



The Oregon Department of Geology and Mineral Industries (DOGAMI) has been identifying and mapping the tsunami inundation hazard along the Oregon coast since 1994. In Oregon, DOGAMI manages the National Tsunami Hazard Mitigation Program, which has been administered by the National Oceanic and Atmospheric Administration (NOAA) since 1995. DOGAMI's work is designed to help cities, counties, and other sites in coastal areas reduce the potential for disastrous tsunami-related consequences by understanding and mitigating this geologic hazard. Using federal funding awarded by NOAA, DOGAMI has developed a new generation of tsunami inundation maps to help residents and visitors along the entire Oregon coast prepare for the next Cascadia Subduction Zone (CSZ) earthquake and tsunami.

The CSZ is the tectonic plate boundary between the North American Plate and the Juan de Fuca Plate (Figure 1). These plates are converging at a rate of about 1.5 inches per year, but the movement is not smooth and continuous. Rather, the plates lock in place, and unreleased energy builds over time. At intervals, this accumulated energy is violently released in the form of a megathrust earthquake, a rupture, where the North American Plate suddenly slips westward over the Juan de Fuca Plate. This rupture causes a vertical displacement of water that creates a tsunami (Figure 2). Similar rupture processes and tsunamis have occurred elsewhere on the planet where subduction zones exist: for example, offshore Chile in 1960 and 2010, offshore Alaska in 1964, near Sumatra in 2004, and offshore Japan in March 2011.

CSZ Frequency: Comprehensive research of the offshore geologic 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 at least 1.2 miles inland, off tsunami 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 490 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 about every 500 years (WGCEP, 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 snaps westward off the Juan de Fuca Plate during a CSZ event. DOGAMI has modeled a wide range of earthquake and tsunami sizes that take into account different fault geometries that could amplify the amount of seawater displacement and increase tsunami inundation. Seismic geophysical profiles show that there may be a steep splay fault running nearly parallel to the CSZ but closer to the Oregon coastline (Figure 1). The effect of this splay fault moving during a full-rupture CSZ event would be an increase in the amount of vertical displacement of the Pacific Ocean, resulting in an increase of the tsunami inundation onshore in

[illegible]

Figure 1: This block diagram depicts the tectonic setting of the region. See Figure 2 for the sequence of

A

B

C

D

E

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

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

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

Displaced and uplifted Pacific Ocean water rushes in all directions.

Along the Oregon coast, tsunami waves run up onto the land for several hours.

		Entire Map Area		Unincorporated Areas	
Total Buildings		143		143	
Buildings within Tsunami Zones*					
Small		5		5	
Medium		5		5	
Large		30		30	
Extra Large		32		32	
Extra Extra Large		32		32	
Percent of Buildings within Tsunami Zones					
Small		3.5%		3.5%	
Medium		3.5%		3.5%	
Large		21.0%		21.0%	
Extra Large		22.4%		22.4%	
Extra Extra Large		22.4%		22.4%	

Country	Percentage
Uganda	10%
Kenya	25%

Area	Percentage of Buildings within Tsunami Zones
Entire Map Area	~4%
Entire Map Area	~22%
Unincorporated Areas	~4%
Unincorporated Areas	~22%

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.

Change in water level for five tsunami scenarios at the simulated gauge station shown on the map

XL
X
L
M
S

Sizes River at Mouth (Station 12)

End of simulated gauge station data

Elevation, feet (NAVD83)

Time since Earthquake (hours)

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 five tsunami scenarios over an 6-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.

A CAPE BLANCO - WEST **A'**

Elevation, feet (NAVD83)

200 ft
160 ft
120 ft
80 ft
40 ft
0 ft

0 mi 0.25 mi 0.5 mi

Distance along Profile, miles

B CAPE BLANCO - EAST **B'**

Elevation, feet (NAVD83)

200 ft
160 ft
120 ft
80 ft
40 ft
0 ft

0 mi 0.25 mi 0.5 mi

Distance along Profile, miles

Legend:

- Cape Blanco Rg
- Pacific Ocean

Figure 6: These profiles depict the expected maximum tsunami wave elevation for the five "Tsunami T-shirt scenarios" along lines A-A' and B-B'. The tsunami scenarios are modeled to occur at high tide and to account for local subsidence or uplift of the ground surface.

Oregon. DOGAMI has also incorporated physical evidence that suggests that portions of the coast may drop 4 to 10 feet during the earthquake; this effect is known as subsidence. Detailed information on fault geometries, subsidence, computer models, and the methodology used to create the tsunami scenarios presented on this map can be found in DOGAMI Special Papers 41 (Priest and others, 2009) and 43 (Witter and others, 2011).

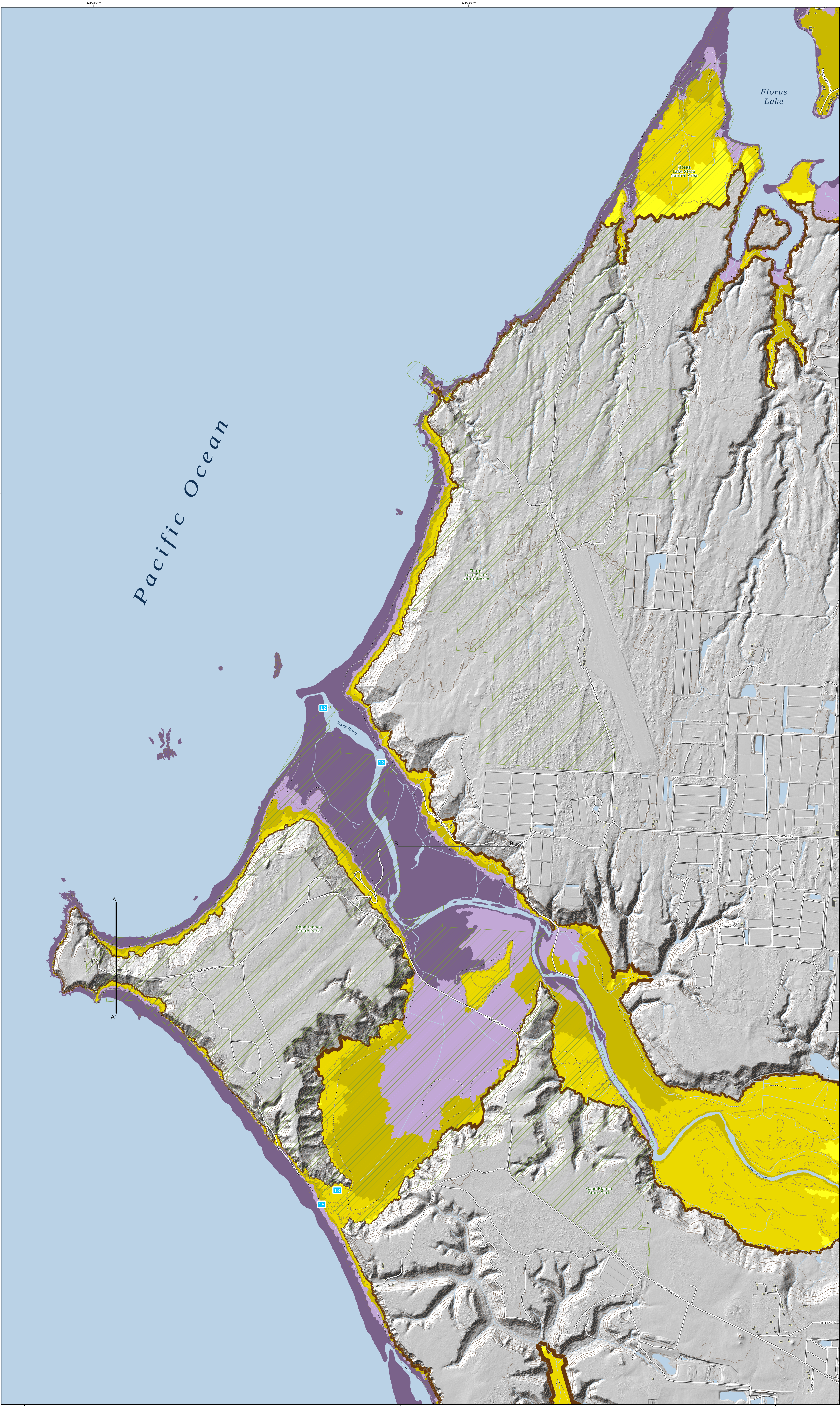
This tsunami inundation map displays the output of computer models representing five selected tsunami scenarios, all of which include the earthquake-produced subsidence and the tsunami-amplifying effects of the spillaway fault. Each scenario assumes that a tsunami occurs at Mean Higher High Water (MHHW) tide; MHHW is defined as the average height of the higher high tides observed over an 18-year period at the Port Orford tide gauge. To make it easier to understand this scientific material and to enhance the educational aspects of hazard mitigation and response, the five scenarios are labeled as "T-shirt sizes" ranging from Small, Medium, Large, Extra Large, to Extra Extra Large (S, M, L, XL, XXL). The map legend depicts the respective amounts of SL, the frequency of occurrences, and the earthquake magnitude for these five scenarios. Figure 4 shows the cumulative number of buildings inundated within the map area.

The computer simulation model output is provided to DCGAMI as millions of points with values that indicate whether the location of each point is wet or dry. These points are converted to wet and dry contour lines that form the extent of inundation. The transition area between the wet and dry contour lines is termed the Wet/Dry Zone, which equates to the amount of error in the model when determining the maximum inundation for each scenario. Only the XXL Wet/Dry Zone is shown on this map.

This map also shows the regulatory tsunami inundation line (Oregon Revised Statutes 455.646 and 455.647), commonly known as the Senate Bill 379 line. Senate Bill 379 (1995) instructed DOGAMI to establish the area of expected tsunami inundation based on scientific evidence and tsunami modeling in order to prohibit the construction of new essential and special occupancy structures in this tsunami inundation zone (Priest, 1996).

Time Series Graphs and Wave Elevation Profiles: In addition to the tsunami scenarios, the computer model produces time series data for "gauge" locations in the area. These points are simulated gauge locations that record the time, in seconds, of the tsunami wave arrival and the wave height observed. It is especially noteworthy that the greatest wave height and velocity observed are not necessarily associated with the first tsunami wave to arrive onshore. Therefore evacuees should not assume that the tsunami event is over until the proper authorities have sounded the all-clear signal at the end of the evacuation. Figure 5 depicts the tsunami waves as they arrive at a simulated gauge station. Figure 6 depicts the overall wave height and inundation extent for all five scenarios at the profile locations shown on this map.

2012



Earthquake Size	Average Slip Range (ft)	Maximum Slip Range (ft)	Time to Accumulate Slip (yrs)	Earthquake Magnitude
XXL	59 to 72	118 to 144	1,200	-9.1
XL	56 to 72	115 to 144	1,050 to 1,200	-9.1
L	36 to 49	72 to 98	650 to 800	-9.0
M	23 to 30	46 to 62	425 to 525	-8.9
S	13 to 16	30 to 36	300	-8.7
XXL Wet/Dry Zone				

Map of Oregon showing 16 numbered locations for the 2009-2010 field season. The locations are distributed across the state, with a concentration in the Willamette Valley and along the coast. An inset map shows the location of Oregon within the Pacific Northwest region.

Location	Location
Curr-01 Longlens	Curr-09 Gold Beach
Curr-02 Cape Nebo	Curr-10 Cape Nebohan
Curr-03 Denmark	Curr-11 Priskel River
Curr-04 Hogue Mountain	Curr-12 Garfieldville
Curr-05 Sisters Rock	Curr-13 Har's Beach
Curr-06 Humboldt Bay	Curr-14 Chiloqu River
Curr-07 Nesika Beach	Curr-15 Winchuck River
Curr-08 New Hope River	Curr-16 Brookings

Source Data:
This map is based on hydrodynamic tsunami modeling by Joseph Zhang, Oregon Health and Science University, Portland, Oregon. Model data were created by John T. English and George R. Priest, Department of Geology and Mineral Industries (DOGAMI), Portland, Oregon.
Hydrology data, contours, critical facilities, and building footprints were created by DOGAMI. Section 819 379 line were redigitized by Rachel R. Lyles Smith and Sean G. Pickner, DOGAMI, in 2011 (GIS file set, in press, 2012).
Urban growth boundaries (2010) were provided by the Oregon Department of Land Conservation and Development (DLCD).
Transportation data (2010) provided by Curry County were edited by DOGAMI to improve the spatial accuracy of the features or to add newly constructed roads not present in the original data layer.
Lidar data are from DOGAMI Lidar Data Quadrangles LDOQ-2009-4212a G4-Sides, LDOQ-2009-4212a G5-CapeBlanca, LDOQ-2009-4212a G4-Sides, LDOQ-2009-4212a G5-CapeBlanca, LDOQ-2009-4212a

Version 2 (UCERF 2). U.S. Geological Survey Open-File Report 2007-1437 and California Geological Survey Special Report 2003 (<http://pubs.usgs.gov/of/2007/1437/>).

Priest, G. R. 1995. Explanation of mapping methods and use of the tsunami hazard maps of the Oregon coast. Oregon Department of Geology and Mineral Industries Open-File Report O-95-67. 95 p.

Priest, G.R., Goldfinger, C., Wang, K., Witter, R.C., Zhang, Y., and Eggebo, A.M. 2009. Tsunami hazard assessment of the northern Oregon coast: a multi-deterministic approach tested at Cannon Beach, Clatsop County, Oregon. Oregon Department of Geology and Mineral Industries Special Report 41. 87 p.

Witter, R.C., Zhang, Y., Wang, K., Priest, G.R., Goldfinger, C., Simey, L.L., Eggebo, A.M., and Zerpa, P.A. 2011. Simulating tsunami inundation at Bendon, Coos County, Oregon, using hypothetical Cascadia and Alaska earthquake scenarios. Oregon Department of Geology and Mineral Industries Special Report 43. 57 p.

Funding: This map was funded under award #NA00NW54670014 by the National Oceanic and Atmospheric Administration (NOAA) through the National Tsunami Hazard Mitigation Program.

Map Data Creation/Development:
Tsunami Inundation Scenario: George R. Priest, Laura L. Stimpely,
Daniel E. Cox, Paul A. Ferro, Sean G. Pickner, Rachel R. Lyles Smith
Basemap Data: Kaleena L.B. Hughes, Sean G. Pickner

Map Production:
Cartography: Kaleena L.B. Hughes, Sean G. Pickner,
Taylore E. Womble
Text: Don W.T. Lewis, Rachel R. Lyles Smith
Editing: Don W.T. Lewis, Rachel R. Lyles Smith
Publication: Deborah A. Schueller
Map Date: 09/12/2012

