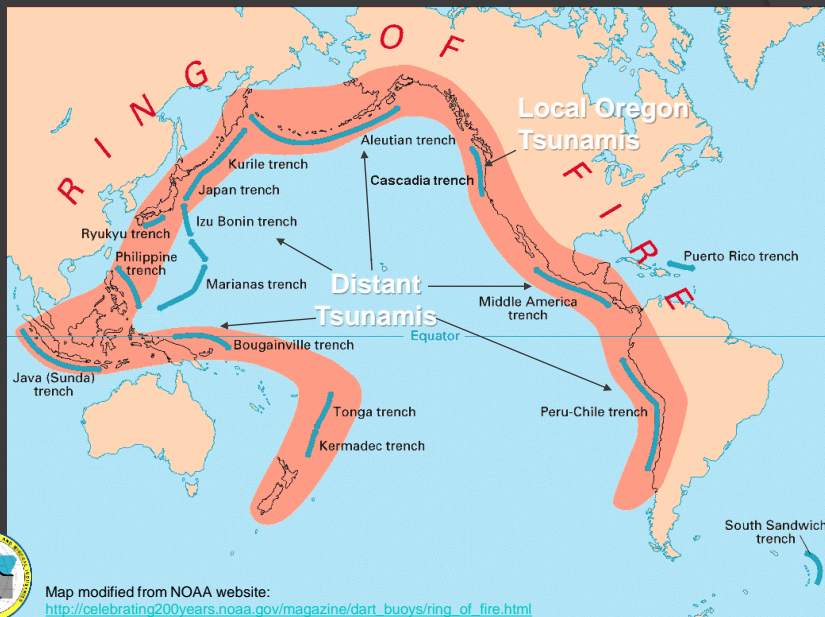


# TSUNAMI HAZARD BASICS



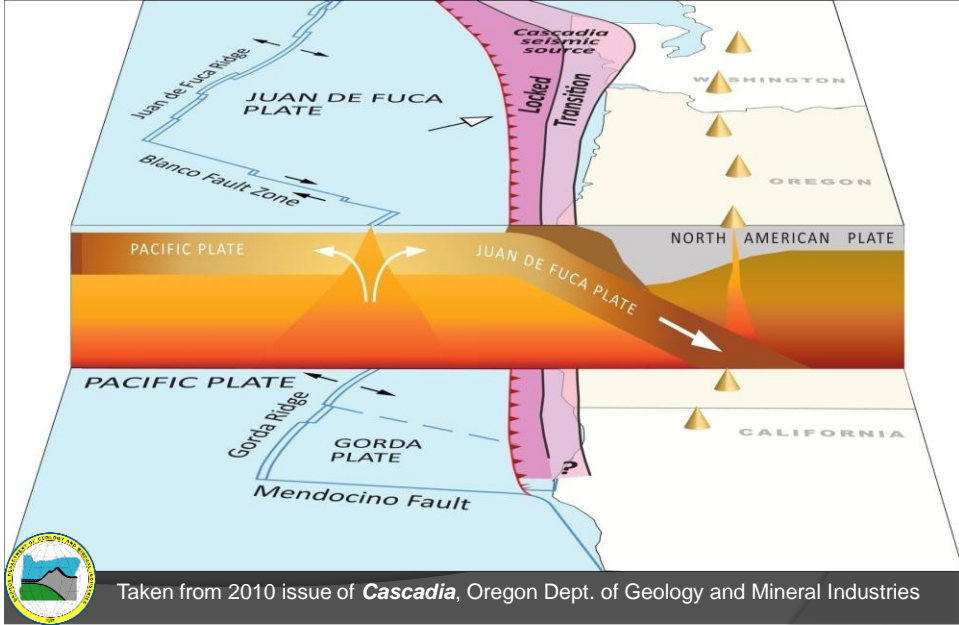
Tsunami Outreach Oregon  
Oregon Department of Geology and Mineral Industries

## Earthquake Sources for Tsunamis



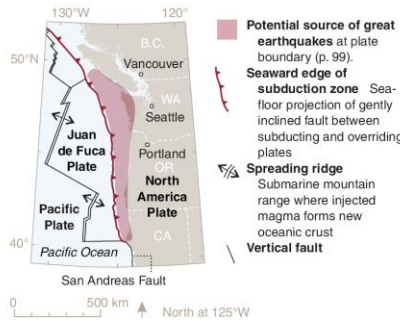
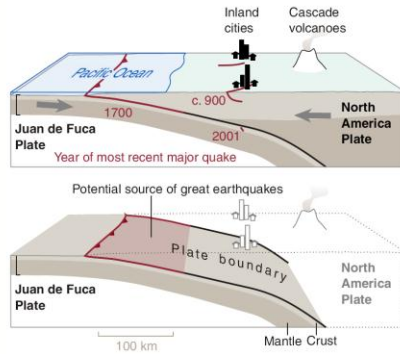
Map modified from NOAA website:  
[http://celebrating200years.noaa.gov/magazine/dart\\_buoys/ring\\_of\\_fire.html](http://celebrating200years.noaa.gov/magazine/dart_buoys/ring_of_fire.html)

# Plate Tectonic Map of the Pacific Northwest – the “Cascadia” Region



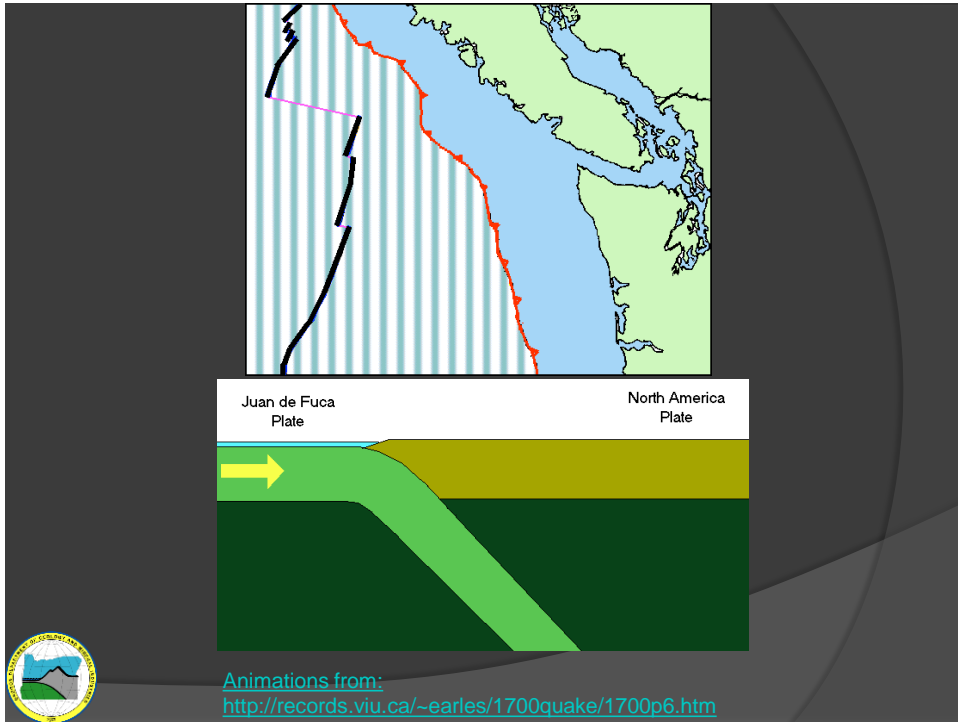
Taken from 2010 issue of *Cascadia*, Oregon Dept. of Geology and Mineral Industries

## EARTHQUAKE SOURCES AT CASCADIA

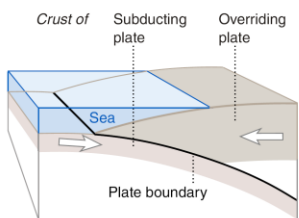


Atwater et al. (2005)

<http://pubs.usgs.gov/pp/pp1707/>

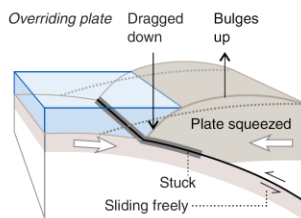


**MAKING A TSUNAMI**

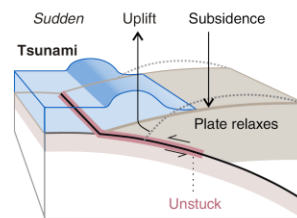


OVERALL, a tectonic plate descends, or "subducts," beneath an adjoining plate. But it does so in a stick-slip fashion.

Taken from Atwater (2005)

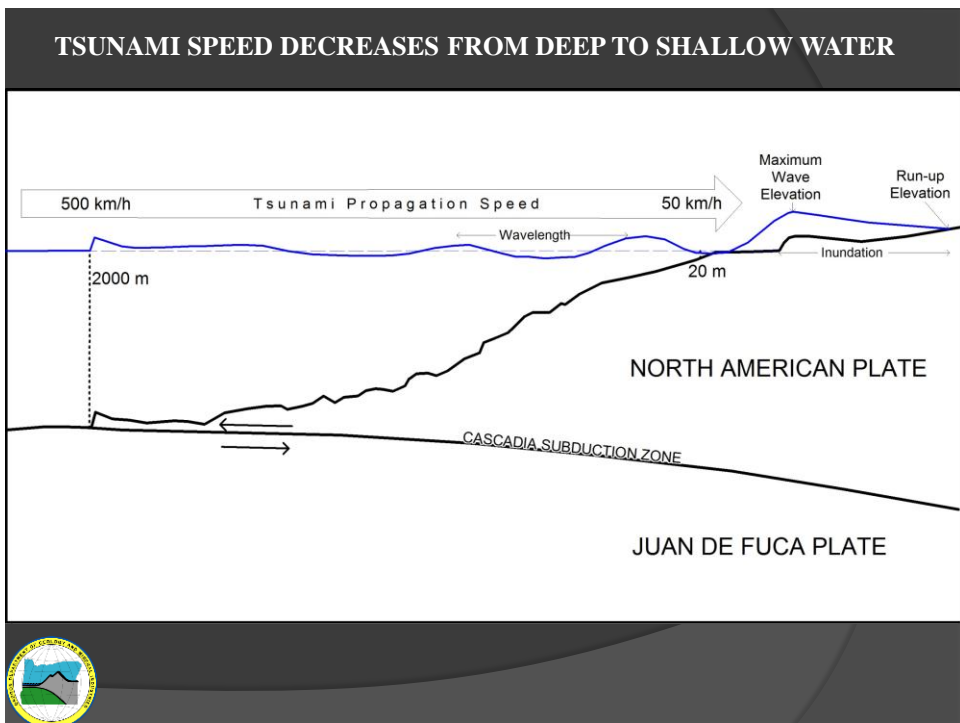
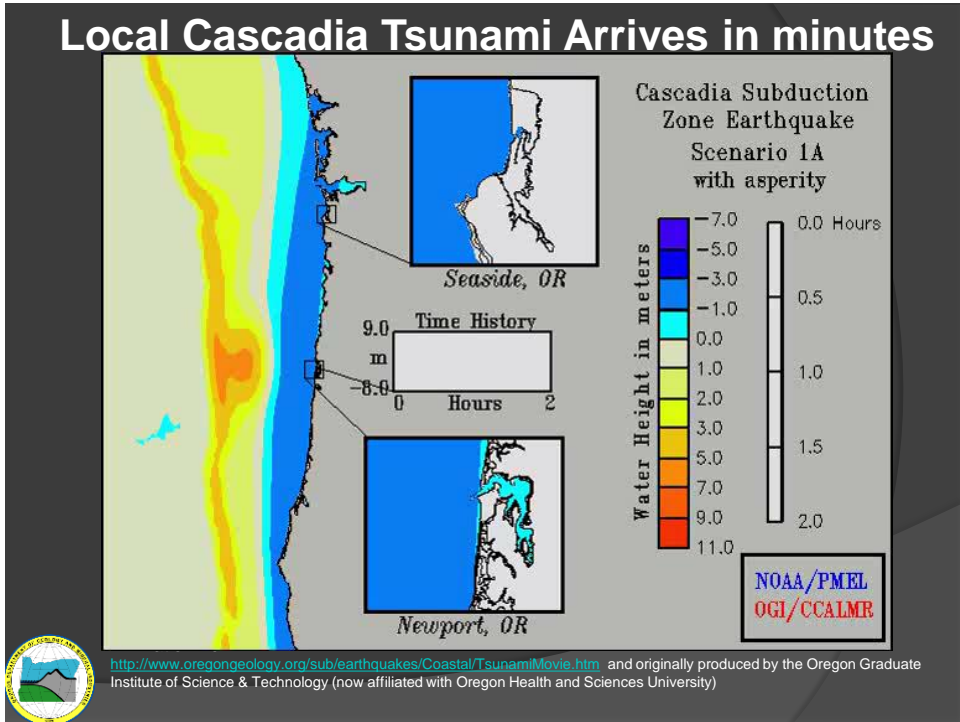


BETWEEN EARTHQUAKES the plates slide freely at great depth, where hot and ductile. But at shallow depth, where cool and brittle, they stick together. Slowly squeezed, the overriding plate thickens.



DURING AN EARTHQUAKE the leading edge of the overriding plate breaks free, springing seaward and upward. Behind, the plate stretches; its surface falls. The vertical displacements set off a tsunami.





# Tsunami Wave Appearance

- A tsunami wave crest has three general appearances from shore:
  - Fast-rising tide
  - Cresting wave
  - A step-like change in the water level that advances rapidly (called a bore)
- Series of waves
  - Most tsunamis come in a series of waves that may last for several hours
  - The outflow of water back to the sea between waves can cause more damage than the original incoming wave fronts
  - The first wave may not be the largest
  - Water rises from the beginning = **leading elevation wave**
  - Water withdraws from the beginning = **leading depression wave**



A bore on the Qian Tang Jiang River, China

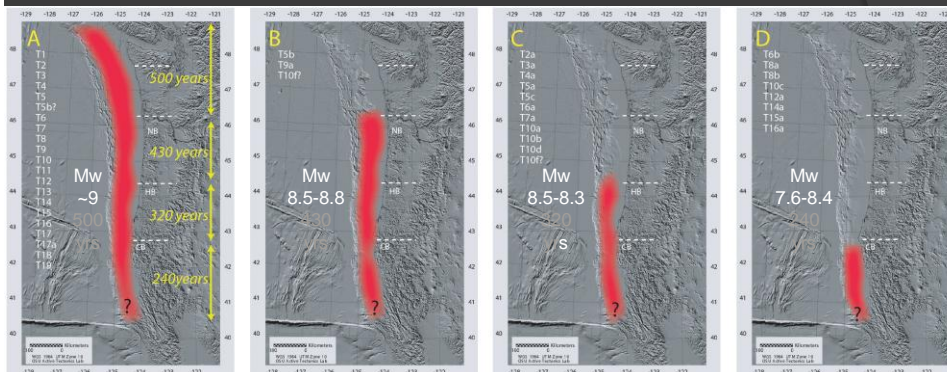


This slide is modified from [http://earth.esa.int/workshops/polinsar2007/presentations/38\\_boerner.pdf](http://earth.esa.int/workshops/polinsar2007/presentations/38_boerner.pdf)

## How big will the “Big One” be from Cascadia?

**Turbidites** reveal what actually happened over the last 10,000 years.

(Illustration below is modified from Goldfinger et al. (in press) by adding magnitude estimates and some labels)

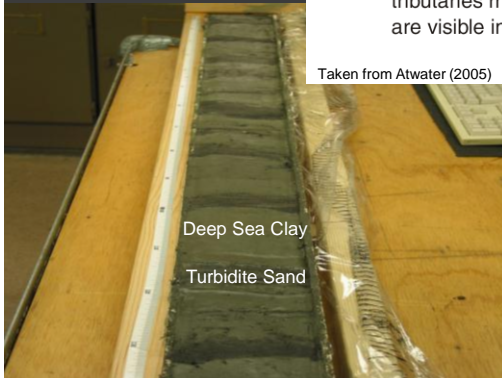


- 20 full length or nearly full length ruptures.
- 2 to 3 ruptures of ~75% of the length of the margin.
- 19 shorter ruptures in the southern part of the margin.



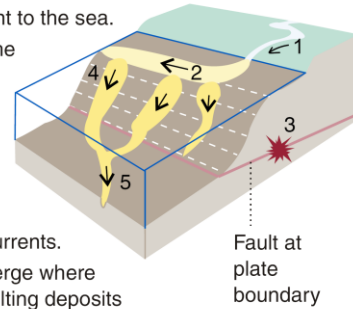
## Turbidites in a deep sea core.

(picture provided by Chris Goldfinger, 2010)



## SHAKING LEAVES A DEEP-SEA DEPOSIT

- 1 **River** delivers sediment to the sea.
- 2 **Sediment** settles on the continental shelf.
- 3 **An earthquake** shakes the continental shelf and slope.
- 4 **Shaken sediment** descends submarine canyons as turbidity currents.
- 5 **Turbidity currents** merge where tributaries meet. Resulting deposits are visible in sediment cores.



Taken from Atwater (2005)

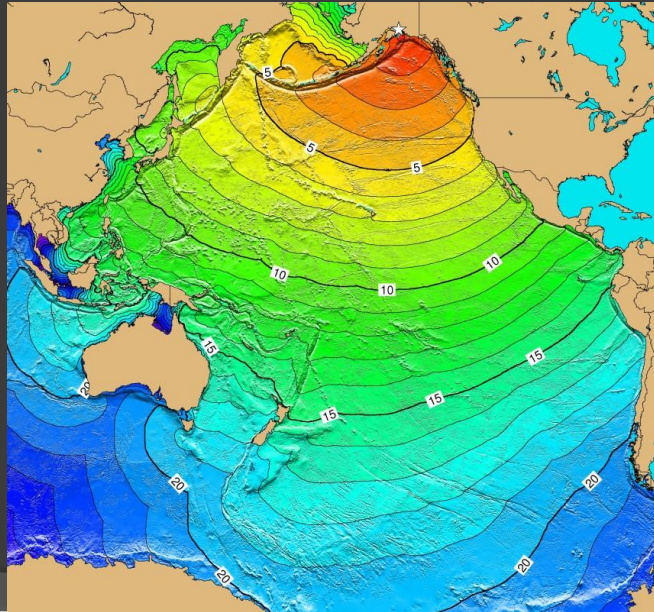


# Distant Tsunami

- **Arrives 4 + hours after the earthquake**
- Lower damage and flooding than local tsunamis
- National Tsunami Warning System can warn you



Nearest Distant Tsunami Source is Alaska  
 1964 Alaska Tsunami – Arrived in ~4 hrs



Map is from [http://www.ngdc.noaa.gov/hazard/icons/1964\\_0328.jpg](http://www.ngdc.noaa.gov/hazard/icons/1964_0328.jpg)

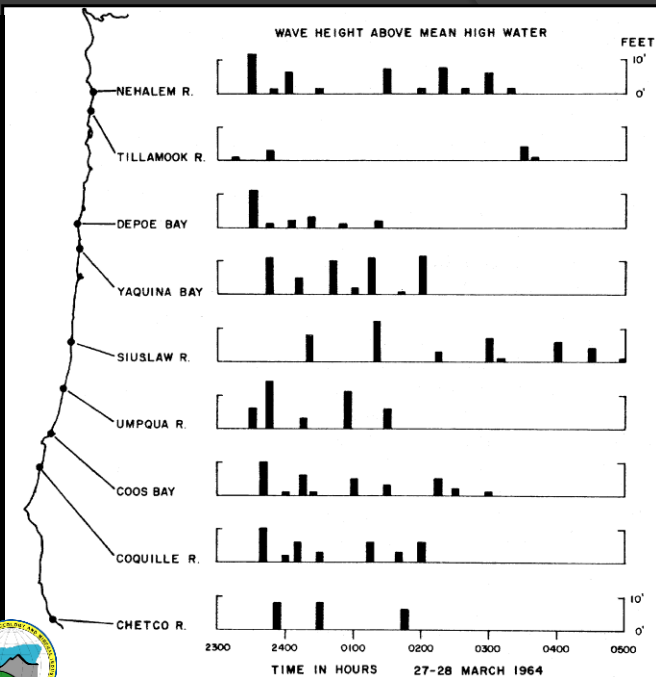


The “Big One” from a distant source already happened!

Great Alaskan Earthquake of 1964 was a magnitude 9.2.

Tsunami run-up in Oregon was generally  $\leq 20$  ft at the open coast.

Figure from Schatz et al. (1964)



# Local Tsunami

- **Arrives minutes after the earthquake**
- Much higher waves
- Much further inland penetration
- NOAA Tsunami Warning System ineffective
- **Earthquake = Only Warning**



Source of picture:

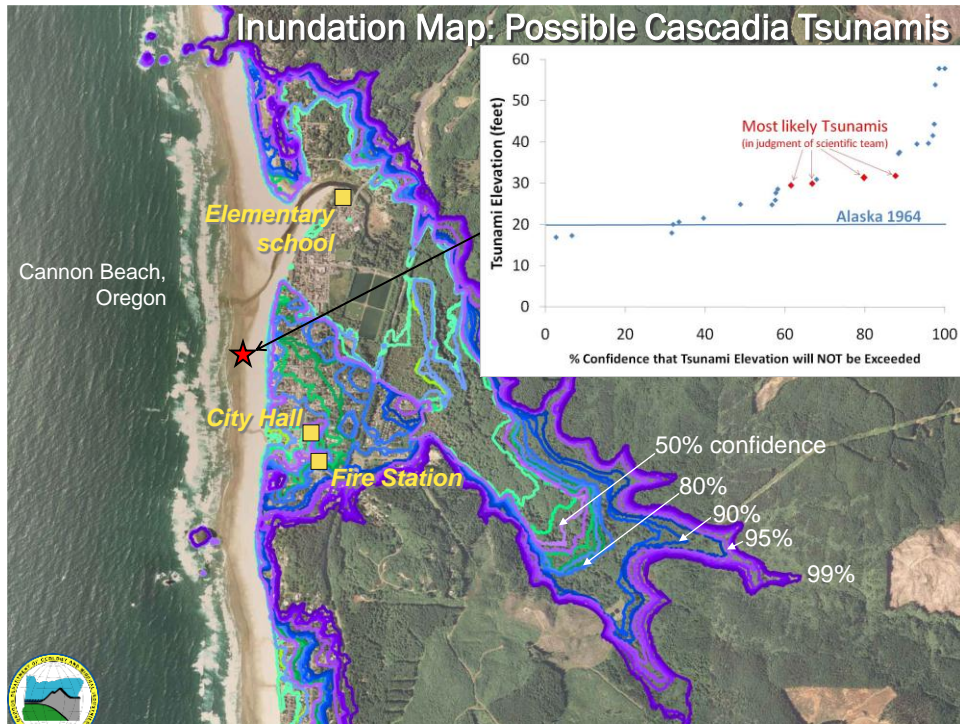
<http://www.usc.edu/dept/tsunamis/2005/tsunamis>

©2005 USC Tsunami Research Group

## Port Damage at Banda Aceh

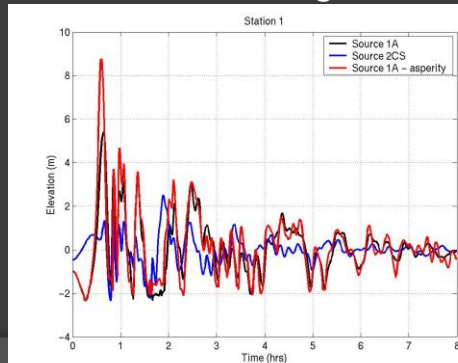






## Tsunami Waves Arrive for Hours for both Distant and Local Tsunamis

- Many waves
- 4-5 hours of big waves
- 8-10 hours of significant waves



Time history is from Priest and others (2003) for Cascadia tsunami wave arrivals at the mouth of the Alsea Bay near Waldport, Oregon.



Tsunami Deposits Record  
- Frequency  
- Relative size

Core Site

Distant Tsunamis

Local Cascadia Tsunami

260 yrs no tsunami sand!

1964  
1960

Jan. 26, 1700

Crescent Beach Motel, 1964

Crescent City 1964 Alaska Tsunami Inundation

Photos provided by Lori Dengler, Humboldt State University

**Tsunami Evacuation Route**  
CANNON BEACH AND ARCH CAPE AREAS, OREGON

IF YOU FEEL AN EARTHQUAKE:  
- Drop, cover, and hold.  
- Move immediately inland to higher ground.  
- Do not walk for an official warning.

SI USTED SIENTE EL TERREMOTO:  
- Tílese al suelo, cúbrase, y agárrase.  
- Déjese de inmediato a un lugar más alto que el nivel del mar.  
- No espere por un aviso oficial.

OUTSIDE HAZARD AREA: Evacuate to this area for all tsunami warnings, if you feel an earthquake.

LOCAL CASCADIA EARTHQUAKE AND TSUNAMI: Evacuate areas for tsunami from an earthquake of the Oregon Coast.

DISTANT TSUNAMI: Evacuate areas from a distant tsunami from an earthquake far away from the Oregon Coast.

ZONA DE PELIGRO EXTERIOR: Evacue a esta área para todos los avisos de tsunami, si usted siente un terremoto.

IMPACTO LOCAL, terremoto de Cascadia: Zona de evacuación para un terremoto local de un tamaño similar al de la costa de Oregón.

IMPACTO DISTANTE: Zona de evacuación para un tsunami distante de un terremoto lejos de la costa de Oregón.

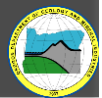
MAP SYMBOLS / SIMBOLOS DEL MAPA

Evacuation route/  
Ruta de evacuación  
Assembly area/  
Área de reunión  
Tsunami warning siren/  
Sirena de aviso de tsunami  
City Hall/Municipalidad  
Bridge/Puentes  
Fire Department/Departamento de Bomberos  
Police/Policia

SCALE / ESCALA  
0 0.5 km  
0 0.5 km

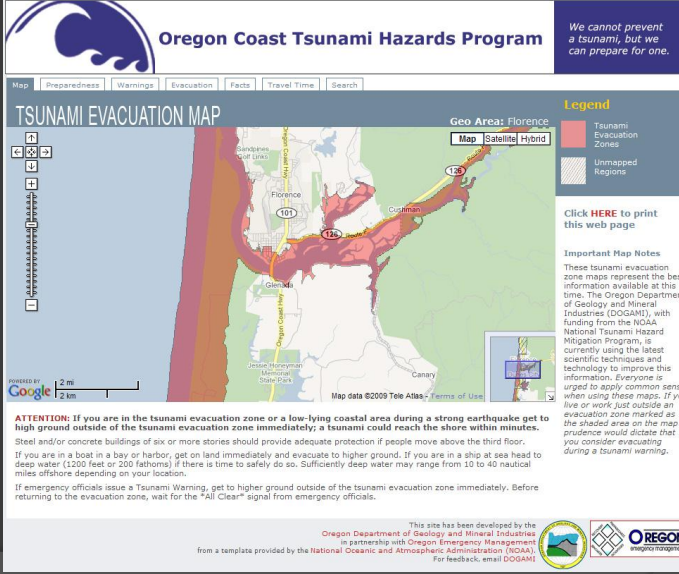
# CANNON BEACH , OREGON EVACUATION MAP

Map downloaded from:  
<http://www.oregontsunami.org>



# Oregon Tsunami Evacuation Map Viewer

<http://www.oregontsunami.org>



**Oregon Coast Tsunami Hazards Program**

*We cannot prevent a tsunami, but we can prepare for one.*

Map | Preparedness | Warnings | Evacuation | Facts | Travel Time | Search

## TSUNAMI EVACUATION MAP

Geo Area: Florence

Map | Satellite | Hybrid

**Legend**

- Tsunami Evacuation Zones
- Unmapped Regions

Click **HERE** to print this web page

**Important Map Notes**

These tsunami evacuation zone maps represent the best information available at this time. The Oregon Department of Geology and Mineral Industries (DOGAMI), with funding from the NOAA National Tsunami Hazard Mitigation Program, is currently using the latest scientific techniques and technology to improve this information. Everyone is urged to apply common sense when using these maps. If you live or work just outside an evacuation zone marked as the shaded area on the map, prudence would dictate that you consider evacuating during a tsunami warning.

**ATTENTION: If you are in the tsunami evacuation zone or a low-lying coastal area during a strong earthquake get to high ground outside of the tsunami evacuation zone immediately; a tsunami could reach the shore within minutes.**

Steel and/or concrete buildings of six or more stories should provide adequate protection if people move above the third floor.

If you are in a boat in a bay or harbor, get on land immediately and evacuate to higher ground. If you are in a shop at sea head to deep water (1200 feet or 200 fathoms) if there is time to safely do so. Sufficiently deep water may range from 10 to 40 nautical miles offshore depending on your location.

If emergency officials issue a Tsunami Warning, get to higher ground outside of the tsunami evacuation zone immediately. Before returning to the evacuation zone, wait for the "All Clear" signal from emergency officials.

This site has been developed by the Oregon Department of Geology and Mineral Industries in partnership with Oregon Emergency Management in partnership with the National Oceanic and Atmospheric Administration (NOAA). For feedback, email [DOGAMI](mailto:DOGAMI).

## FINAL MESSAGE

If you feel a strong earthquake at the coast,  
get to high ground as fast as you can.

**DO NOT** wait around for any other warning!

**DO NOT** go back to the evacuation zone until  
local officials say it is okay.

