Lake
Coos-04 Haystack
Coos-05 Coos Bay - North Bend
Coos-06 Coos Bay North
Coos-07 Coos Bay - South
Coos-08 Charleston
Coos-09 Barriere - Cape Arago
Coos-10 Isthmus Slough
Coos-11 Canning Slough
Coos-12 Bullards Beach
Coos-13 Lemuel
Coos-14 Coquilt
Coos-15 Quillite River
Coos-16 Bendon
Coos-17 New River

Source Data:
This map is based on hydrodynamic tsunami modeling by Joseph Zhang and the Oregon Sea Grant, Oregon State University, Portland, Oregon. Model data input were created by John T. English and George R. Priest, Department of Geology and Mineral Industries (DOGAMI), Portland, Oregon.

Hydrology data: streams, critical facilities, and building footprints were created by DOGAMI. Senate Bill 379 fire line data were digitized by Rachel R. Lyle and Sean D. Pickett (DOGAMI), in 2013. GIS file here: https://www.dogami.state.or.us/arcgis/rest/services/SL379_FireLine/FeatureServer/0 (p. 10, 2012).

Urban growth boundaries: (2016) were provided by the Oregon Department of Land Conservation and Development (OLCD).

Topographic data: (2009) provided by Coos County were edited by DOGAMI to include the 2009 LIDAR data. The data were then added to a newly constructed north map in the original data layer.

Lidar data: from DOGAMI Lidar Data Quadrangles LDQ0-2009-431254-LD-C2-Coosbay and LDQ0-2009-43124-C3-Charleston

Coordinate System: Oregon Statewide Lambert Conformal Conic, Unit: International Feet, Horizontal Datum: NAD 83 HARN, Vertical Datum: GDA 1988. The map is shown with geographic coordinates: (latitude; longitude).

2007 Working Group on California Earthquake Probabilities (WGCEP)
2008 The Uniform California Earthquake Rupture Functions (UCERF)
2 UCRF 2005 U.S. Geological Survey Open-File Report 2007-1437 and
2008 U.S. Geological Survey Open-File Report 2008-1233
<http://pubs.usgs.gov/of/2007/1437/>

Priest, G. R., 1995. Explanation of mapping methods and use of the hazard maps of the Oregon coast. Oregon Department of Geology and Mineral Industries Online-File Report O-96-57, 65 pp.

Priest, G. R., Goldfinger, C., Wang, K., Zhang, Y., Chang, Y., and Sapsito, A.-M., 2008. Trenching based assessment of the northern Oregon coast: multi-disciplinary approach to define the northern Cascadia Subplateau. Oregon Department of Geology and Mineral Industries Special Paper 41, 87 p.

Wilber, R.C., Zhang, Y., Wang, K., Priest, G.R., Goldfinger, C., Stiemly, L.L., English, T.J., and Farris, P.A., 2014. Simulating tsunami inundation at the Oregon coast: Coupling using hydrodynamic and coastal hazard models. Oregon Department of Geology and Mineral Industries Special Paper 43, 57 p.

Software: Esri ArcGIS® 10.0, Microsoft® Excel®, and Adobe® Illustrator®

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