OREGON DEPARTMENT OF GEOLOGY & MINERAL INDUSTRIES

Mission: "Provide Earth Science Information To Make Oregon Safe and Prosperous"

EARTHQUAKES & TSUNAMIS

Lidar

Earthquake/Tsunami Science

Educate & Mitigate

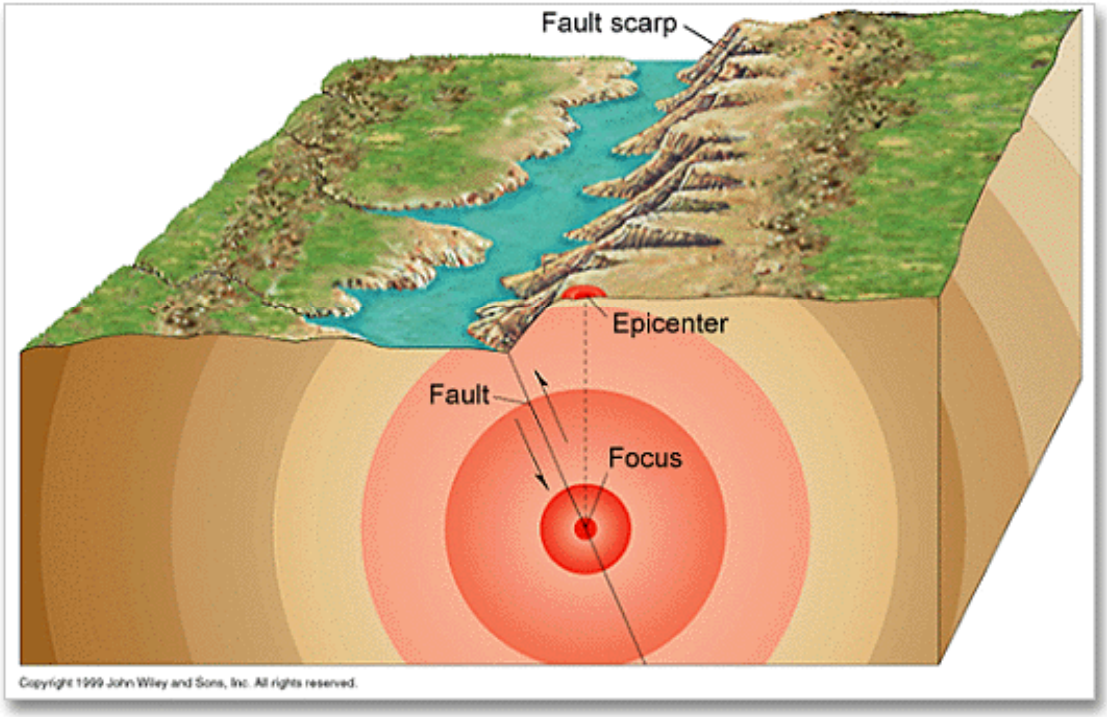
Today's Presentation

- Earthquake Science
- Two Kinds of Tsunami: Distant vs. Local
- Lessons from Japan
- 10,000-year History of Oregon Earthquakes
- New Tsunami Maps
- How You Can Prepare

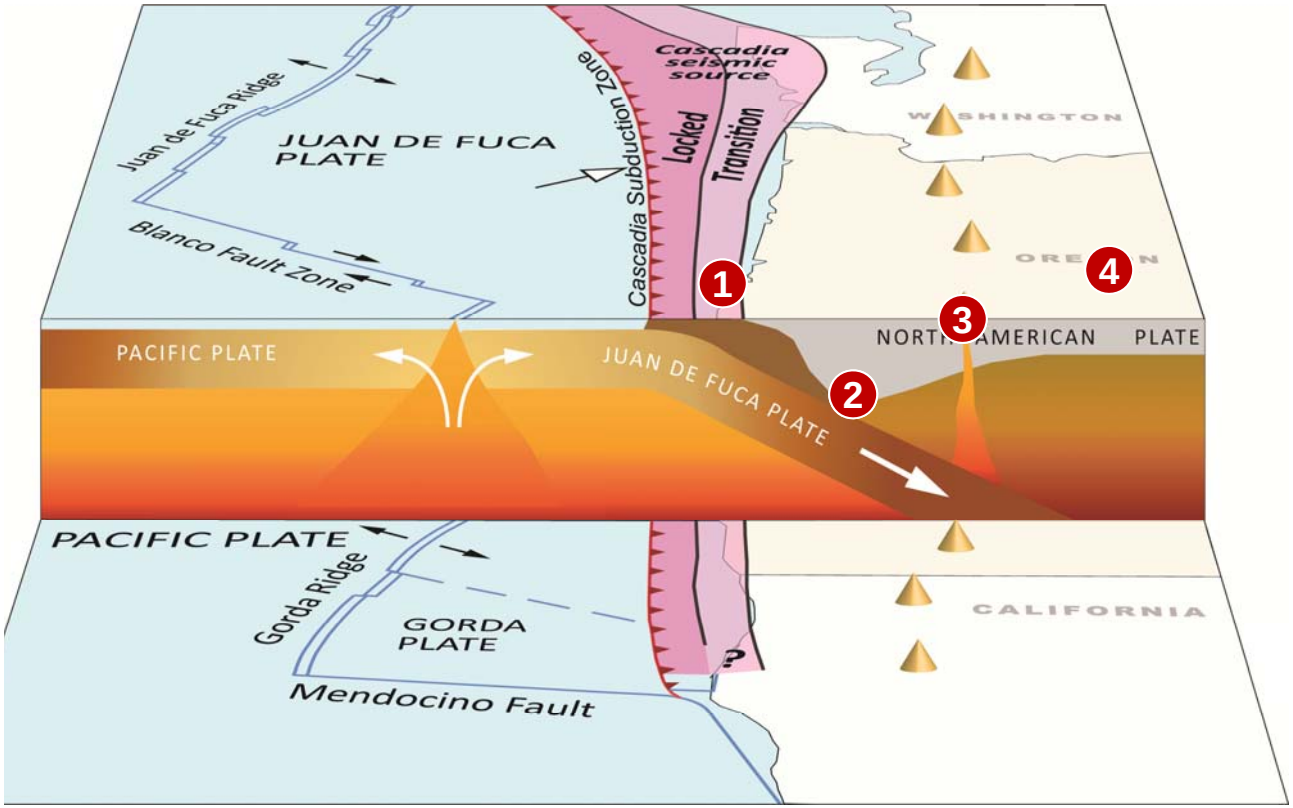
Earthquake and Tsunami Science

Earthquake Basics

- Earthquakes occur along a fault or fault system
- Epicenter = the location on the earth's surface directly above the origin of the earthquake
- Magnitude = a measure of how much energy is released in all directions
- Bigger faults make bigger earthquakes
- Bigger earthquakes last a longer time



Do you know Oregon's four kinds of earthquake sources?



1 Cascadia Subduction Zone

Example: the 1700 earthquake that caused shaking and a tsunami that inundated the OR coast and reached as far as Japan.

2 Interplate

Example: the 2001 Nisqually, WA earthquake that affected Washington and northwestern Oregon.

3 Volcanic

Example: the 1980 Mount St. Helens eruption-related earthquakes.

4 Crustal

Example: the 1993 Scotts Mills and Klamath Falls earthquakes. Crustal earthquakes also occur in SE Oregon where the crust is pulling apart.

Earthquake Frequency & Size

There are many earthquakes each year, only some are felt.

Number of Earthquakes per Year (World)	Number of Earthquakes per Year (USA)	Earthquake Magnitude	Energy Released [Number of Atom Bombs]	Examples
1,300,000	?	2.0	0.00	
130,000	?	3.0	0.00	
13,000	380	4.0	0.00	
1,319	57	**5.0**	0.03	
134	6	**6.0**	0.79	Klamath Falls ('93)
15	1	**7.0**	25	LA ('84) SF ('89) Kobe ('95) Haiti ('10)
1	-	**8.0**	791	China ('76)
-	-	**9.0**	**25,003**	**Sumatra ('04), Japan ('11)**
		9.1	35,005	
		9.3	75,010	Alaska ('64)
		9.5	137,518	Chile ('60)

What Controls the Level of Shaking?

- **Magnitude**: **More Energy Released**
- **Distance**: **Shaking declines with distance**
- **Local Soils**: **the soil type can amplify the shaking**

Possible Shaking Intensity/Effects

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

III. **Weak** – Felt indoors, especially on upper floors of buildings. Vibrations similar to a passing truck.

IV. **Light** – Vibration felt like passing of heavy trucks. Stopped cars rock. Windows, dishes, doors rattle. Wooden walls and frames creak.

V. **Moderate** – Felt by nearly everyone; sleepers awakened. Small, unstable objects overturned. Doors swing. Pictures move. Pendulum clocks stop.

VI. **Strong** – Felt by all. People walk unsteadily. Some heavy furniture moved. Small objects fall off shelves. Pictures off walls.

VII. **Very strong** – Difficult to stand or walk. Noticed by drivers of cars. Slight to moderate damage in well-built structures; considerable damage in poorly built structures.

VIII. **Severe** – Steering of cars affected. Extensive damage to buildings with partial collapse. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Wood-frame houses moved on foundations if not bolted.

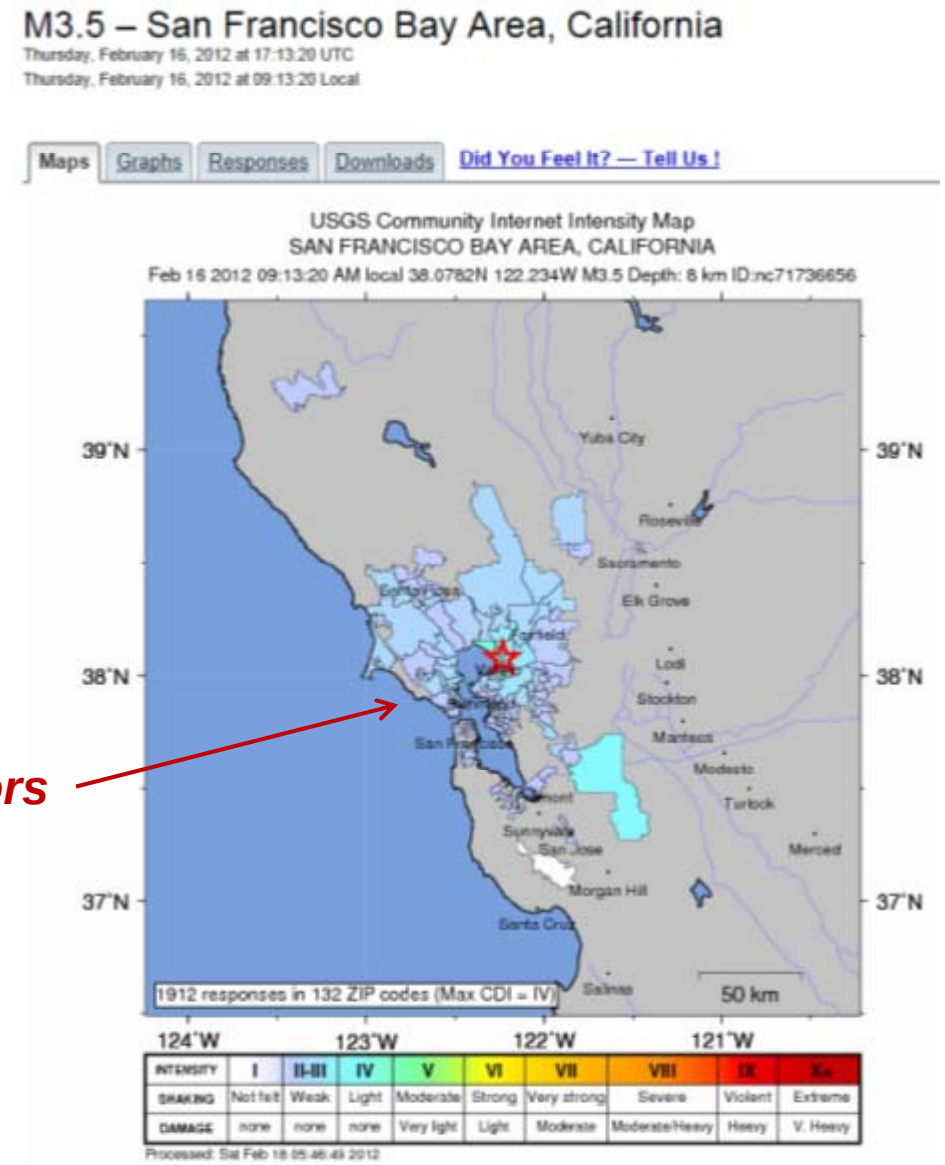
IX. **Violent** – General panic. Damage to buildings ranges from collapse to serious damage.

M3.5 Earthquake *Might* be Felt

February 16, 2012

- **San Francisco Area**
  - **Magnitude 3.5**
  - **5 miles deep**
    - **9:13am local time**
    - **Reported as Felt by 1,912 people**

Note the shaking intensity colors

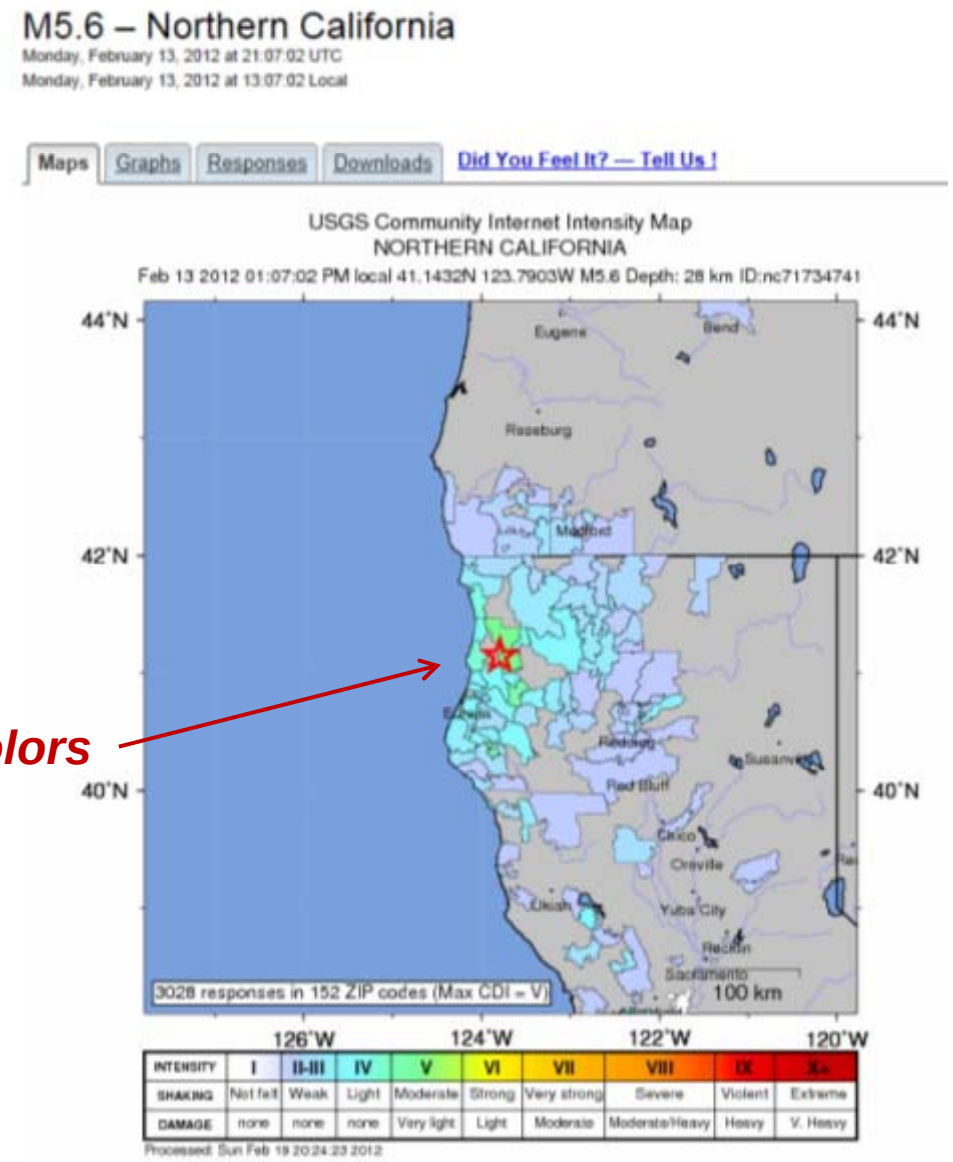


M5+ Earthquake *Usually* Felt

February 13, 2012

- **Northern California**
  - **Magnitude 5.6**
  - **17 miles deep**
    - **1:07pm local time**
    - **Reported as Felt by 3,028 people**

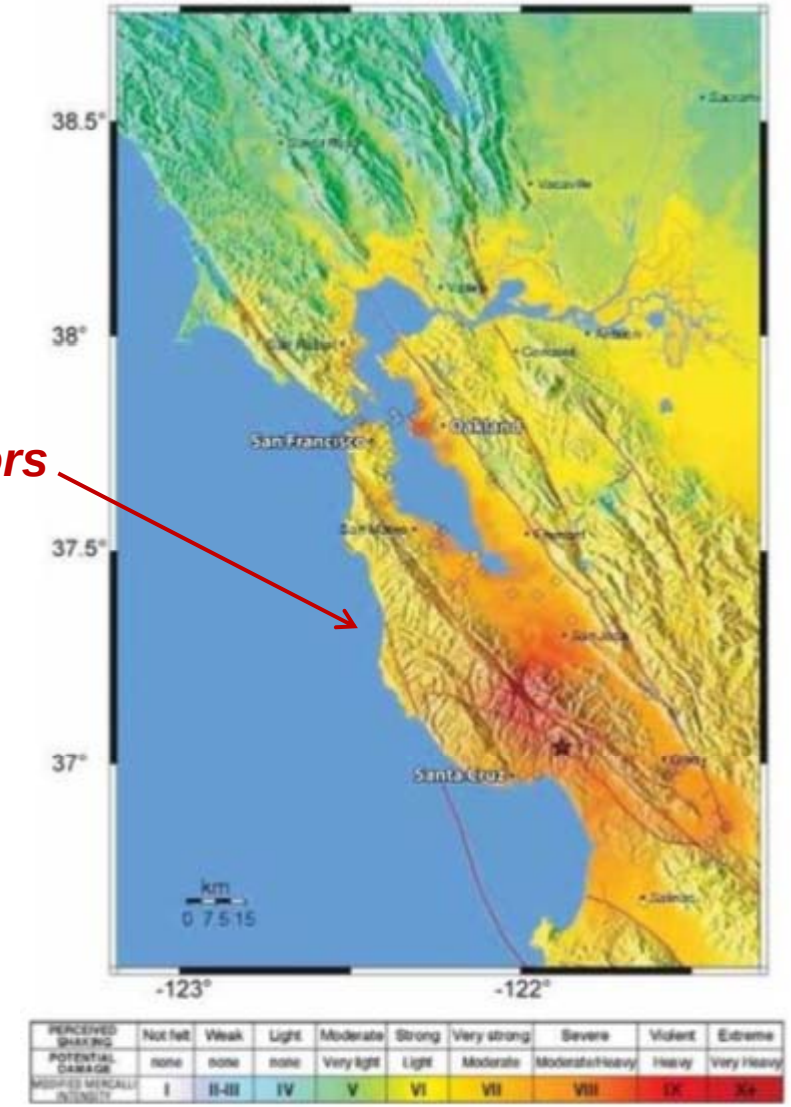
Note the shaking intensity colors



M7 Earthquake

- **Ground Can Shake *Moderately* For 30 Seconds**
- **Poor Soils Can *Amplify* Effects**
- **Damage Can be *Moderate to Heavy* (*even* with current building codes)**

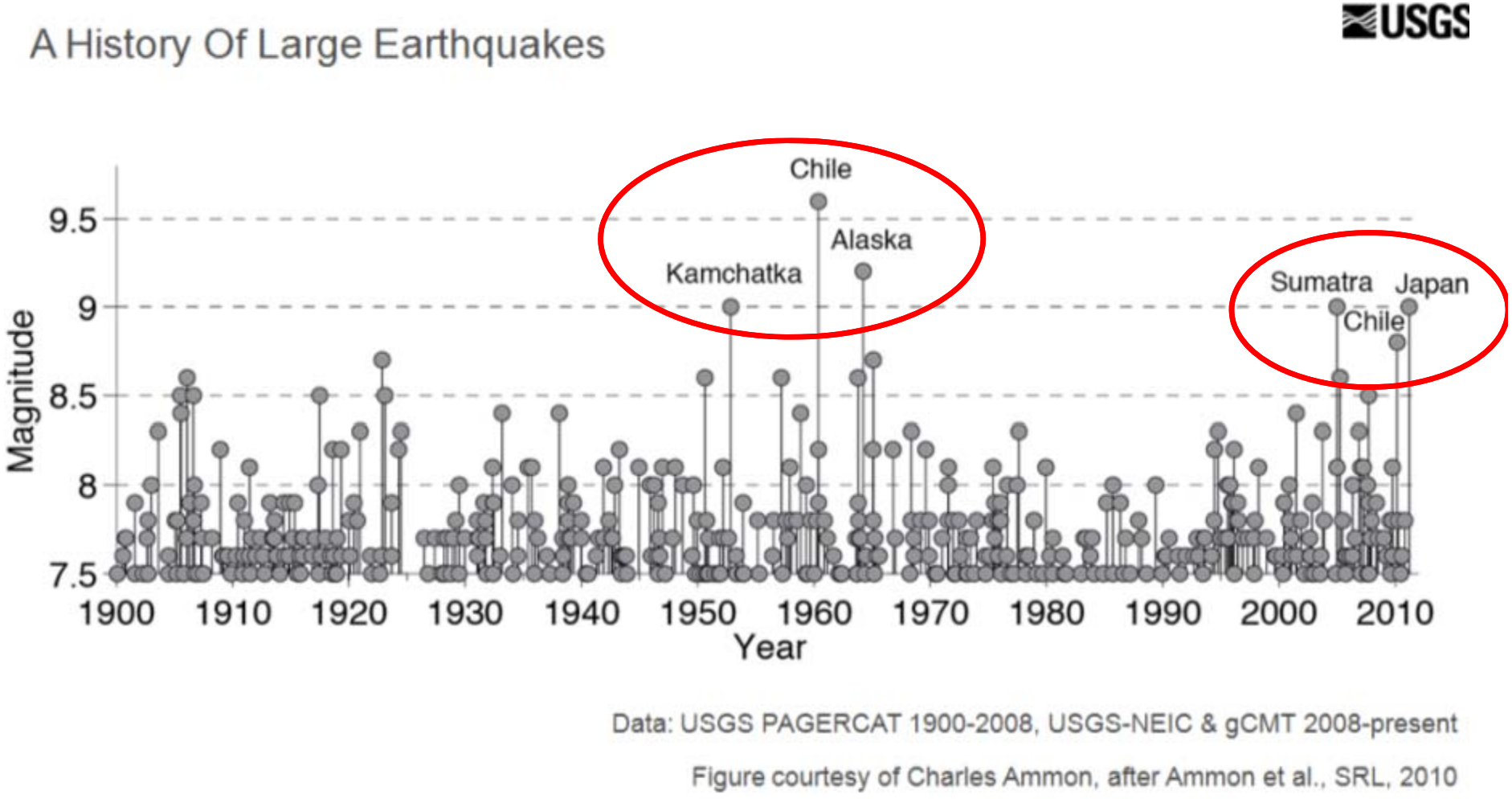
Note the shaking intensity colors



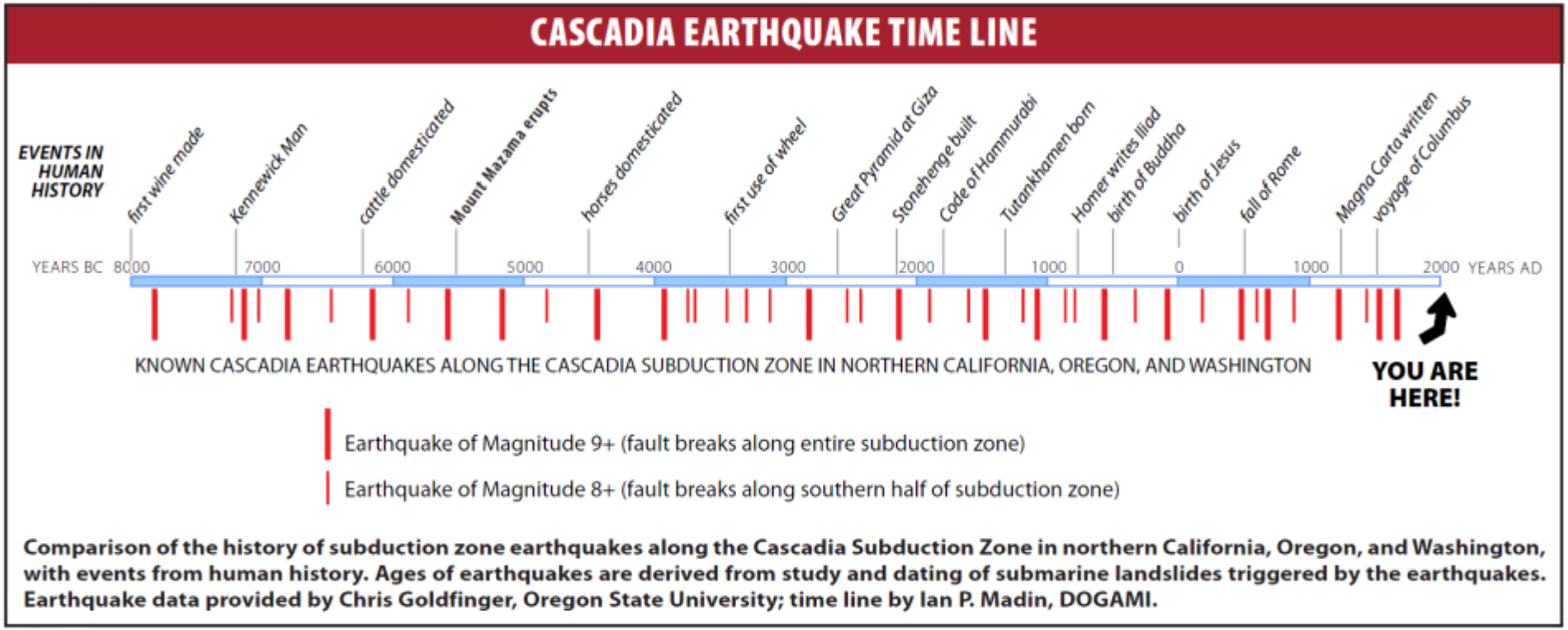
Other Earthquake Effects:

- **Liquefaction**
- **Subsidence/Uplift**
- **Landslides**
- **Fires**
- **Tsunamis**

Large Earthquake Frequency



A 10,000 year history of great Cascadia earthquakes in Oregon

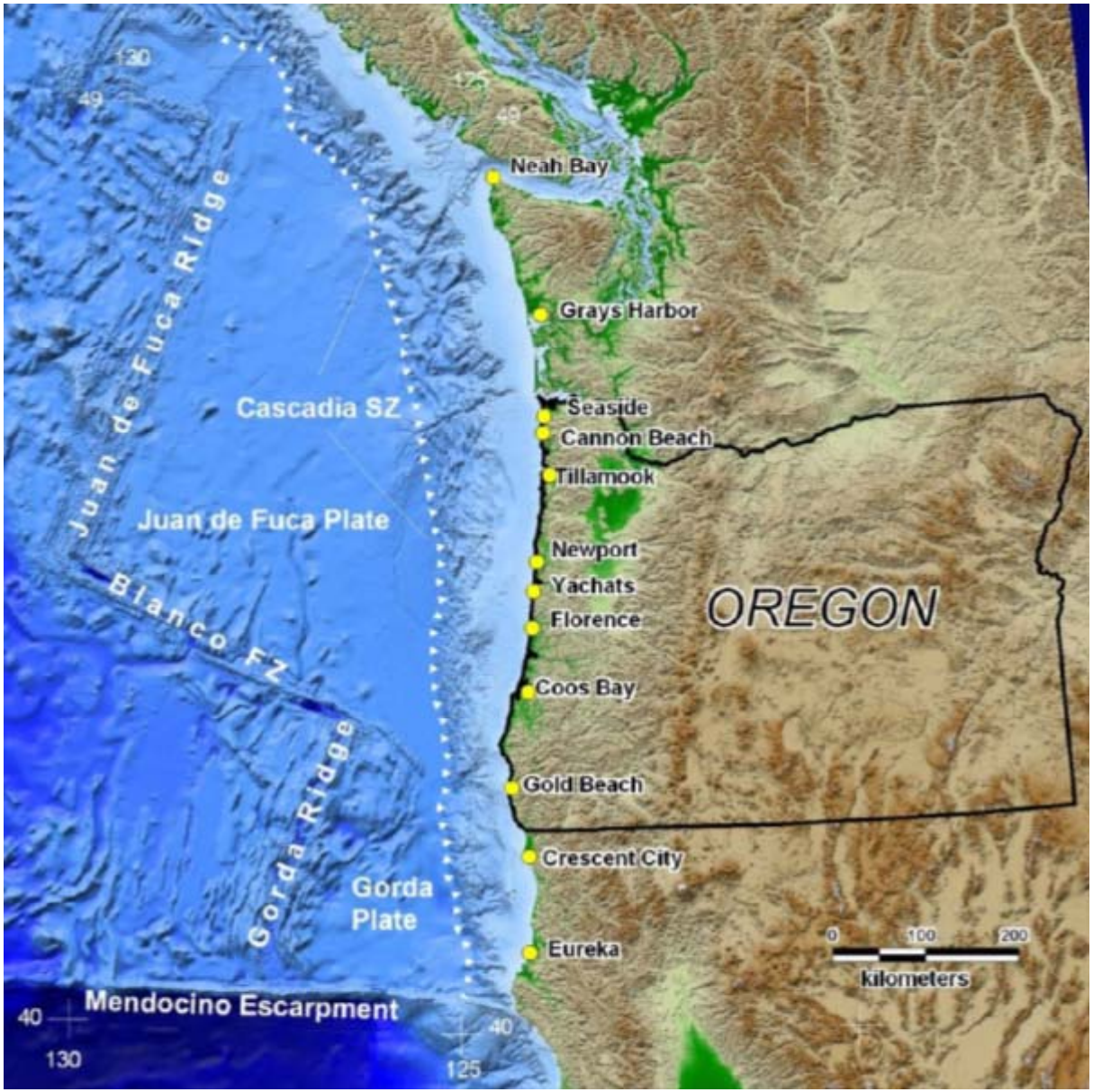


The last big Cascadia earthquake and *local* tsunami in the Northwest was on January 26,1700.

Topography Reflects Tectonic Plates

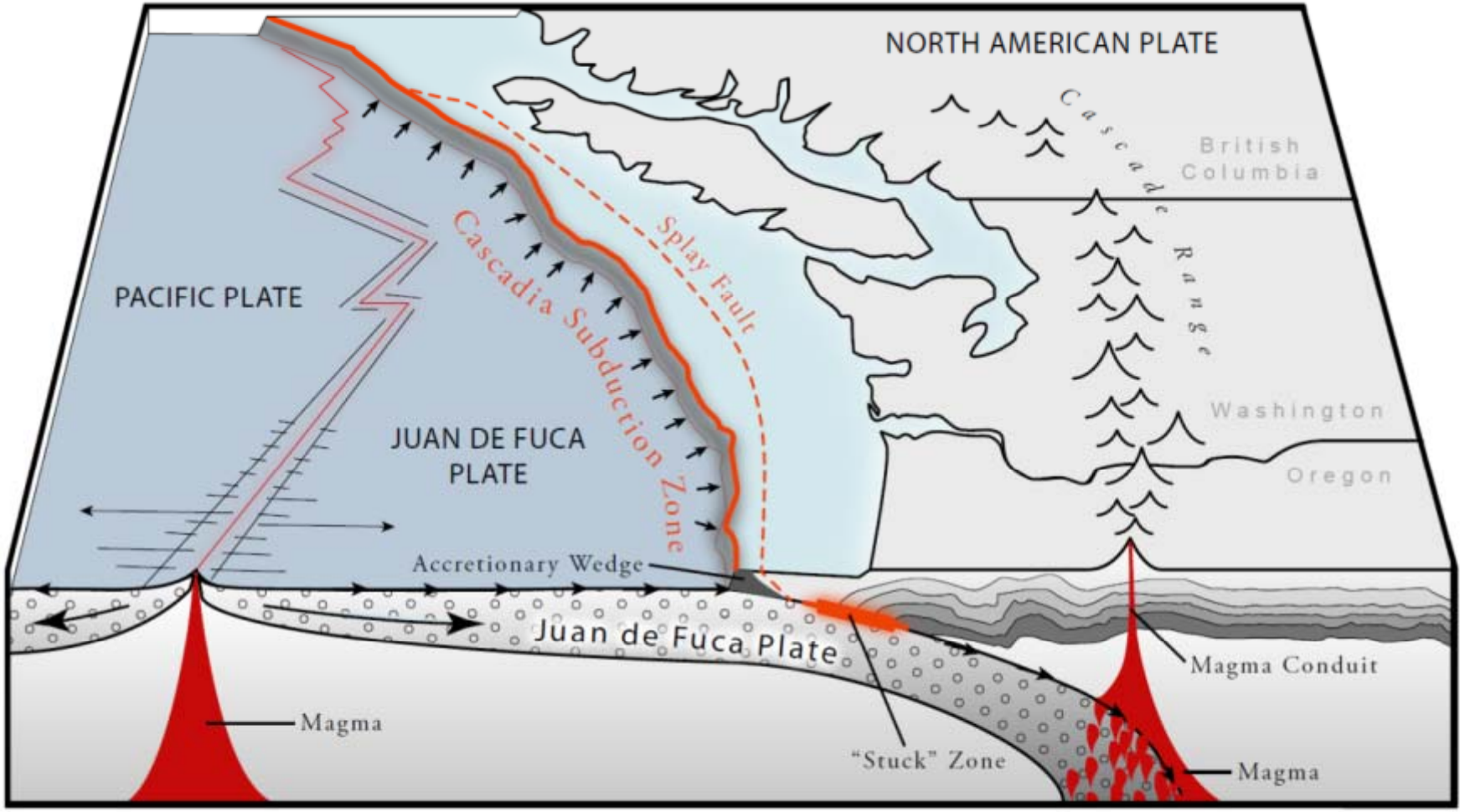
Plates Move in 3 Ways:

- **Slide Past**
- **Spread Out**
- **Dive Under (Subduction)**



Cascadia Subduction Zone (CSZ)

North American Plate Overrides Juan de Fuca Plate Along Cascadia Subduction Zone at a rate of 1.5 inches/year



What to do: Earthquakes

Indoors: Drop, cover, and hold on. Drop to the floor, take cover under a sturdy desk or table, and hold on to it firmly.

In Bed: Hold on and stay there, protecting your head with a pillow.

Outdoors: Move to a clear area if you can do so safely ; avoid power lines, trees, signs, buildings, vehicles, and other hazards.

Driving: Pull over, stop, and set the parking brake. Avoid overpasses, bridges, power lines, signs and other hazards. Stay inside the vehicle until the shaking is over.

.

At the beach: Drop, cover and hold on until the shaking stops. Evacuate to high ground on foot as quickly as possible

What is a tsunami?

Japan, 2011

The Boston Globe

•A tsunami is a *series* of waves usually caused by an undersea earthquake that displaces the ocean floor.

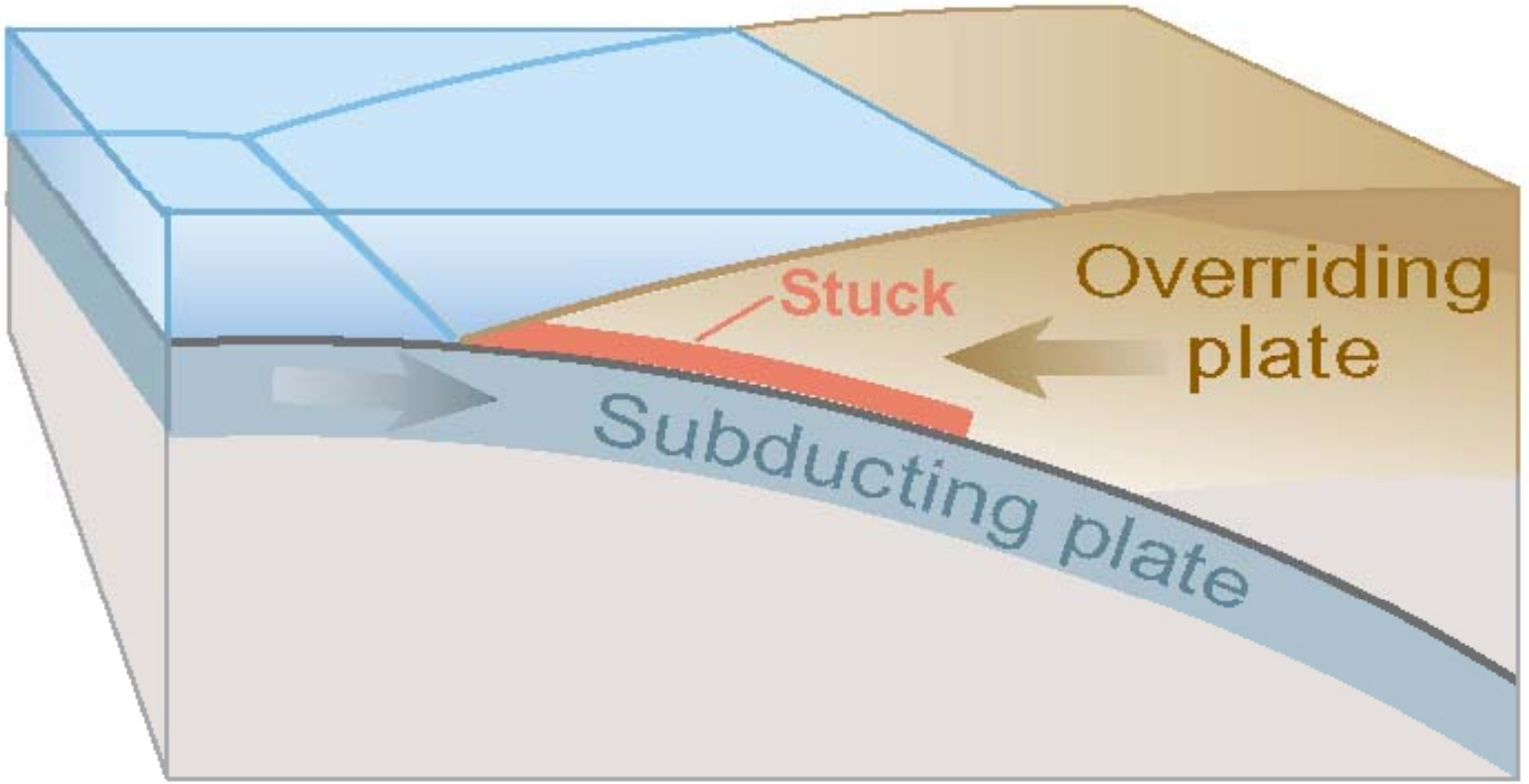
•But a tsunami is not really a “wave” that moves up and down; it’s actually the ocean moving sideways as a massive surge or a wall of water. It’s also known as a tidal wave. The Japanese word *tsunami* means “harbor wave.”

•A tsunami can generate waves for 12 to 24 hours. And the first wave is not always the biggest!

•A tsunami travels across the open ocean at over 500mph, the speed of a jet airplane. As it reaches shallower water and approaches shore, it slows down but grows in height.

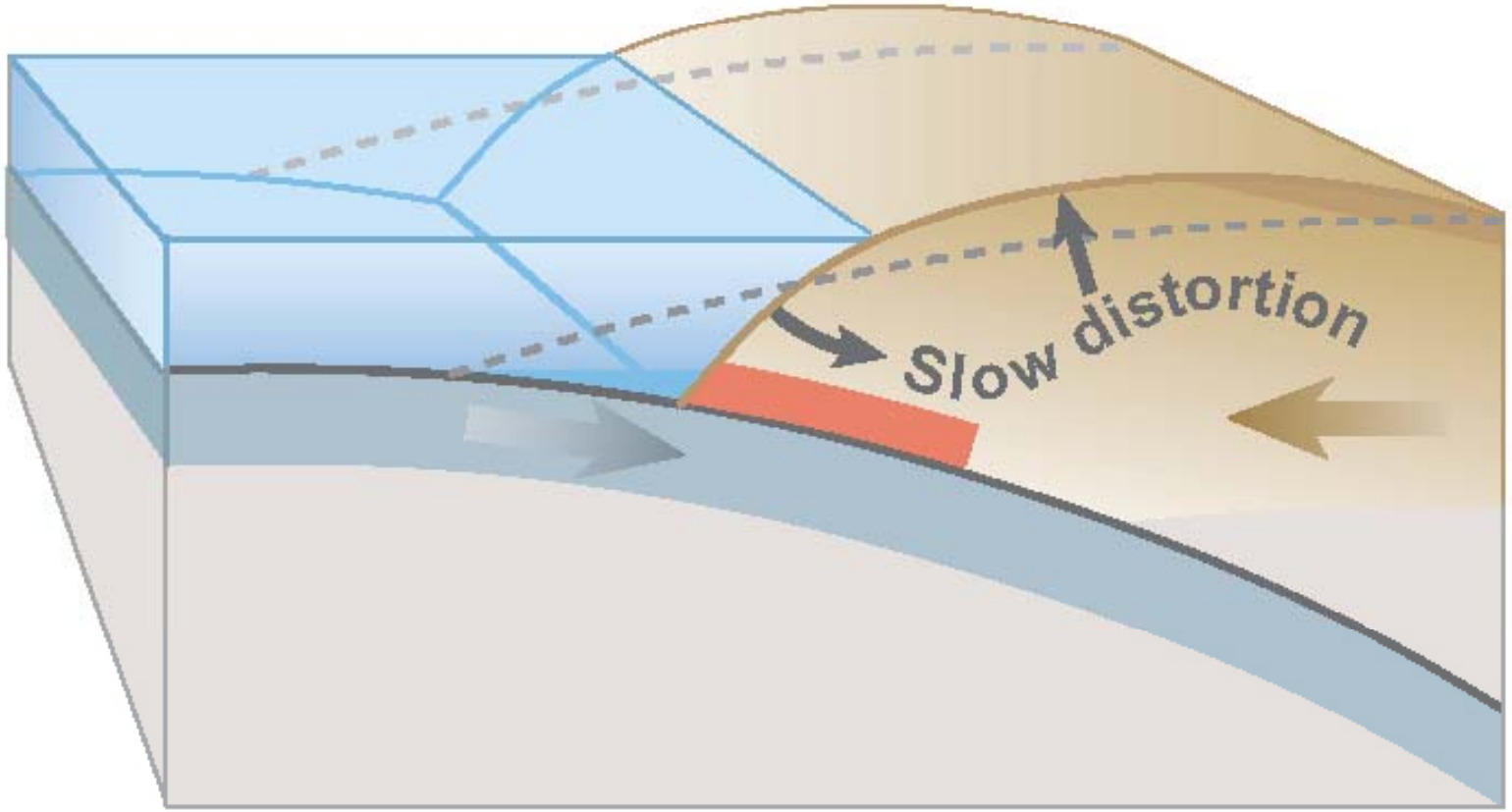
•A tsunami can happen at any time of day or year.

How are tsunamis created?



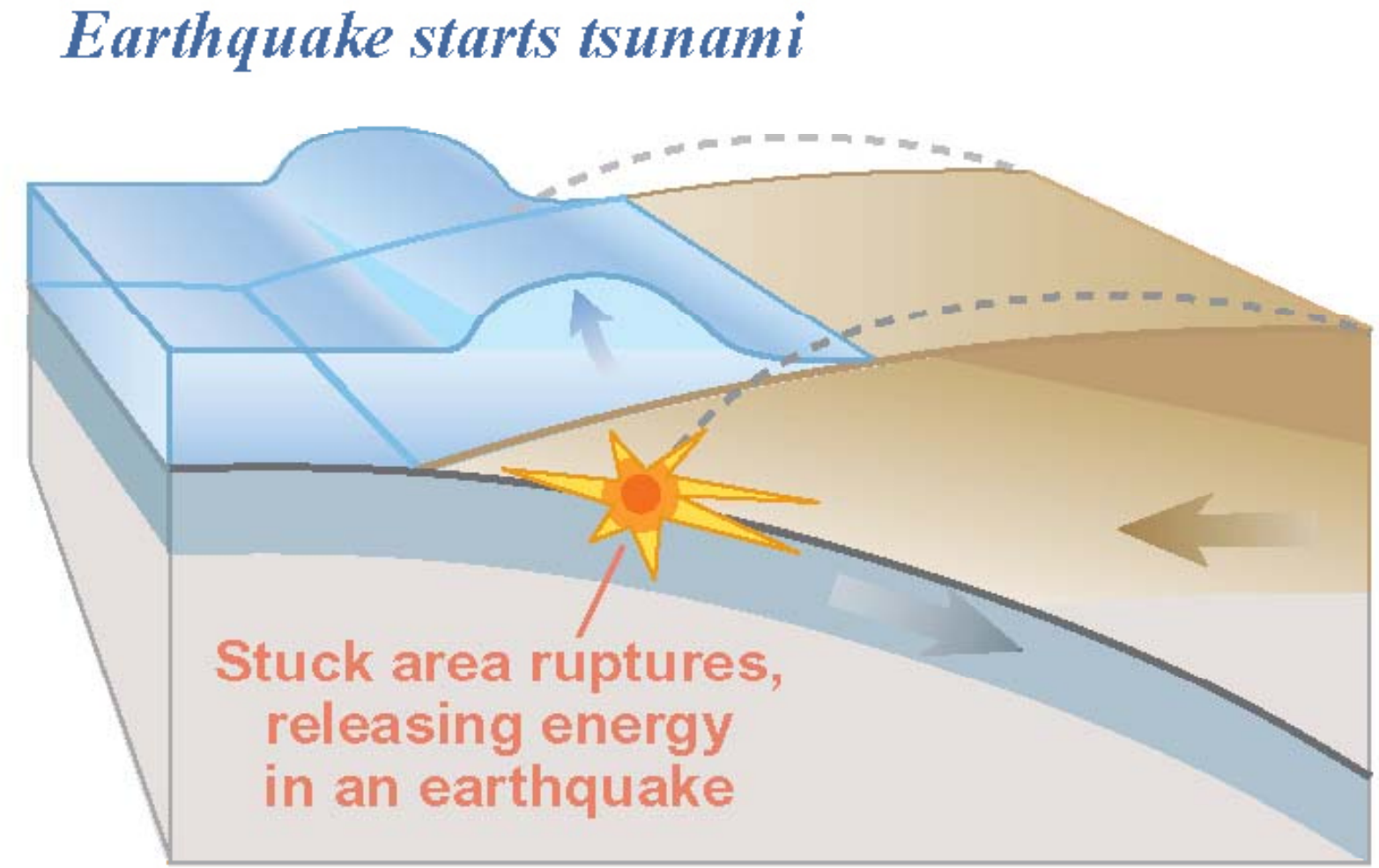
How are tsunamis created?

Between earthquakes



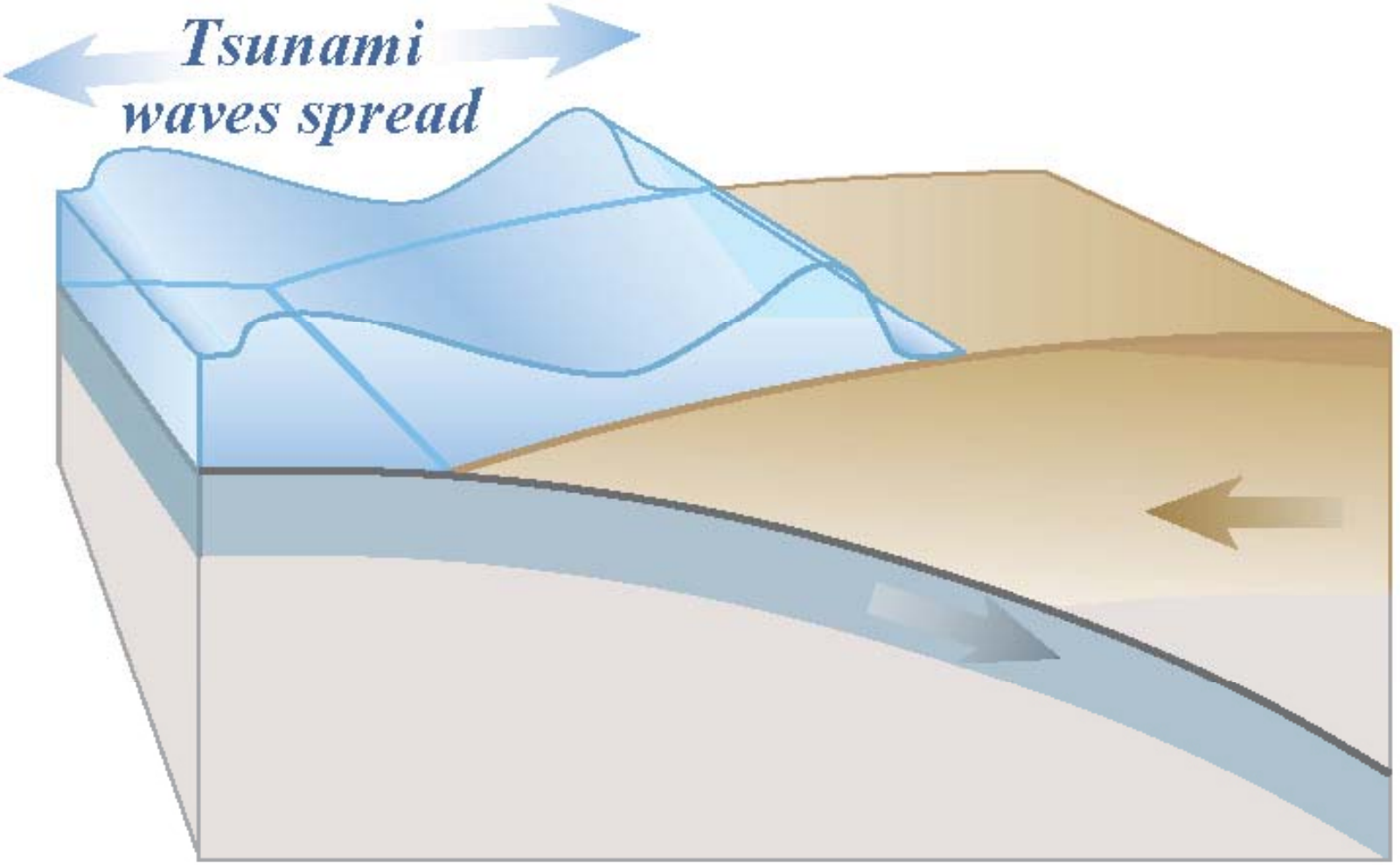
How are tsunamis created?

During an earthquake



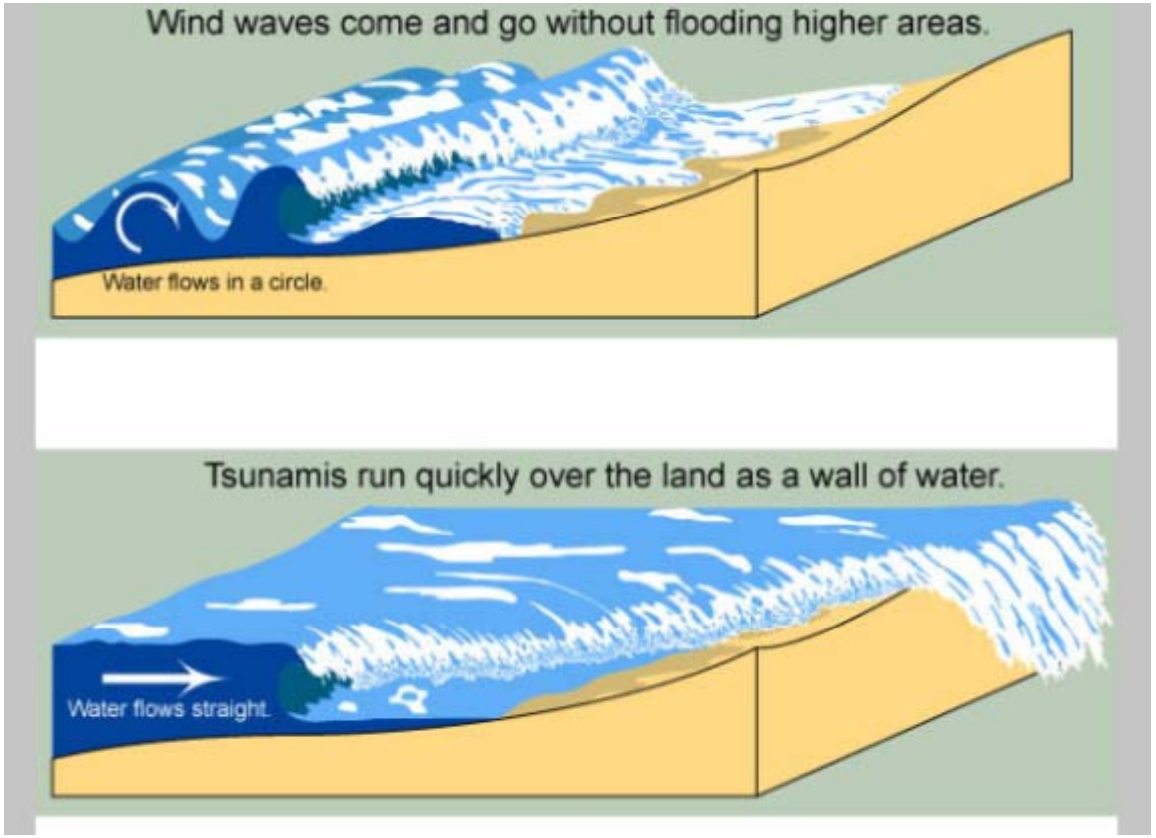
How are tsunamis created?

Minutes later



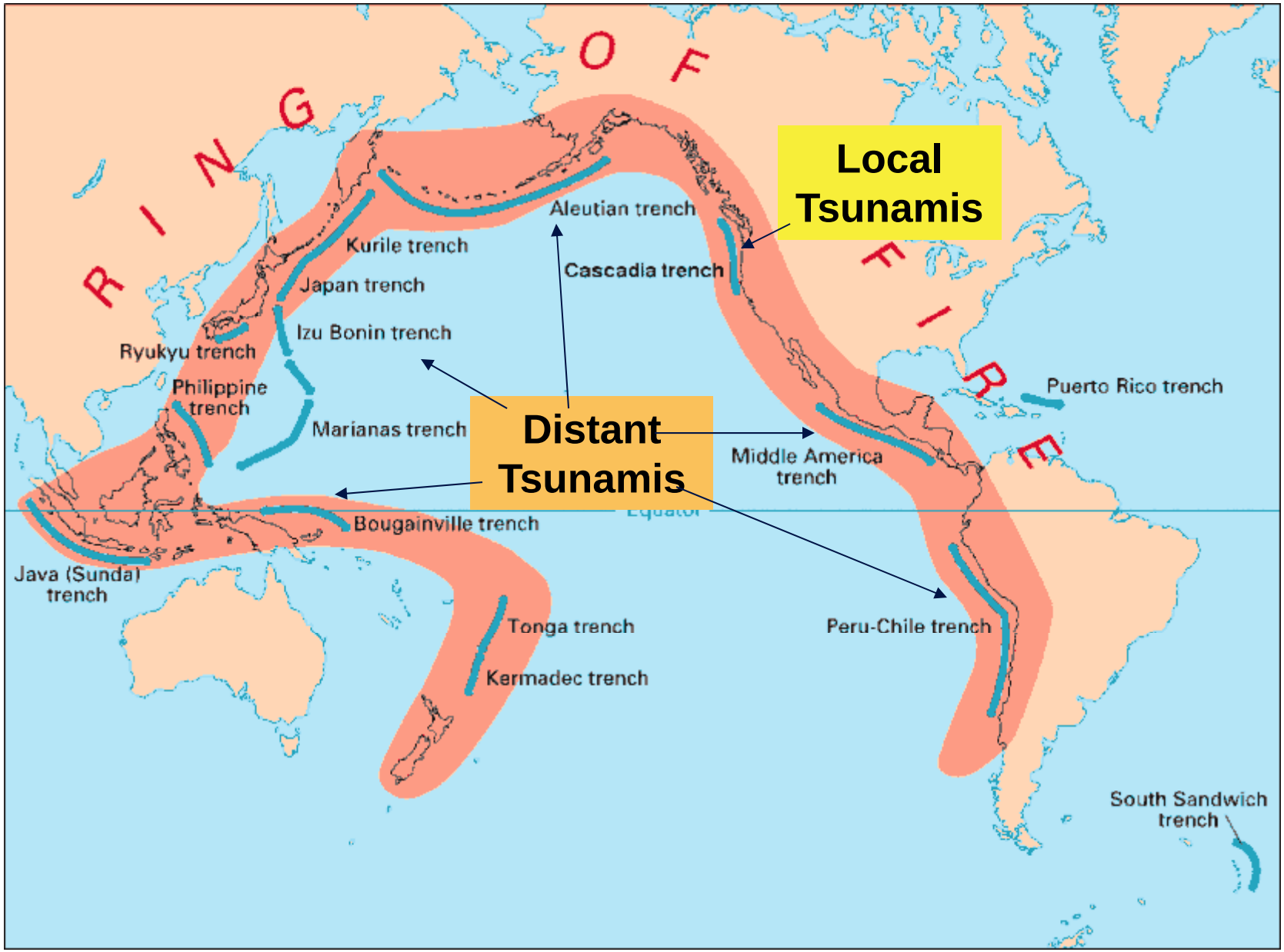
Tsunamis are more than a “wave”

- Waves break on shore
- Tsunamis are a higher ocean surface that just keep coming

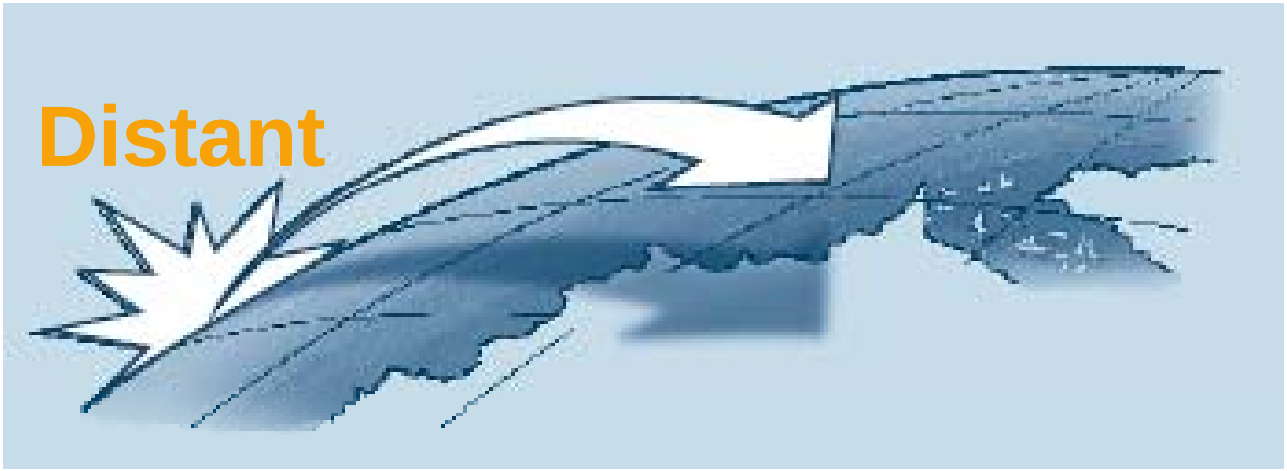


Two Kinds of Tsunami:
Distant vs. Local

Where do tsunamis come from?

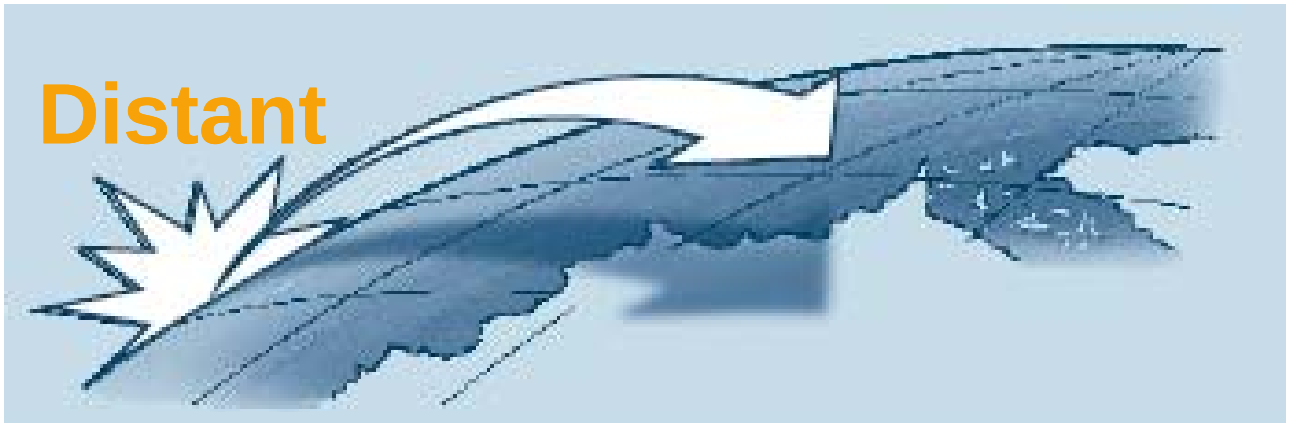


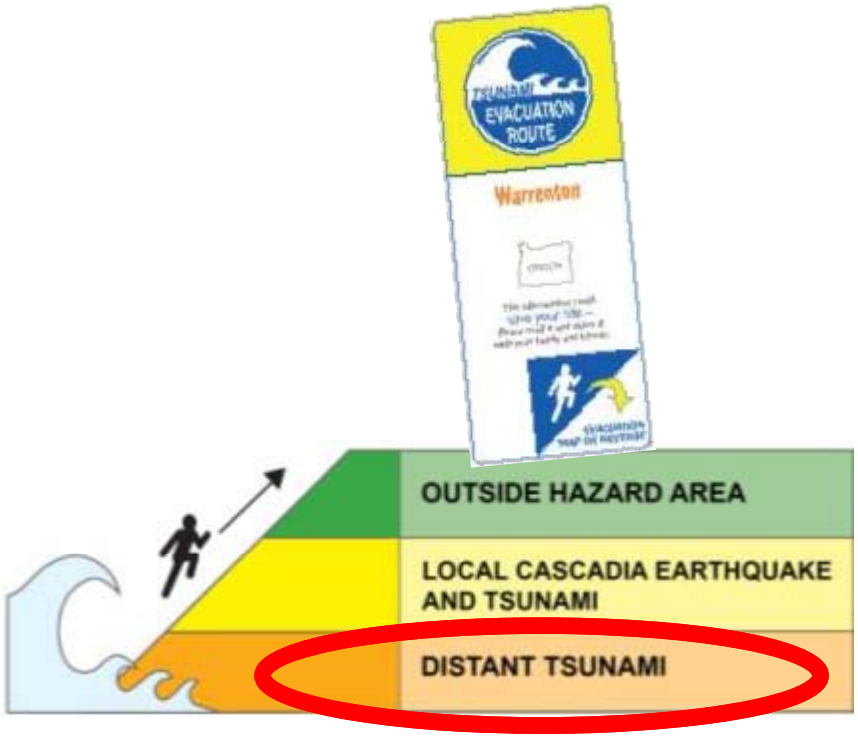
Two Kinds of Tsunamis



Your response should be very different,
depending which kind of tsunami is coming.
Know where to go (and when!).

Distant Tsunamis
caused by earthquakes across the Pacific Rim





In a *distant* tsunami…

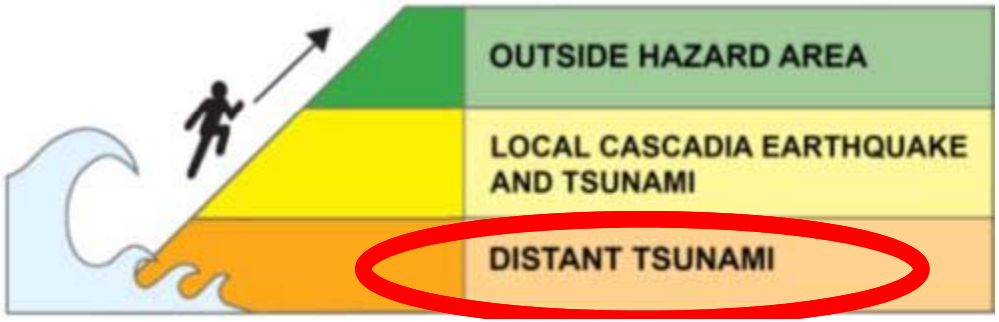
- You won't feel the far-away earthquake.
- There's time for an official warning.
- First wave arrives 4 hours or more after earthquake in Alaska or elsewhere around the Pacific Rim.
- If you're already outside hazard area, please stay there.
- If your area has tsunami sirens, you might hear them. If not, a sudden sea level change is your last-ditch warning.

Distant Tsunami from Alaska, 1964

1964 earthquake, magnitude 9.2. Fourth Avenue in Anchorage, Alaska.

A 2x6 wooden plank driven through a ten-ply tire by the tsunami that hit nearby Whittier, Alaska.

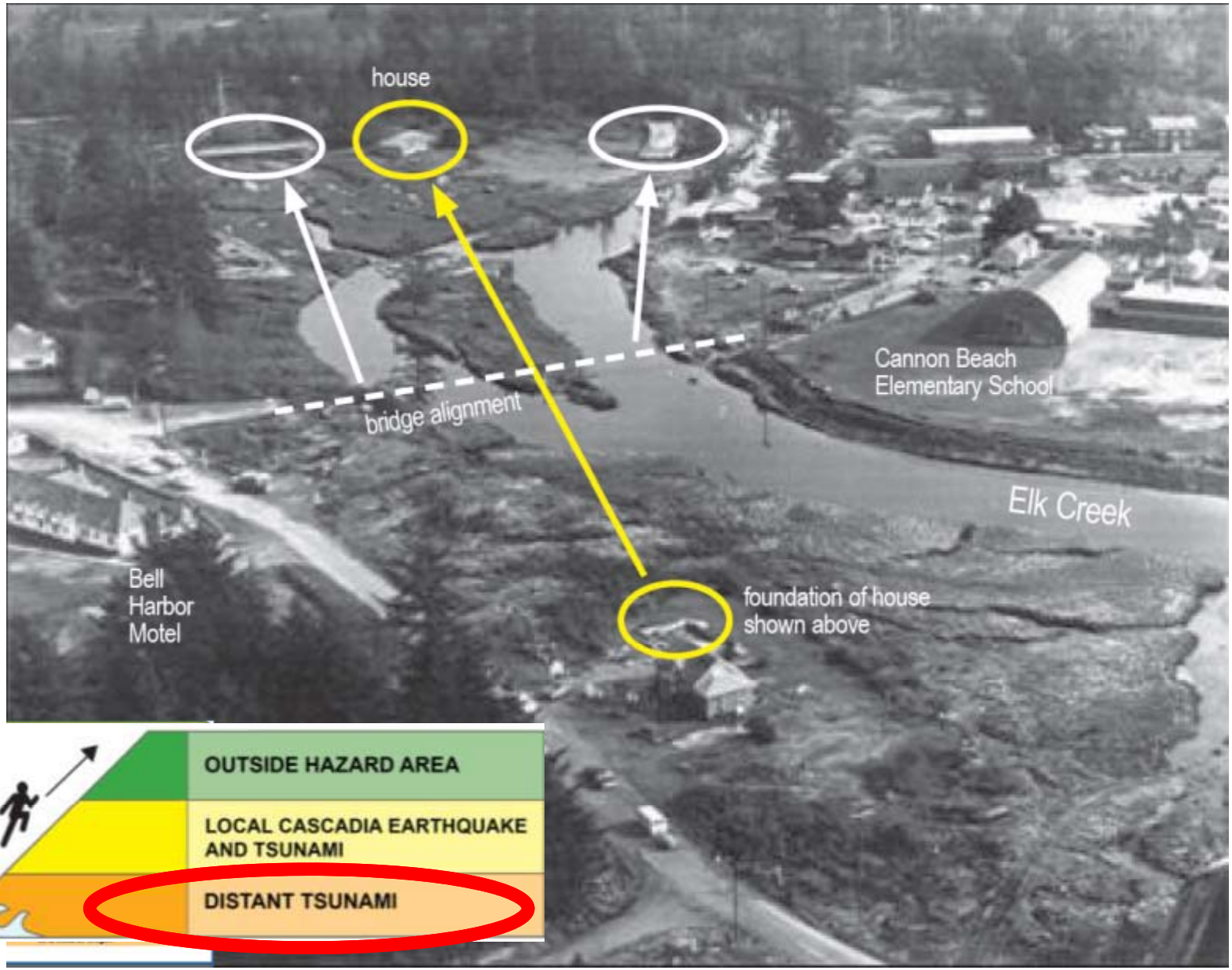
Distant Tsunami from Alaska



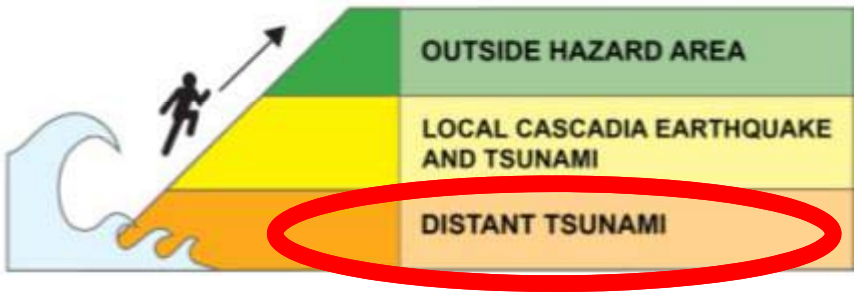
Generally smaller waves than from a *local* earthquake and tsunami.

Nearest source is 4 hours away in Alaska

Distant Tsunami from Alaska, 1964
Damage in Cannon Beach



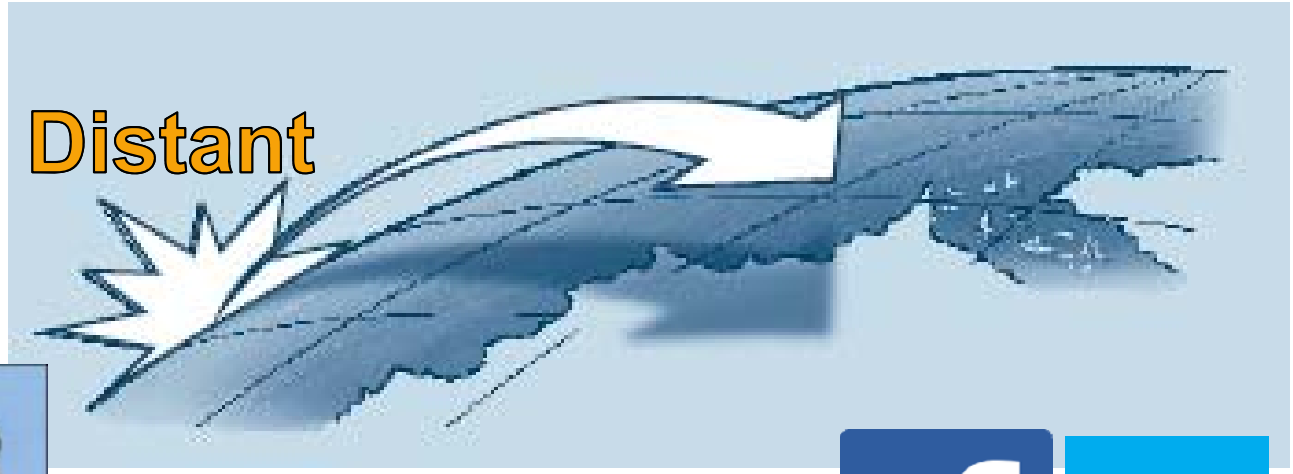
Distant Tsunami from Alaska, 1964
Damage in Seaside



Five lives were lost in Oregon, and 11 in northern California.

What to Do: Distant Tsunamis

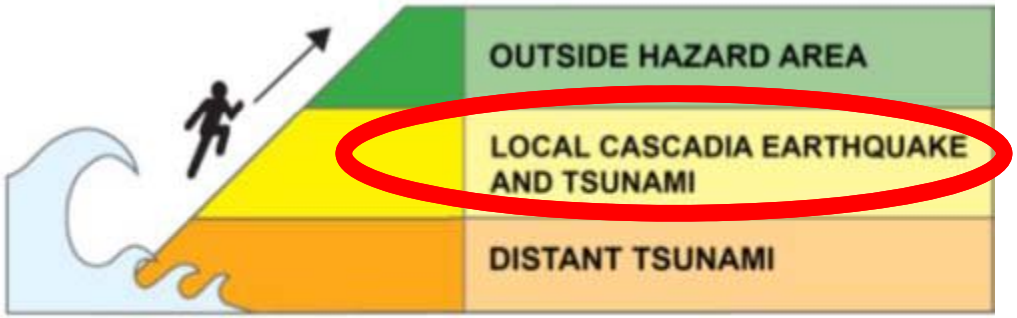
You'll have at least four hours to respond, and could be notified by one or more of these methods…



Citizen Alert
Notification Sign Up

All Hazards NOAA Weather Radio
NOAA's National Weather Service

Local Tsunamis
caused by an earthquake near Oregon's coast



- You will feel shaking: the Big One!
- Drop, cover, and hold on until shaking stops. Protect yourself.
- Waves are larger than from a *distant* tsunami.
- First wave arrives 15-20 minutes after earthquake. But first wave is not always the biggest!
- Don't wait for an official warning. Evacuate immediately!
- Evacuate *on foot* (bridges fail, roads blocked, traffic jams).
- Don't delay. Have a "grab and go" bag of emergency supplies.
- Tsunami sirens not likely to work.
- **Stay on high ground for 12-24 hours until waves are finished!**

What to Do: Local Tsunamis

In review…

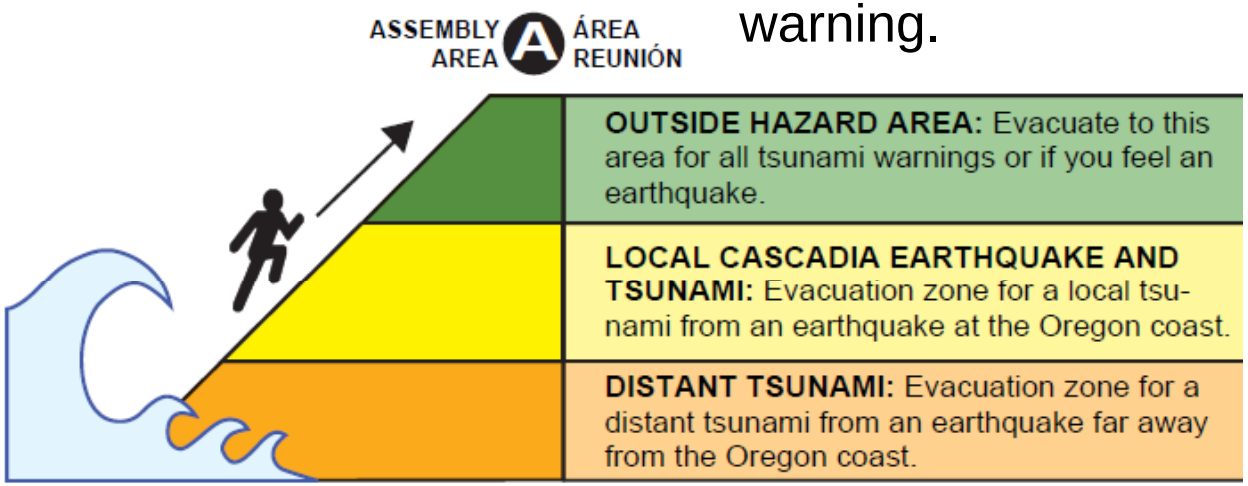
Know Where to Go! (or not)

In a *local* tsunami…

- First wave arrives 15-20 minutes after earthquake
- Evacuate *on foot*. Why? Bridges fail, roads blocked, traffic jams.
- Have a “grab and go” bag ready.

In a *distant* tsunami…

- First wave arrives 4 hours or more after earthquake in Alaska or elsewhere on Pacific Rim.
- If already outside hazard zone stay there.
- Time for an official warning
- If your area has sirens, you might hear 3-minute siren blast. If not, sudden sea level change is last-ditch warning.



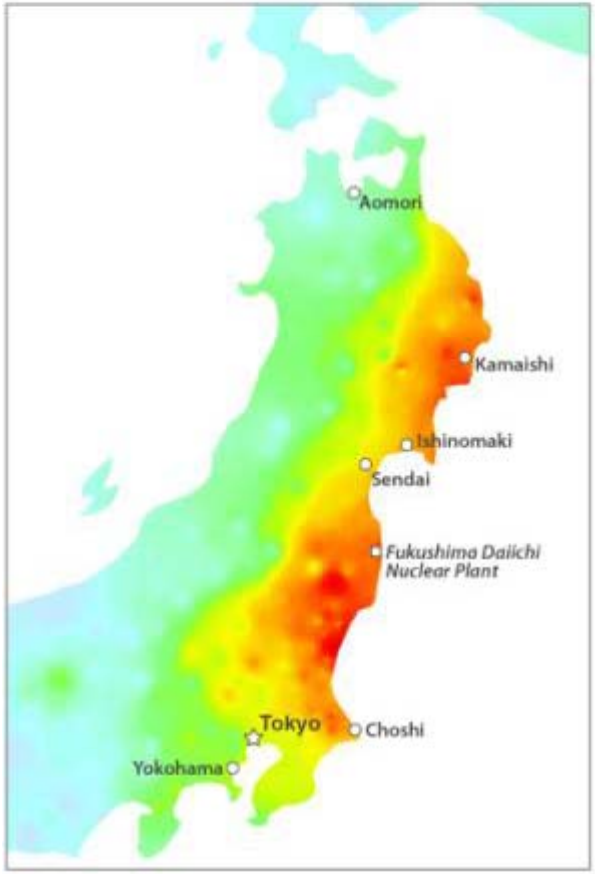
Lessons from Japan's Local Tsunami, March 2011

Subduction Zones – Japan vs. Oregon

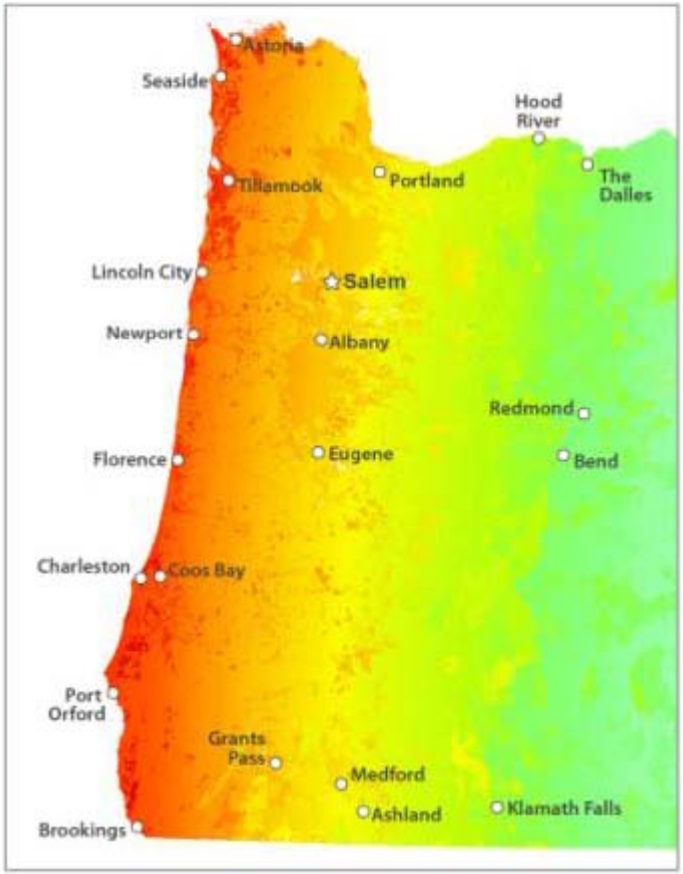
(left) **Green zone is the exact footprint of the Tōhoku rupture zone.** *(right)* **Green zone indicates a region where earthquakes can occur in the Pacific Northwest.**

ShakeMap Comparison

ShakeMap for March 11, 2011 Tohoku M9 Earthquake



ShakeMap for Simulated M9 Cascadia Earthquake

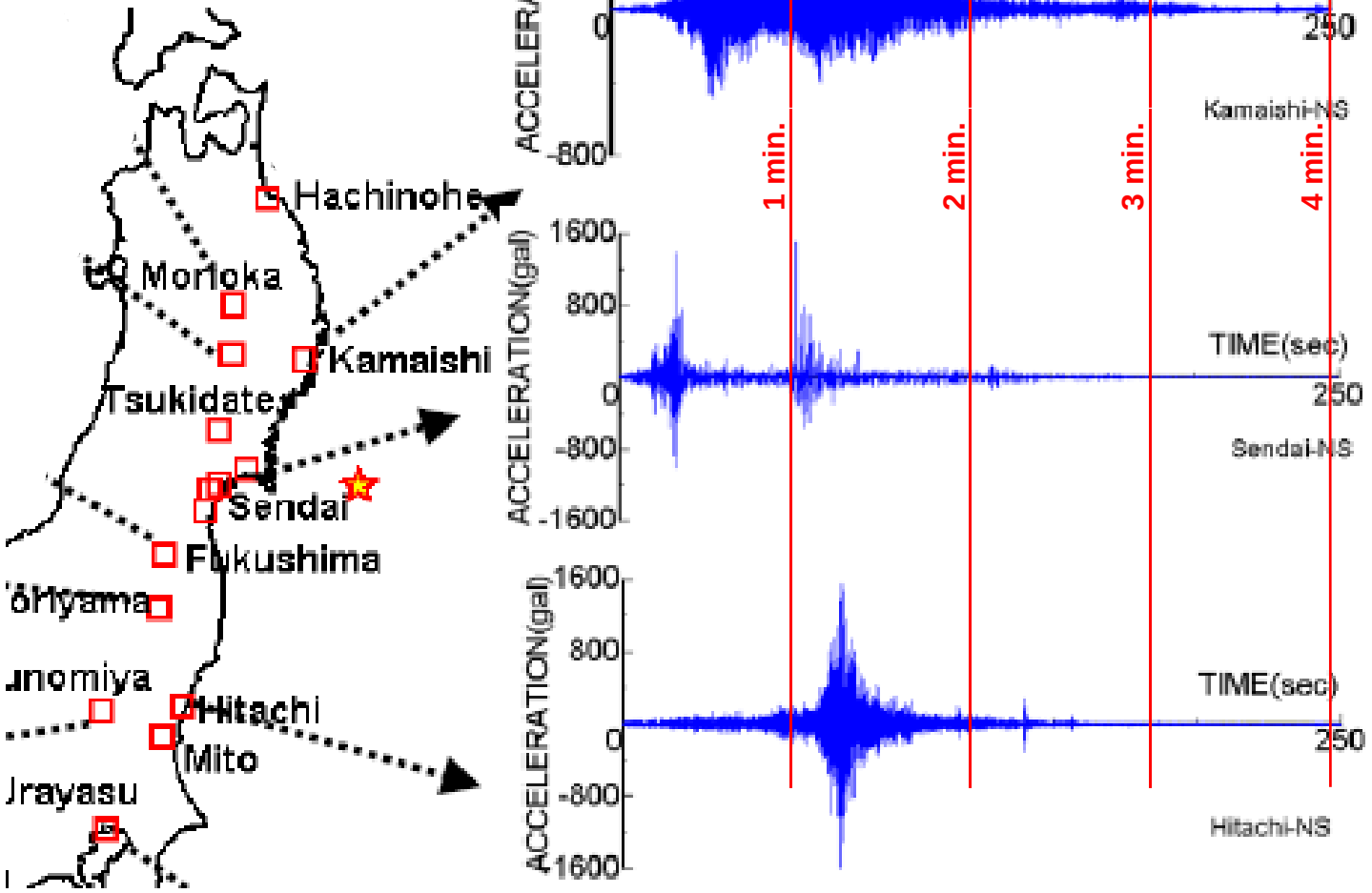


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

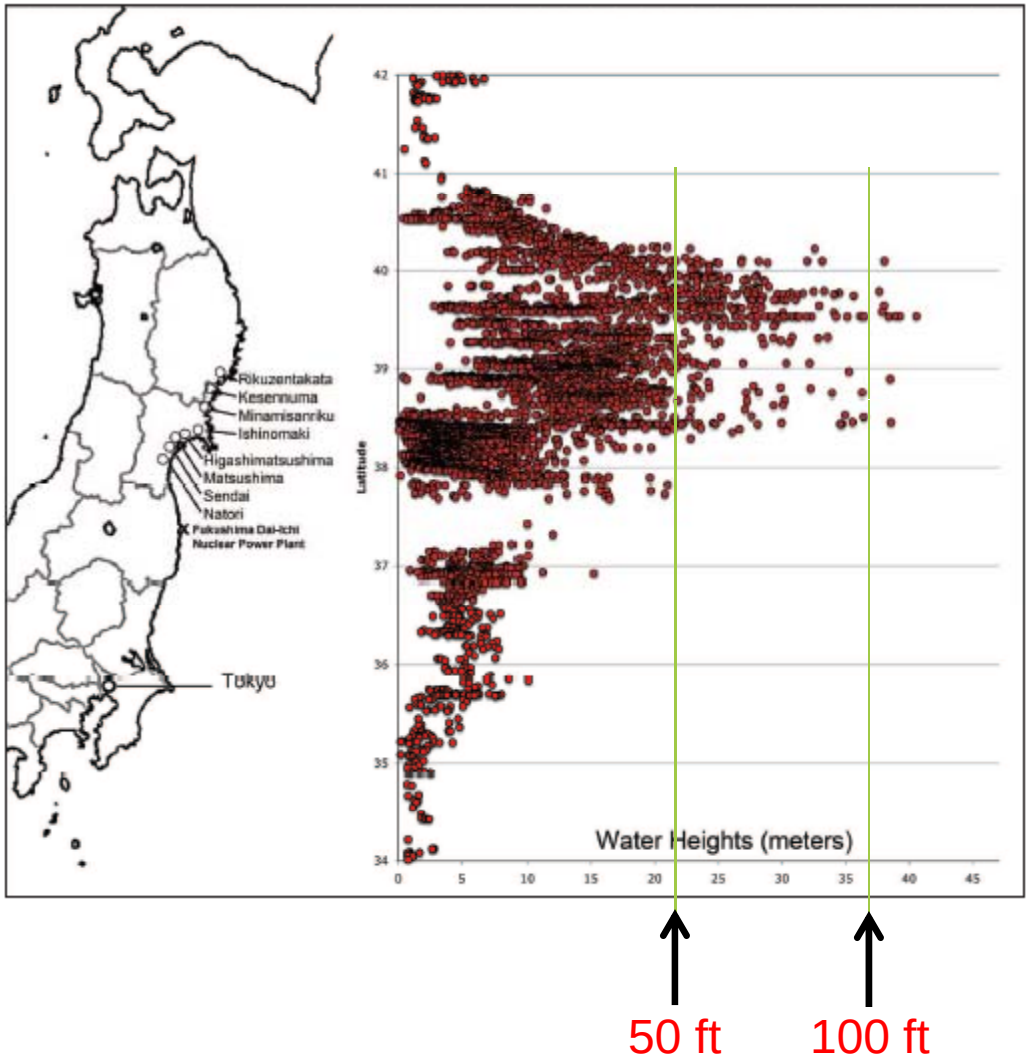
Japan's Local Tsunami
March 2011

How long did the earthquake shaking last?

3-4 minutes!



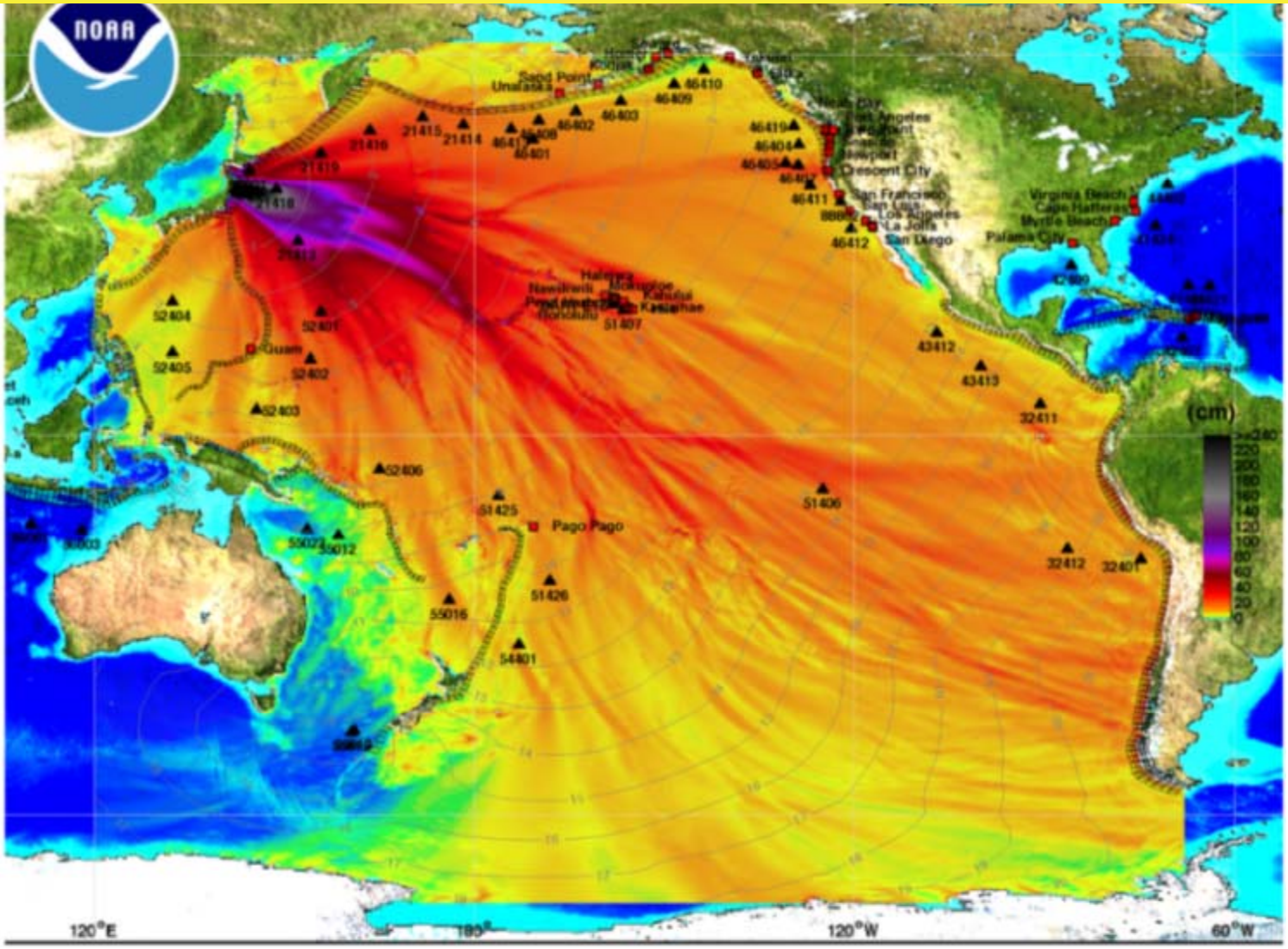
Japan's Local Tsunami
Water Elevations in Japan



- **First tsunami surges arrived in 15 minutes (Japan, 2011)**

Japan's **Local Tsunami**

Wave energy across the Pacific Ocean

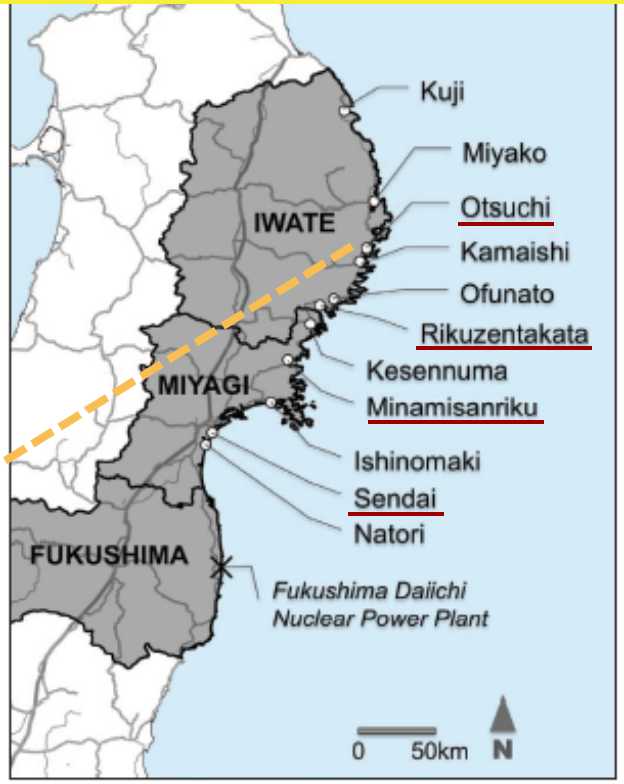


It was a *local* tsunami for Japan,
but a *distant* tsunami for Oregon. Make sense? ☺

Japan's Local Tsunami

Rivers and creeks are danger zones, too!

An aerial view of damage to Ōtsuchi, Iwate prefecture, Japan on March 15, 2011, after the magnitude 9.0 Tōhoku earthquake and subsequent tsunami devastated the area; 11.6% (1,378 people) of the exposed population were killed or are missing. In Iwate prefecture, 4,667 were killed and 1,363 remain missing. *(U.S. Navy photo by Mass Communication Specialist 3rd Class Alexander Tidd/Released)*



Defenses Failed

Pine Forests

Sea Walls

Infrastructure Failed

Overturned and Underwater Central Pier

- Tsunami wave height reached 39 feet
- Six spans of this bridge washed from 1,000 to 1,300 feet away
- Railroads no longer usable

Vertical Evacuation Failed

Figure 8. *The approximate inundation zone in Minimisanriku Town. The tsunami surges destroyed the town center and went up the narrow Hachiman River (center) and the Sakura River (on left) and the Oretate River (on right). Black arrow is 2 km long. (A) marks the location of the disaster management building shown in Figure 10 and (B) shows the tsunami evacuation building in*

In this City: 31 of 80 designated tsunami evacuation centers destroyed

Disaster Management HQ

Go to high ground!

Disaster Management HQ

30 officials went to the roof…11 survived

Wood Buildings Perform Well in Earthquakes, But *Poorly* in Tsunamis

Wood Houses Destroyed By Water Depth & Velocity

- **At 6.5 to 8 feet deep: 72% destroyed**
- **65% of “destroyed buildings” were simply washed away**

Reinforced Concrete Buildings Survive Better Than Wood

…but not always

Tsunami water carries an enormous amount of debris

Before Tsunami at Sendai

Arahama in Sendai

After Tsunami at Sendai

Arahama in Sendai

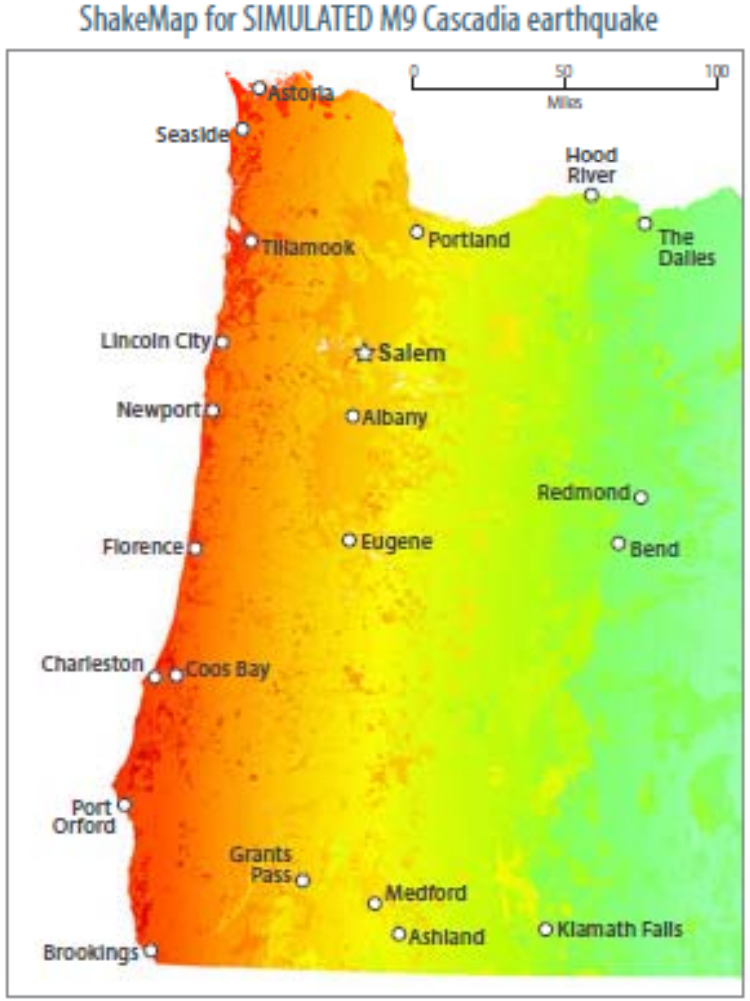
Lessons from Japan

- Prepare your evacuation plan and "go bag" **now**
- When the ground shakes hard for a long time, **evacuate immediately** to high ground on foot
- Vertical evacuation is a "**last resort**" option
- Tsunami waves will arrive for several hours
  - First wave *may not* be the largest
- Wood buildings will **not survive**
  - Not all concrete or steel frame buildings will survive
- Help may not arrive for several to many days

You *can survive* if you prepare and take action!

What should you expect in Oregon?

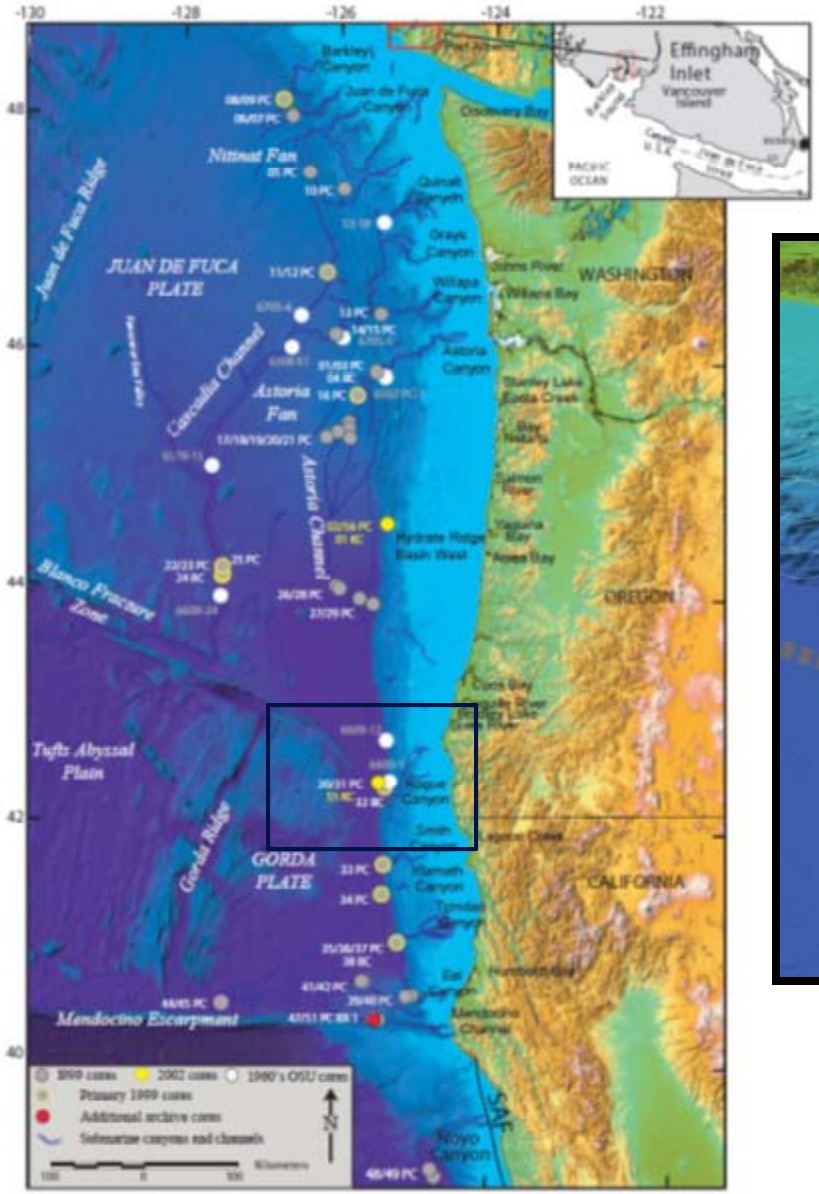
- **M9.0 Great Earthquake**
  - **Western Oregon will experience strong to violent shaking lasting for *2 or more* minutes**
  - **This experience will be unmistakable**
  - **Bridges will fail; Expect to walk to high ground**
  - **15 to 30 minutes later = *start* of tsunami**
  - **Tsunami waves will continue for at least 4 hours**



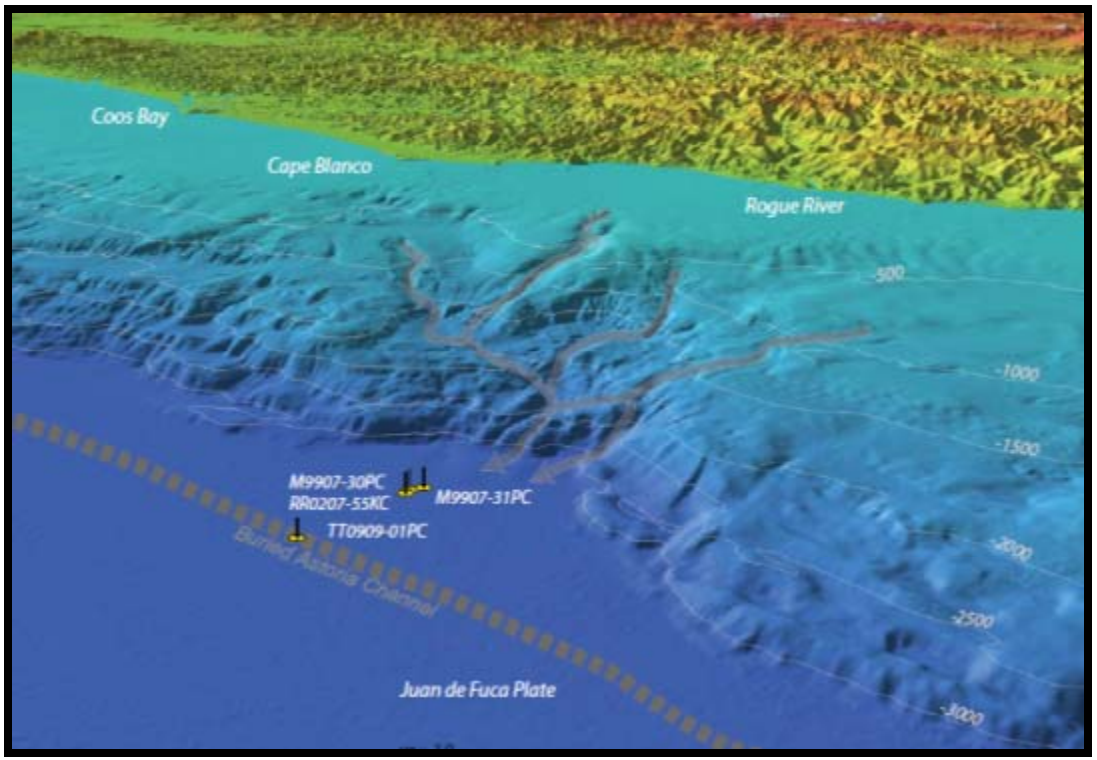
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

10,000 Year History of Earthquakes in the Pacific Northwest

10,000-year History of Oregon Earthquakes



Locations of soil core samples taken off the Oregon coast



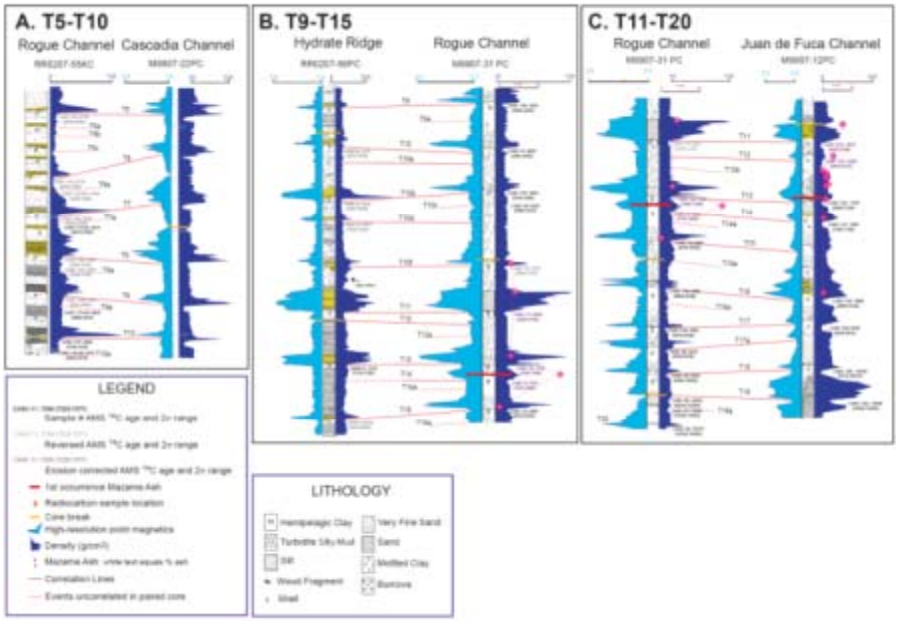
Offshore Landslides Record Earthquakes

- Offshore landslides that have been generated from CSZ earthquakes produce turbidites.

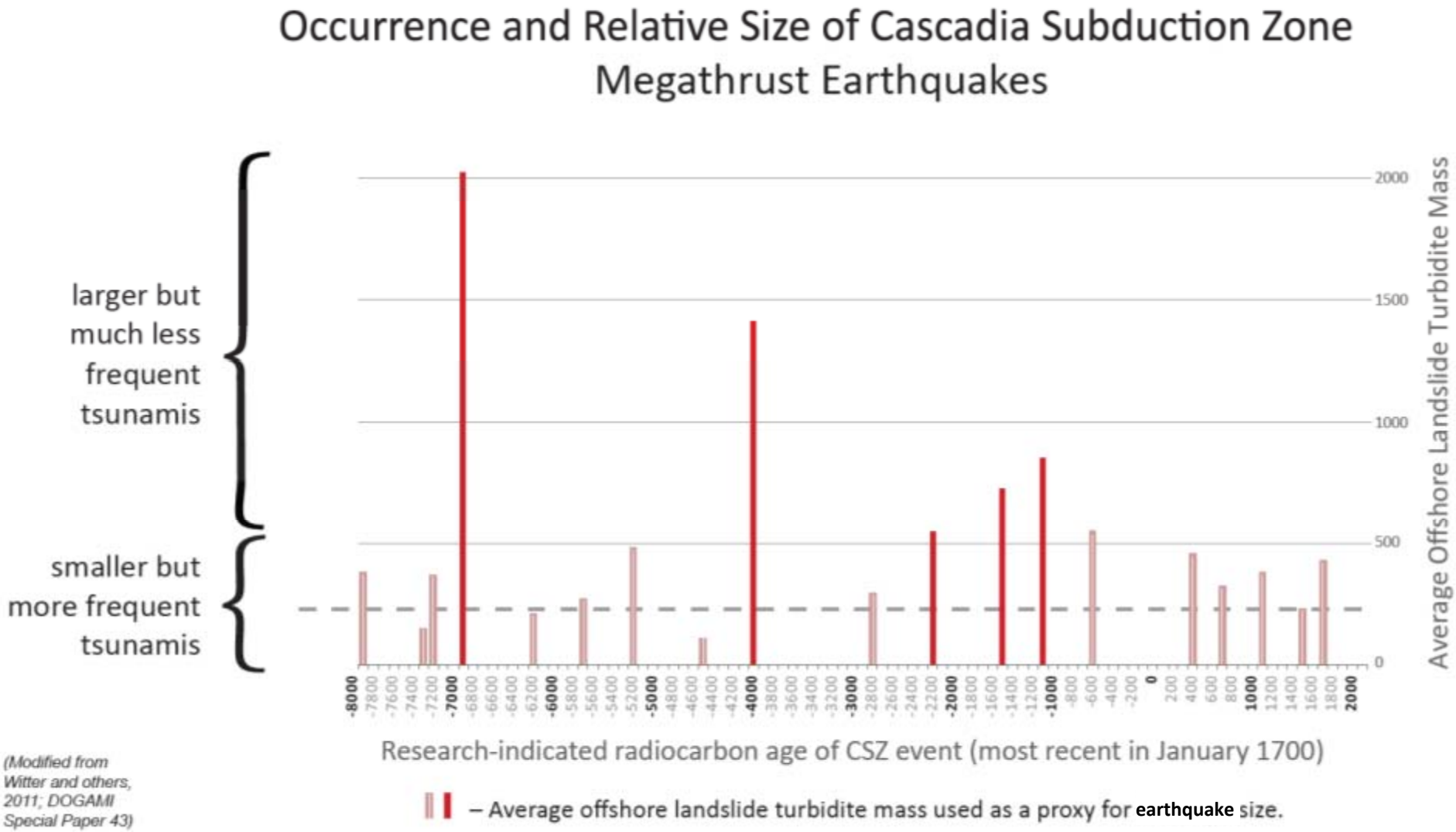
- These turbidites can be measured from core samples like the one pictured here.

- The measuring of this mass, in addition to other sand deposits left in onshore estuaries, allow scientists to date and measure historical CSZ events.

- These historical CSZ events are then correlated between samples to create a comprehensive history of cascadia subduction zone events.



19 CSZ Events in Past 10,000 Years



(Modified from Witter and others, 2011; DOGAMI Special Paper 43)

Science Team Modeled Many Tsunami Scenarios

=

5 Final Local CSZ Scenarios (S, M, L, XL, XXL)

- and -

2 Distant Scenarios (AK64 and AKMax)

Reference:

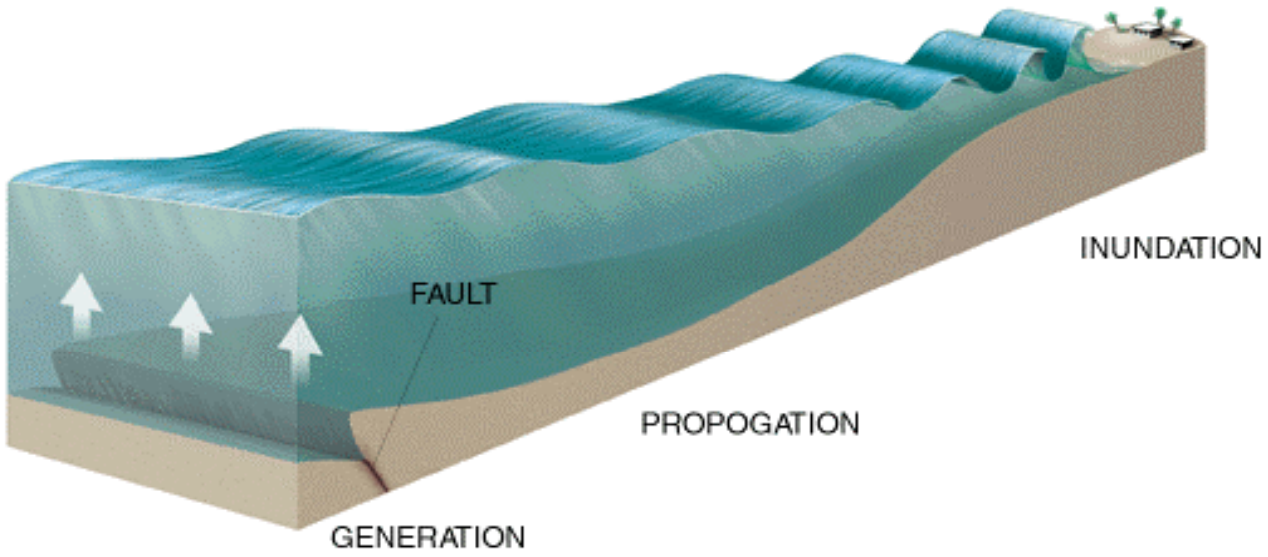
Simulating tsunami inundation at Bandon, Coos County, Oregon, using hypothetical Cascadia and Alaska earthquake scenarios

Authors: Witter, R.C., Zhang, Y., Wang, K., Priest, G.R., Goldfinger, C., Stimely, L.L., English, J.T., and Ferro, P.A.

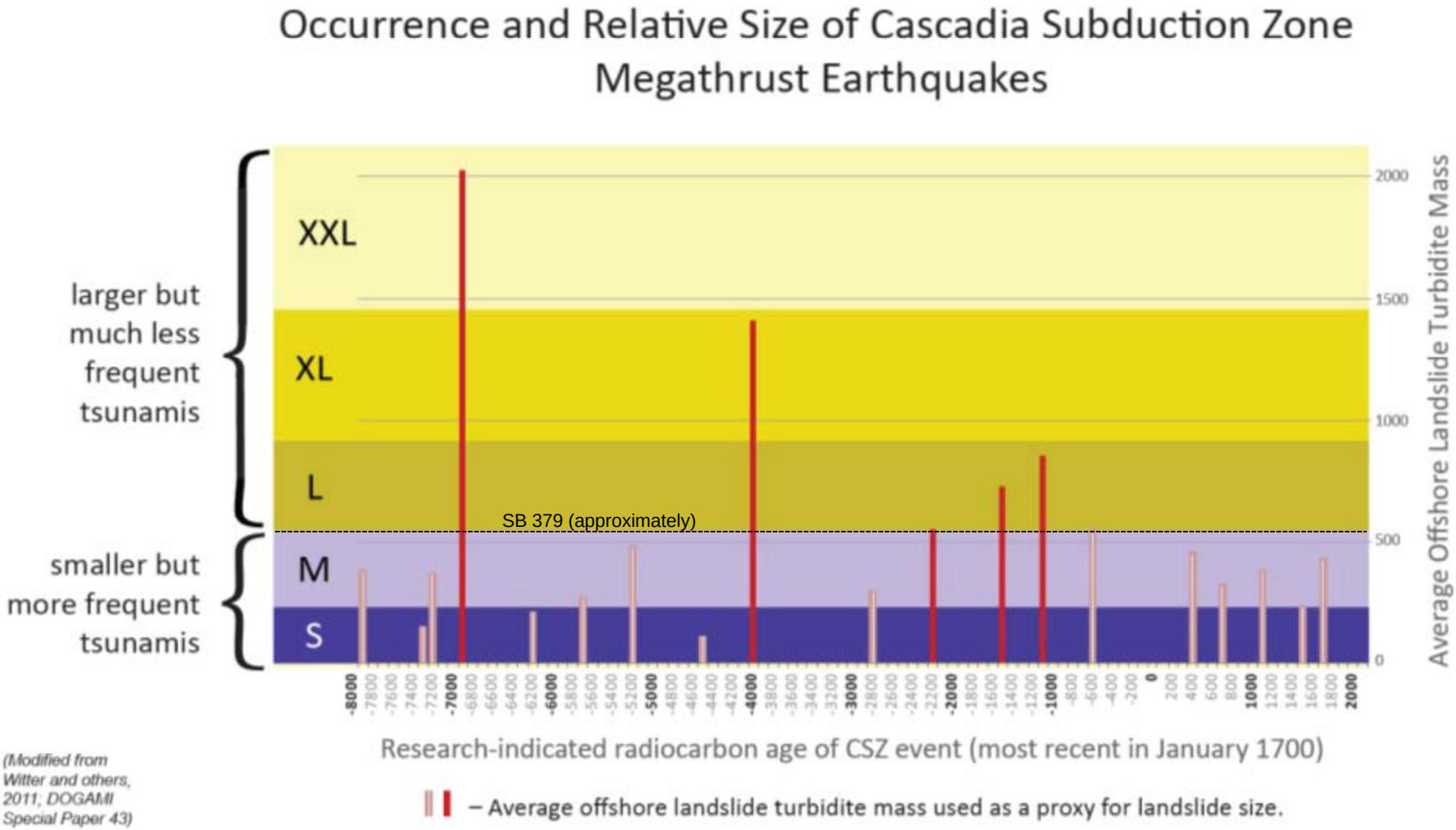
Oregon Department of Geology and Mineral Industries Special Paper 43

DOGAMI Tsunami “T-Shirts”

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



Historical Event Size & Frequency Relate to the 5 Scenarios



(Modified from Witter and others, 2011; DOGAMI Special Paper 43)

What the computer model looks like ☺

n, x, y, init_D_MHHW, post_D_MHHW, Wet_Dry, Elev_NGVD29, Elev_NAVD88, Elev_MHHW, flow_depth, max_vel, u_comp, v_comp
1,-123.4124823,48.1177411,0.0000000e+00,0.726997,1,0.9362,1.9842,-0.858E-01,0.641197,0.223E-01,-0.217E-01,0.507E-02
2,-123.3491970,48.1170438,0.0000000e+00,0.620038,1,0.718,1.766,-0.304E+00,0.316038,0.171E-01,0.150E-01,-0.821E-02
3,-123.3876455,48.1850616,0.0000000e+00,0.624265,1,1.166,2.214,0.144E+00,0.768265,0.198E-01,-0.181E-01,0.820E-02
4,-123.4919613,48.2606155,9.6301000e+01,97.026440,1,0.9673,2.0153,-0.547E-01,96.971740,0.443E-01,-0.443E-01,0.167E-02
5,-123.4260940,48.2530792,1.0826700e+02,108.887694,1,1.375,2.423,0.353E+00,109.240694,0.202E-01,-0.200E-01,0.251E-02
6,-123.4645425,48.3210969,9.2585000e+01,93.196579,1,0.9,1.948,-0.122E+00,93.074579,0.321E-01,-0.321E-01,-0.276E-03
7,-123.5422453,48.3078662,0.0000000e+00,0.763511,1,0.882,1.93,-0.140E+00,0.623511,0.637E-01,-0.637E-01,0.236E-02
8,-123.4422246,48.1634134,8.9617200e+01,90.355914,1,1.0747,2.1227,0.527E-01,90.408614,0.259E-01,-0.250E-01,0.656E-02
9,-123.4687333,48.2073812,9.3093400e+01,93.835189,1,0.9701,2.0181,-0.519E-01,93.783289,0.257E-01,-0.247E-01,0.691E-02
10,-123.4740094,48.1292864,1.0000000e-04,0.839128,1,0.9548,2.0028,-0.672E-01,0.771928,0.283E-01,-0.272E-01,0.775E-02
11,-123.5336894,48.2181953,9.7700800e+01,98.565458,1,0.9382,1.9862,-0.838E-01,98.481658,0.538E-01,-0.537E-01,0.389E-02
12,-123.5477731,48.2613762,1.0360510e+02,104.443073,1,0.9366,1.9846,-0.854E-01,104.357673,0.645E-01,-0.644E-01,0.388E-02
13,-123.5997704,48.2762571,1.1619160e+02,117.127619,1,1.0607,2.1087,0.387E-01,117.166319,0.772E-01,-0.768E-01,0.781E-02
14,-123.6050986,48.3135779,1.0066500e+02,101.551608,1,1.1157,2.1637,0.937E-01,101.645308,0.802E-01,-0.790E-01,0.134E-01
15,-123.4804545,48.1525553,8.2756000e+01,83.582494,1,0.9718,2.0198,-0.502E-01,83.532294,0.297E-01,-0.288E-01,0.706E-02
16,-123.4903681,48.1747690,9.4158100e+01,94.981179,1,0.9602,2.0082,-0.618E-01,94.919379,0.292E-01,-0.287E-01,0.545E-02
17,-123.5226499,48.1840083,9.4302200e+01,95.185473,1,0.9438,1.9918,-0.782E-01,95.107273,0.407E-01,-0.405E-01,0.360E-02
18,-123.4984604,48.1342013,1.0000000e-04,0.889827,1,0.9765,2.0245,-0.455E-01,0.844327,0.344E-01,0.331E-01,-0.924E-02
19,-123.5541540,48.1830143,1.0203360e+02,102.994448,1,0.9483,1.9963,-0.737E-01,102.920748,0.536E-01,-0.534E-01,0.532E-02
20,-123.5824688,48.1935587,1.1003980e+02,111.061933,1,0.9557,2.0037,-0.663E-01,110.995633,0.650E-01,-0.646E-01,0.712E-02
21,-123.5847900,48.2318036,1.1638980e+02,117.358957,1,0.9575,2.0055,-0.645E-01,117.294457,0.713E-01,-0.711E-01,0.644E-02
22,-123.6349726,48.2421904,1.4080520e+02,141.889640,1,0.9658,2.0138,-0.562E-01,141.833440,0.838E-01,-0.835E-01,0.718E-02
23,-123.6629896,48.2860035,1.3965010e+02,140.735491,1,0.9412,1.9892,-0.808E-01,140.654691,0.878E-01,-0.874E-01,0.884E-02
24,-123.6638895,48.3275073,1.0066500e+02,101.674988,1,0.937,1.985,-0.850E-01,101.589988,0.831E-01,-0.805E-01,0.204E-01
25,-123.5155600,48.1563925,8.4513600e+01,85.414770,1,0.9705,2.0185,-0.515E-01,85.363270,0.337E-01,0.334E-01,-0.499E-02
26,-123.5475761,48.1622947,1.0053090e+02,101.504770,1,0.9511,1.9991,-0.709E-01,101.433870,0.459E-01,-0.456E-01,0.532E-02
27,-123.5229115,48.1391161,1.0000000e-04,0.939272,1,1.0873,2.1353,0.653E-01,1.004572,0.365E-01,0.359E-01,-0.625E-02
28,-123.5799807,48.1667515,1.0448020e+02,105.535706,1,0.9421,1.9901,-0.799E-01,105.455806,0.595E-01,-0.589E-01,0.868E-02
29,-123.6121547,48.1720770,1.1027770e+02,111.418977,1,0.94,1.988,-0.820E-01,111.336977,0.707E-01,-0.699E-01,0.107E-01
30,-123.6227935,48.2004240,1.2262990e+02,123.754661,1,0.9595,2.0075,-0.625E-01,123.692161,0.768E-01,-0.763E-01,0.856E-02
31,-123.6649629,48.2077849,1.3718330e+02,138.433214,1,0.9551,2.0031,-0.669E-01,138.366314,0.876E-01,-0.873E-01,0.746E-02
32,-123.6821209,48.2470625,1.5928290e+02,160.509958,1,0.955,2.003,-0.670E-01,160.442958,0.949E-01,-0.948E-01,0.367E-02
33,-123.7229283,48.2693001,1.7100520e+02,172.319753,1,0.9222,1.9702,-0.998E-01,172.219953,0.100E+00,-0.100E+00,0.256E-02
34,-123.7208599,48.3068316,1.4621140e+02,147.433921,1,0.903,1.951,-0.119E+00,147.314921,0.931E-01,-0.927E-01,0.822E-02
35,-123.7180876,48.3507275,0.0000000e+00,1.115322,1,0.891,1.939,-0.131E+00,0.984322,0.860E-01,-0.845E-01,0.160E-01
36,-123.5475817,48.1433992,1.0066500e+02,101.665324,1,0.9766,2.0246,-0.454E-01,101.619924,0.396E-01,-0.391E-01,0.642E-02
37,-123.5724745,48.1470402,1.0066500e+02,101.729693,1,0.9472,1.9952,-0.748E-01,101.654893,0.523E-01,-0.515E-01,0.897E-02
38,-123.5973678,48.1506796,1.0066500e+02,101.794298,1,0.9436,1.9916,-0.784E-01,101.715898,0.651E-01,-0.641E-01,0.112E-01
39,-123.6223958,48.1538234,1.0066500e+02,101.873202,1,0.9424,1.9904,-0.796E-01,101.793602,0.737E-01,-0.726E-01,0.124E-01

DOGAMI Turns Models to Maps

- **Turn Model Output Into Inundation Maps**
  - **5 Local CSZ "Tsunami T-Shirt Scenarios"**
    - **(S, M, L, XL, XXL)**
      - **Occurs at High Tide**
      - **Land Subsidence Taken Into Account**
      - **Maps Include Other Relevant Information such as Wave Time Series, Inundation Exposure, and Wave Elevation Profiles**
  - **2 Distant Alaska Scenarios**
    - **(Alaska 1964 (M9.2) & Alaska Max)**

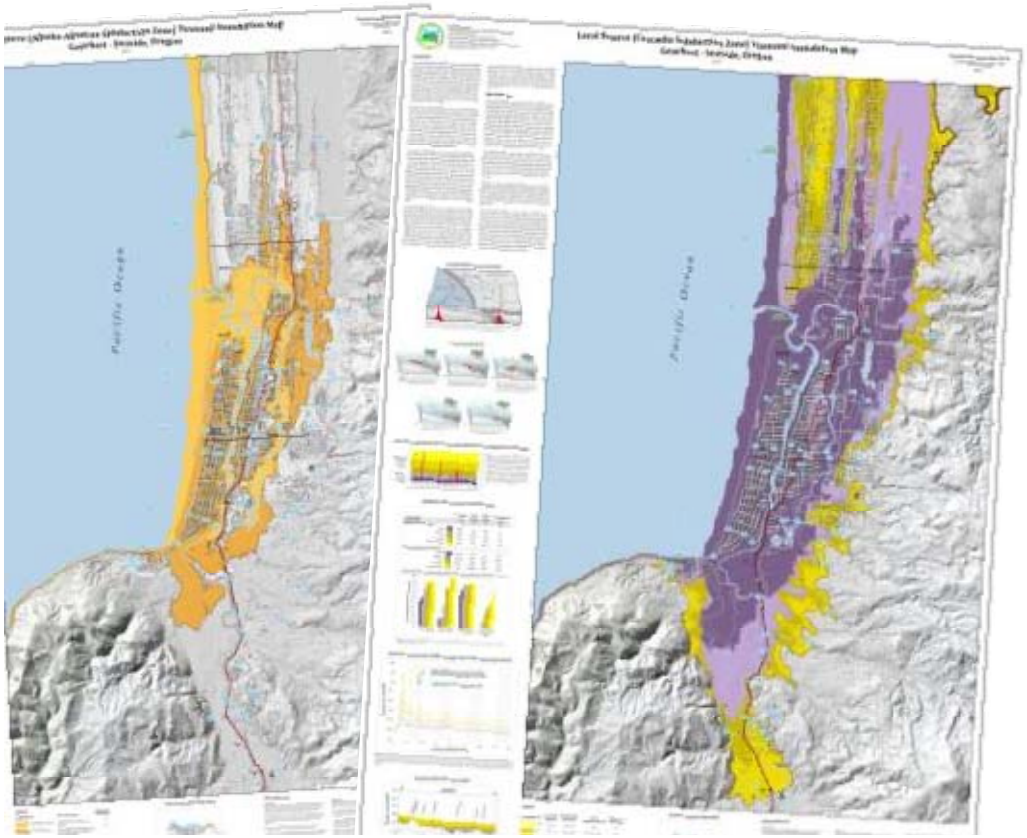
- **Use XXL (worst local) and Alaska Max (worst distant) for Evacuation Brochures**

New Tsunami Maps

Two Kinds of *New* Tsunami Maps

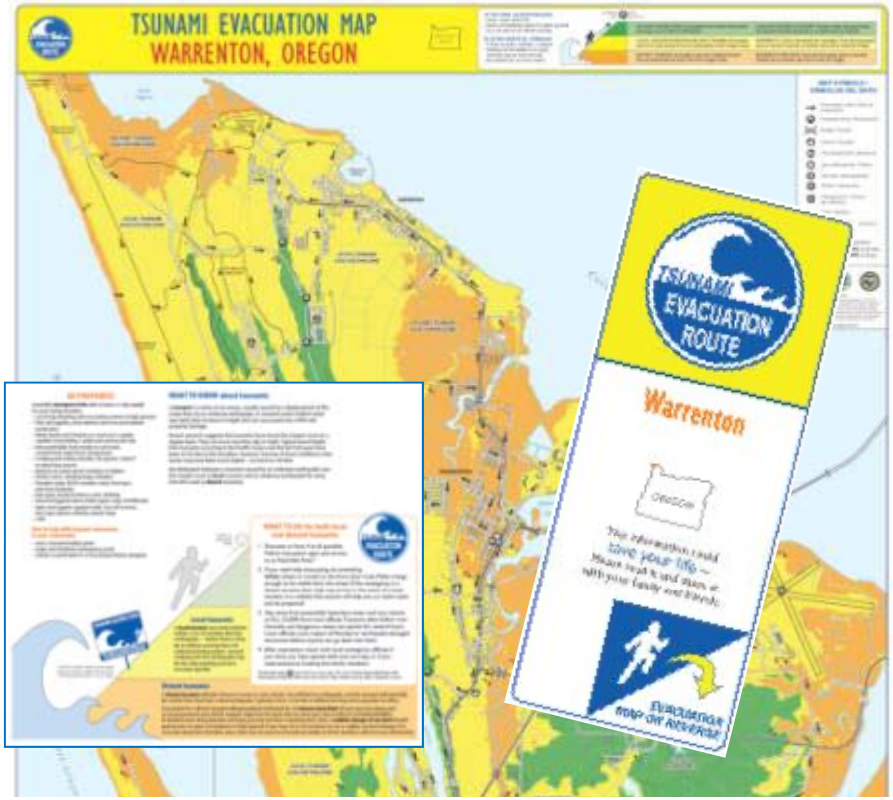
Tsunami inundation maps (TIMs)

- 87 publications for Oregon's coast, each with two maps (local and distant).
- Available for purchase via www.OregonTsunami.org



Tsunami evacuation brochures

- 42 maps for Oregon's coast, covering population centers. Free maps.
- Do you live outside the map areas? See Evacuation Zone Map Viewer at www.OregonTsunami.org

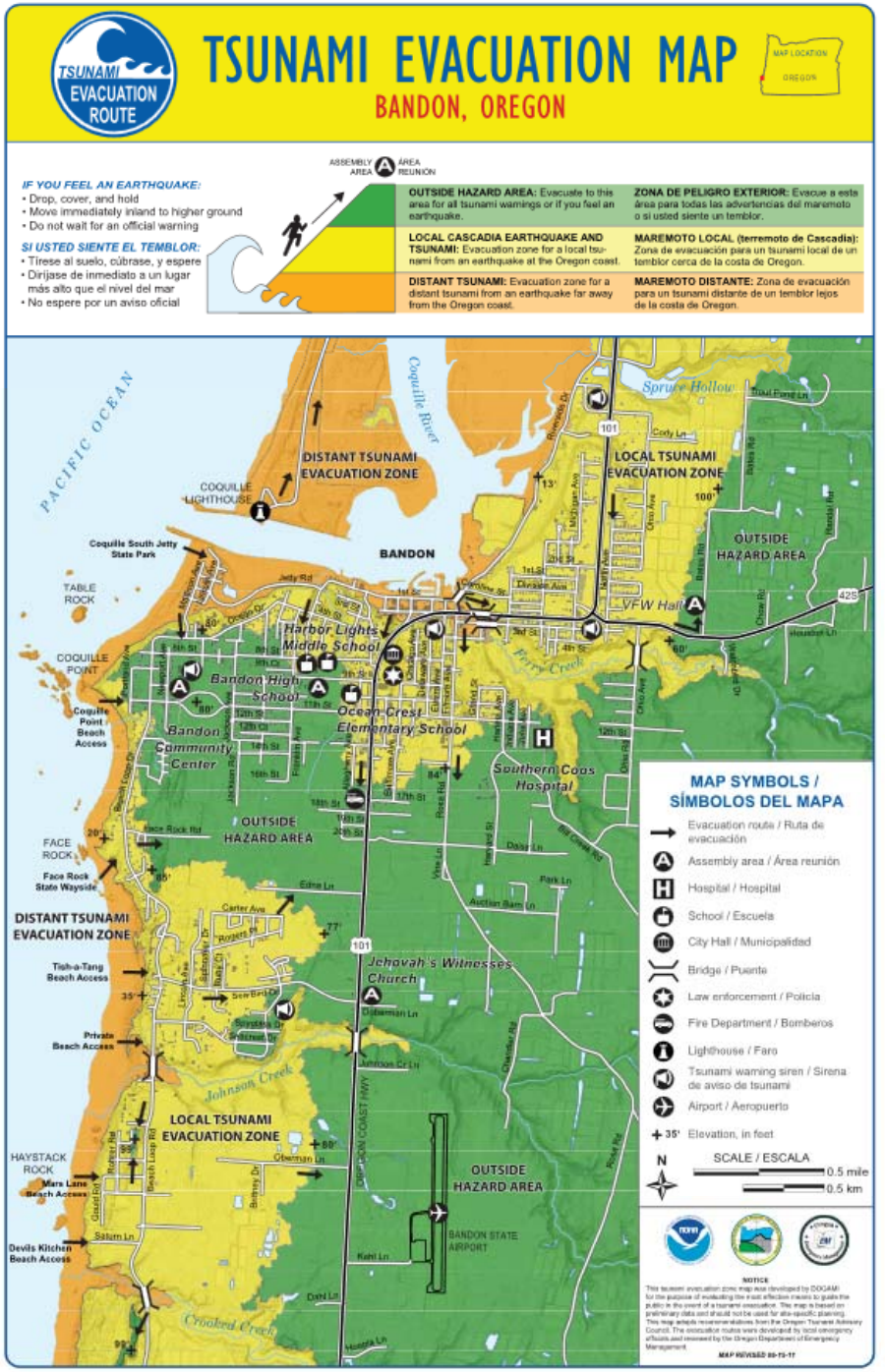


NEW!

Evacuation Maps

Show two scenarios:

- Worst-case *local* tsunami (XXL) in yellow
- Worst-case *distant* tsunami (Alaska maximum) in orange



If you feel an earthquake, a tsunami may be coming...

WHAT TO DO:

- **DROP, COVER, HOLD** until the earthquake is over; protect yourself
- **MOVE IMMEDIATELY INLAND** to high ground and away from low-lying coastal areas
- **FOLLOW EVACUATION ROUTE SIGNS**
- **DO NOT WAIT** for an official warning
- **GO ON FOOT** if at all possible
- **DO NOT PACK** or delay
- **DO NOT RETURN** to the beach – large waves may continue to come onshore for several hours
- **WAIT** for an "all clear" from local emergency officials before returning to low-lying areas

TSUNAMI EVACUATION ROUTE

www.OregonTsunami.org

BE PREPARED!

Assemble emergency kits with at least a 3-day supply for each family member:

- Local map showing safe evacuation routes to high ground.
- First-aid supplies, prescriptions and non-prescription medication.
- Water: bottle and filtration or treatment supplies capable of providing 1 gallon per person per day.
- Non-perishable food (ready-to-eat meals, canned food, baby food, energy bars).
- Cooking and eating utensils, can opener, Sterno® or other heat source.
- Matches in water-proof container or lighter.
- Shelter (tent), sleeping bags, blankets.
- Portable radio, NOAA weather radio, flashlight, and extra batteries.
- Rain gear, sturdy footwear, extra clothing.
- Personal hygiene items (toilet paper, soap, toothbrush).
- Tools and supplies (pocket knife, shut-off wrench, duct tape, gloves, whistles, plastic bags).
- Cash.

How to help with tsunami awareness in your community

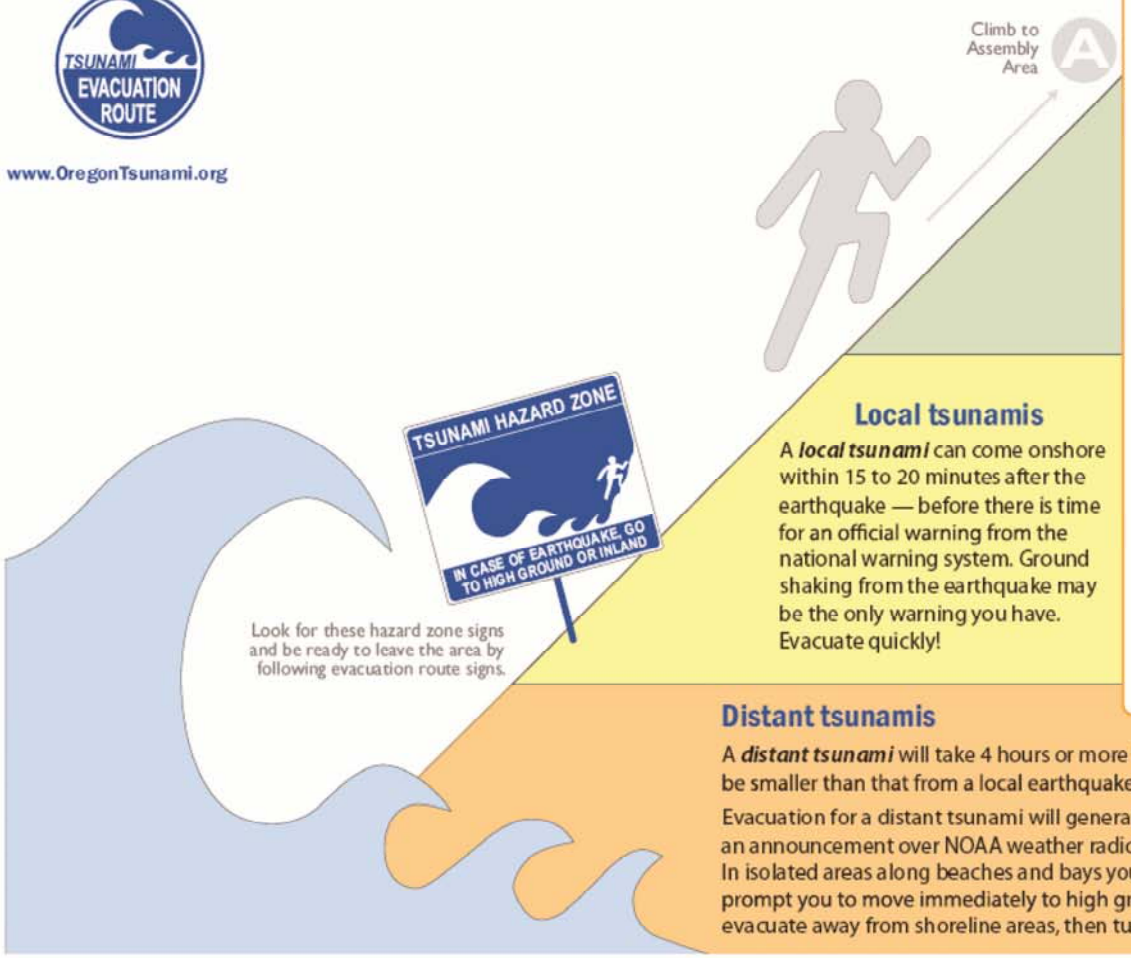
- start a tsunami buddy system
- make and distribute emergency packs
- initiate or participate in a local preparedness program
- visit OregonTsunami.org to find more great resources

WHAT TO KNOW about tsunamis

A ***tsunami*** is a series of sea waves, usually caused by a displacement of the ocean floor by an undersea earthquake. As tsunamis enter shallow water near land, they increase in height and can cause great loss of life and property damage.

Recent research suggests that tsunamis have struck the Oregon coast on a regular basis. They can occur any time, day or night. Typical wave heights from tsunamis occurring in the Pacific Ocean over the last 500 years have been 20–65 feet at the shoreline. However, because of local conditions a few waves may have been much higher — as much as 100 feet.

We distinguish between a tsunami caused by an undersea earthquake near the Oregon coast (a **local** tsunami) and an undersea earthquake far away from the coast (a **distant** tsunami).



Local tsunamis

A ***local tsunami*** can come onshore within 15 to 20 minutes after the earthquake — before there is time for an official warning from the national warning system. Ground shaking from the earthquake may be the only warning you have. Evacuate quickly!

WHAT TO DO for both local and distant tsunamis

TSUNAMI EVACUATION ROUTE

1. Evacuate on foot, if at all possible. Follow evacuation signs and arrows to an Assembly Area.*
2. If you need help evacuating, tie something **white** (sheet or towel) to the front door knob. Make it large enough to be visible from the street. If the emergency is a distant tsunami, then help may arrive. In the event of a local tsunami, it is unlikely that anyone will help you, so make a plan and be prepared!
3. Stay away from potentially hazardous areas until you receive an ALL CLEAR from local officals. Tsunamis often follow river channels, and dangerous waves can persist for several hours. Local officials must inspect all flooded or earthquake-damaged structures before anyone can go back into them.
4. After evacuation, check with local emergency officials if you think you have special skills and can help, or if you need assistance locating lost family members.

*Assembly areas (A) are shown on the map. Do not confuse Assembly Areas with Evacuation Centers, which are short-term help centers set up *after* a disaster occurs.

Distant tsunamis

A ***distant tsunami*** will take 4 hours or more to come ashore. You will feel no earthquake, and the tsunami will generally be smaller than that from a local earthquake. Typically, there is time for an official warning and evacuation to safety.

Evacuation for a distant tsunami will generally be indicated by a **3-minute siren blast** (if your area has sirens) and an announcement over NOAA weather radio that the local area has been put into an official TSUNAMI WARNING. In isolated areas along beaches and bays you may not hear a warning siren. Here, a **sudden change of sea level** should prompt you to move immediately to high ground. If you hear the 3-minute blast or see a sudden sea level change, first evacuate away from shoreline areas, then turn on your local broadcast media or NOAA weather radio for more information.

Community Determines Evacuation Elements

MAP SYMBOLS / SÍMBOLOS DEL MAPA

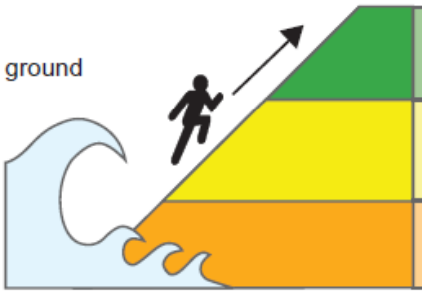
- Evacuation route / Ruta de evacuación
- Assembly area / Área reunión
- Hospital / Hospital
- School / Escuela
- City Hall / Municipalidad
- Bridge / Puente
- Law enforcement / Policía
- Fire Department / Bomberos
- Tsunami warning siren / Sirena de aviso de tsunami
- Airport / Aeropuerto
- 35′ Elevation, in feet

IF YOU FEEL AN EARTHQUAKE:

- Drop, cover, and hold
- Move immediately inland to higher ground
- Do not wait for an official warning

SI USTED SIENTE EL TEMBLOR:

- Tírese al suelo, cúbrase, y espere
- Diríjase 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 or if you feel an earthquake.	**ZONA DE PELIGRO EXTERIOR:** Evacue a esta área para todas las advertencias del maremoto o si usted siente un temblor.
LOCAL CASCADIA EARTHQUAKE AND TSUNAMI: Evacuation zone for a local tsunami from an earthquake at the Oregon coast.	**MAREMOTO LOCAL (terremoto de Cascadia):** Zona de evacuación para un tsunami local de un temblor cerca de la costa de Oregon.
DISTANT TSUNAMI: Evacuation zone for a distant tsunami from an earthquake far away from the Oregon coast.	**MAREMOTO DISTANTE:** Zona de evacuación para un tsunami distante de un temblor lejos de la costa de Oregon.

www.OregonTsunami.org

State of Oregon Department of Geology and Mineral Industries | Clearinghouse | DOGAMI | Oregon.gov

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

Oregon Tsunami Clearinghouse

Home | Coastal Residents | Visitors | Kids & Teachers | Community Planners | Scientists

Frontpage | Evacuation Zone Map Viewer | Evacuation Brochures | Regulatory Maps | Resource Library | Calendar

Is your family prepared for disaster?

Tsunami Evacuation Zone Map Viewer

Search by address or coastal area.

web map | iPhone app | Android app

Tsunami Evacuation Brochures

For coastal communities.

TsunamiReady, TsunamiPrepared News

DOGAMI Events Calendar

» 05/06/13 - TIM series inundation maps complete for Douglas County

» upcoming: **Tsunami Readiness Rallies:**

May 7- Lincoln City
May 9-Waldport
May 11-Newport
May 14-Florence
May 21-Lakeside/Hauser

» 05/01/13 - Evacuation

Search

Tsunami news around the web

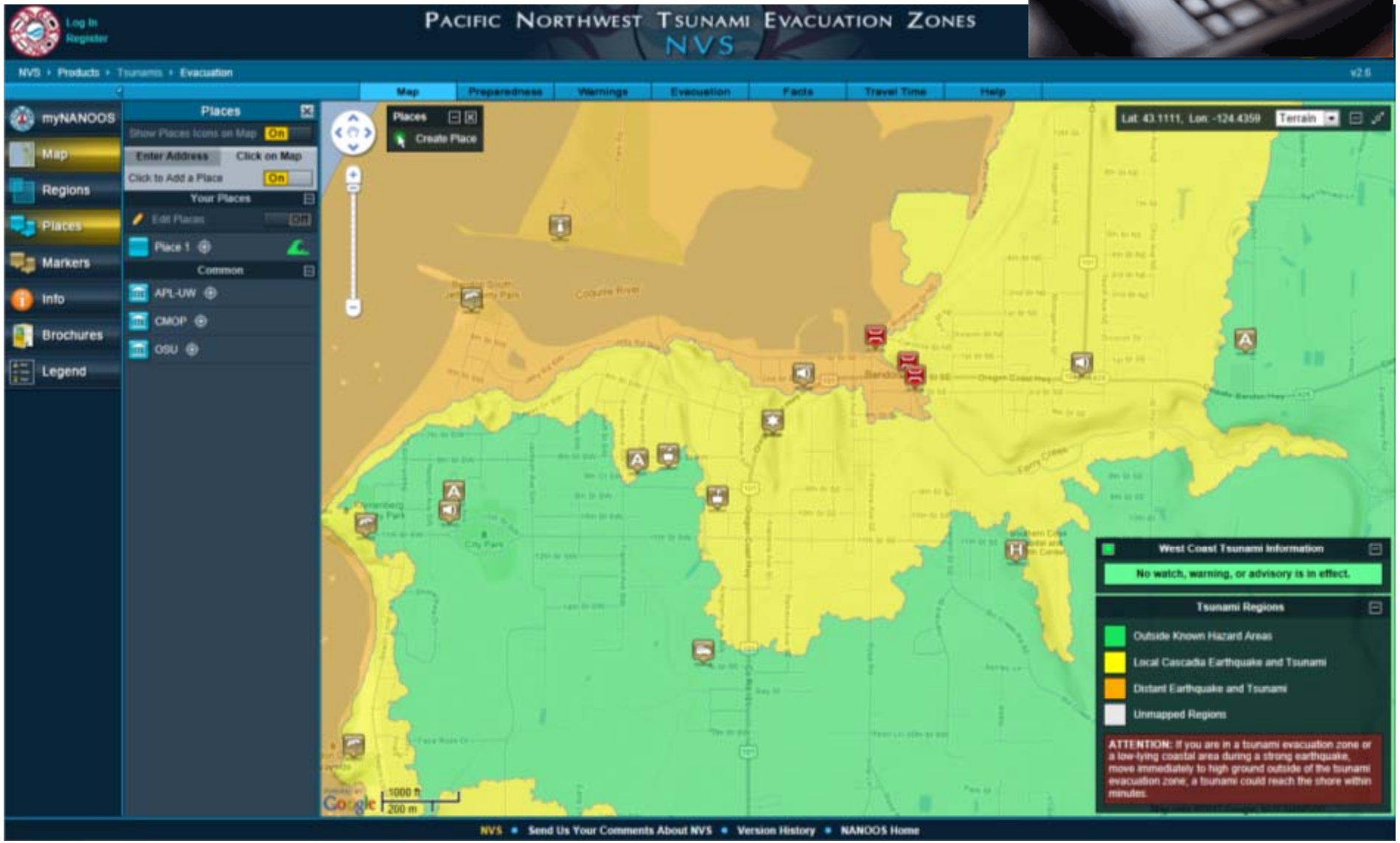
Fishing float rides 2 tsunamis -- NBCNews.com (blog)

Geologists are still puzzling over the unusual Haida Gwaii earthquake, which surprised scientists because of its unexpected style. Understanding what caused the quake will help them forecast the region's earthquake and tsunami hazards. Two tectonic

...

Evacuation Zone Map Viewer

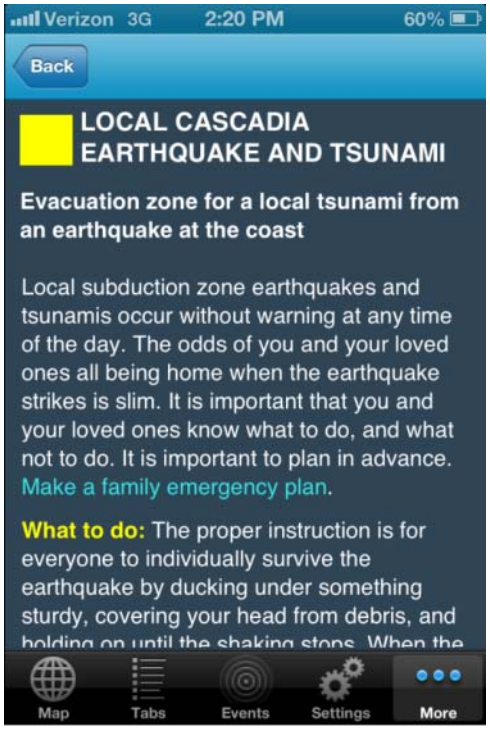
www.OregonTsunami.org



App for Smartphones

For iPhone and Android. Free!

TsunamiEvac-NW



And now for the good news:
You *can survive* if you prepare and take action.

How You Can Prepare

Tsunami Outreach Oregon

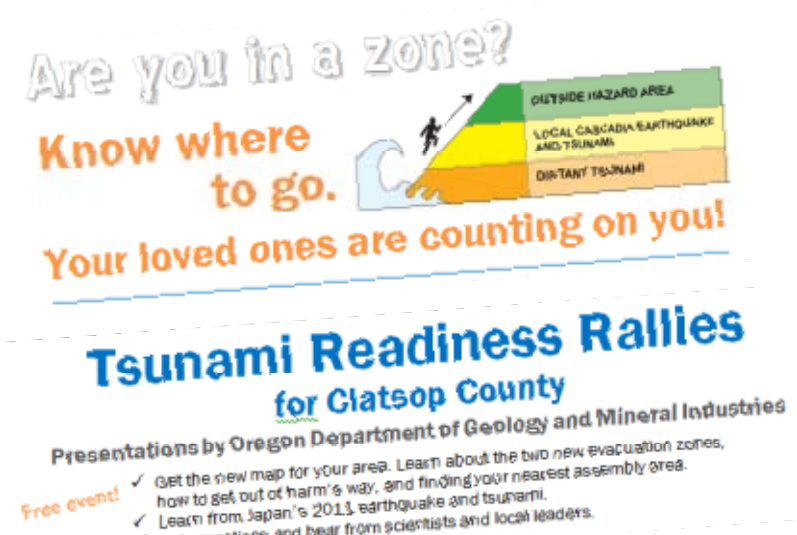
- To assist coastal communities in creating a local *culture of preparedness and response*

Mapping and modeling

TsunamiReady™ *communities*

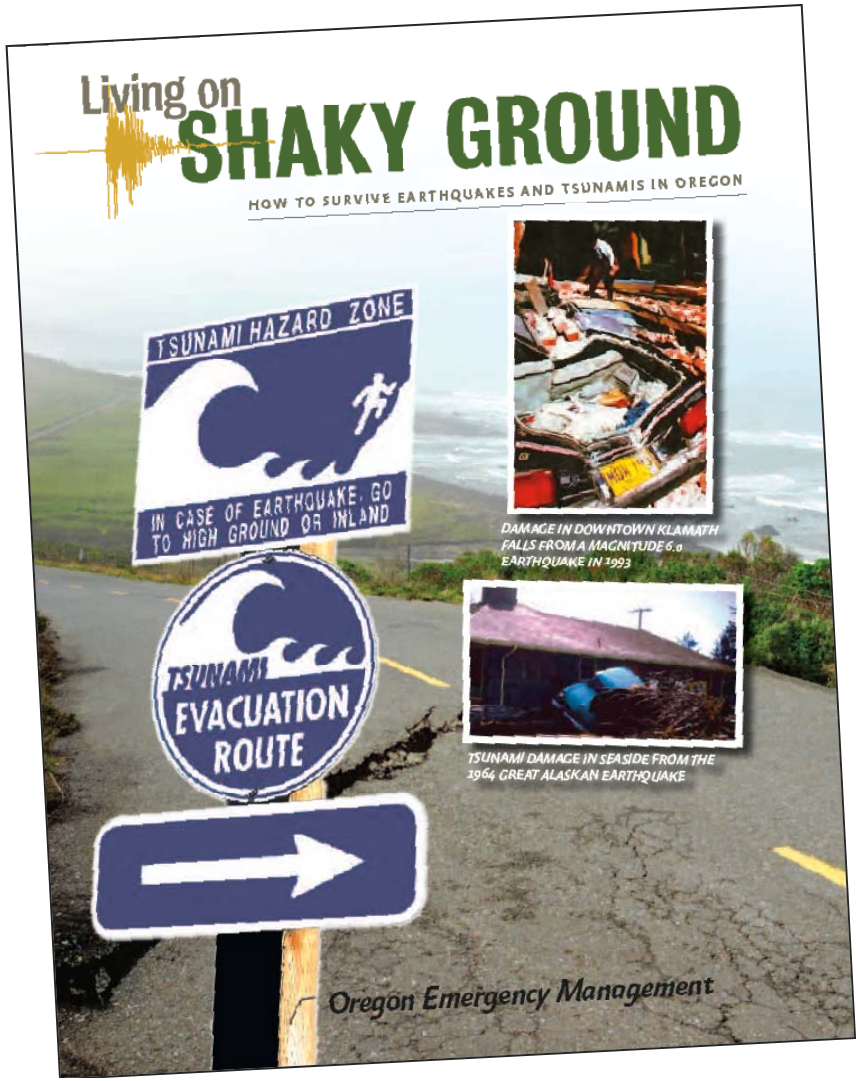
Grass-roots outreach and education

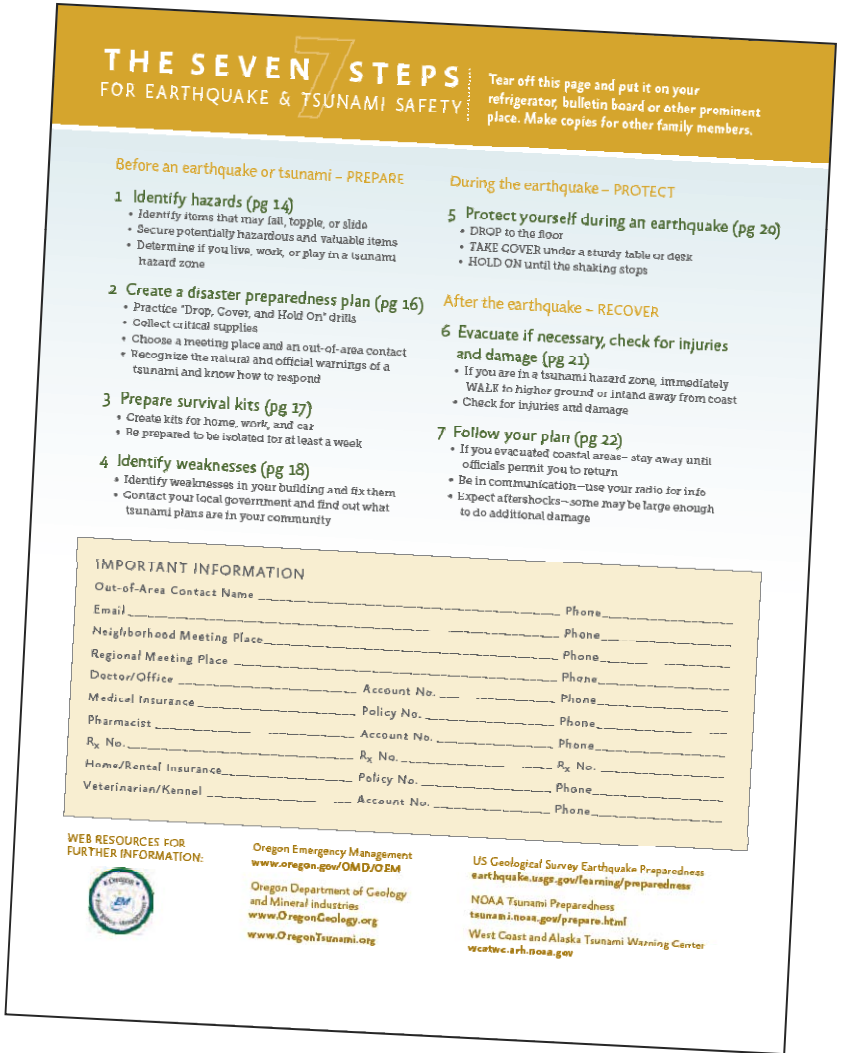
Tsunami Readiness Rallies Helped to Spread the Word



How You Can Prepare
At Home

Free booklet available from
http://www.oregon.gov/omd/oem/plans_train/earthquake/shakygroundmagazine_final.pdf
Or by calling Oregon Emergency Management at (503) 378-2911 extension 22237





THE SEVEN STEPS
FOR EARTHQUAKE & TSUNAMI SAFETY

Tear off this page and put it on your refrigerator, bulletin board or other prominent place. Make copies for other family members.

Before an earthquake or tsunami – PREPARE

1 Identify hazards (pg 14)
- Identify items that may fall, topple, or slide
- Secure potentially hazardous and valuable items
- Determine if you live, work, or play in a tsunami hazard zone

2 Create a disaster preparedness plan (pg 16)
- Practice "Drop, Cover, and Hold On" drills
- Collect critical supplies
- Choose a meeting place and an out-of-area contact
- Recognize the natural and official warnings of a tsunami and know how to respond

3 Prepare survival kits (pg 17)
- Create kits for home, work, and car
- Be prepared to be isolated for at least a week

4 Identify weaknesses (pg 18)
- Identify weaknesses in your building and fix them
- Contact your local government and find out what tsunami plans are in your community

During the earthquake – PROTECT

5 Protect yourself during an earthquake (pg 20)
- DROP to the floor
- TAKE COVER under a sturdy table or desk
- HOLD ON until the shaking stops

After the earthquake – RECOVER

6 Evacuate if necessary, check for injuries and damage (pg 21)
- If you are in a tsunami hazard zone, immediately WALK to higher ground or inland away from coast
- Check for injuries and damage

7 Follow your plan (pg 22)
- If you evacuated coastal areas– stay away until officials permit you to return
- Be in communication—use your radio for info
- Expect aftershocks—some may be large enough to do additional damage

IMPORTANT INFORMATION

Out-of-Area Contact Name _____ Phone _____
Email _____ Phone _____
Neighborhood Meeting Place _____ Phone _____
Regional Meeting Place _____ Phone _____
Doctor/Office _____ Account No. _____ Phone _____
Medical Insurance _____ Policy No. _____ Phone _____
Pharmacist _____ Account No. _____ Phone _____
R_x No. _____ R_x No. _____ R_x No. _____
Home/Rental Insurance _____ Policy No. _____ Phone _____
Veterinarian/Kennel _____ Account No. _____ Phone _____

WEB RESOURCES FOR FURTHER INFORMATION:

Oregon Emergency Management
www.oregon.gov/OMD/OEM

Oregon Department of Geology and Mineral Industries
www.OregonGeology.org
www.OregonTsunami.org

US Geological Survey Earthquake Preparedness
earthquake.usgs.gov/learning/preparedness

NOAA Tsunami Preparedness
tsunami.noaa.gov/prepare.html

West Coast and Alaska Tsunami Warning Center
wcatwc.arh.noaa.gov

Three things to keep next to your bed:

1. **Headlamp** (so you can see when electricity goes out and it's nighttime)
2. **Gloves** (so you can pick up broken glass and other sharp objects in your way)
3. **Boots or shoes** (so you can walk safely over all the sharp, broken debris without cutting your feet)

Darth Vader headlamp. Cool!

BE PREPARED!

Assemble **emergency kits** with at least a 3-day supply for each family member:

- Local map showing safe evacuation routes to high ground
- First-aid supplies, prescriptions and non-prescription medication
- Water bottle and filtration or treatment supplies capable of providing 1 gallon per person per day
- Non-perishable food (ready-to-eat meals, canned food, baby food, energy bars)
- Cooking and eating utensils, can opener, Sterno® or other heat source
- Matches in water-proof container or lighter
- Shelter (tent), sleeping bags, blankets
- Portable radio, NOAA weather radio, flashlight, and extra batteries
- Rain gear, sturdy footwear, extra clothing
- Personal hygiene items (toilet paper, soap, toothbrush)
- Tools and supplies (pocket knife, shut-off wrench, duct tape, gloves, whistles, plastic bags)
- Cash

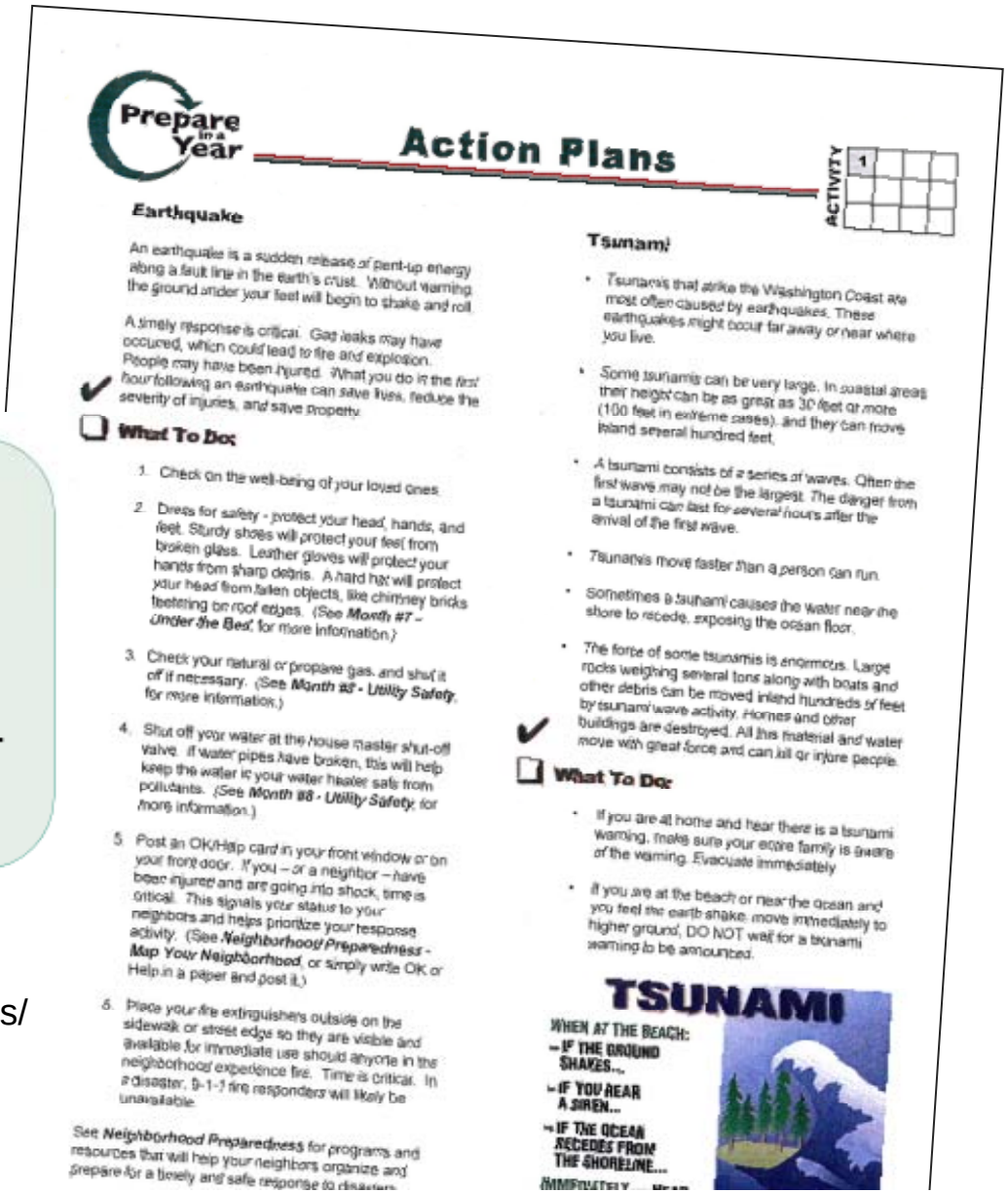
How You Can Prepare
At Home

ONE HOUR

of disaster preparedness activity

EACH MONTH

helps you be ready for disasters – whenever they occur.



Prepare in a Year

Action Plans

ACTIVITY 1

Earthquake

An earthquake is a sudden release of pent-up energy along a fault line in the earth's crust. Without warning the ground under your feet will begin to shake and roll.

A timely response is critical. Gas leaks may have occured, which could lead to fire and explosion. People may have been injured. What you do in the first hour following an earthquake can save lives, reduce the severity of injuries, and save property.

✔ ❑ **What To Do:**

1. Check on the well-being of your loved ones.
2. Dress for safety - protect your head, hands, and feet. Sturdy shoes will protect your feet from broken glass. Leather gloves will protect your hands from sharp debris. A hard hat will protect your head from falling objects, like chimney bricks teetering on roof edges. (See ***Month #7 - Under the Bed***, for more information.)
3. Check your natural or propane gas, and shut it off if necessary. (See ***Month #8 - Utility Safety***, for more information.)
4. Shut off your water at the house master shut-off valve. If water pipes have broken, this will help keep the water in your water heater safe from pollutants. (See ***Month #8 - Utility Safety***, for more information.)
5. Post an OK/Help card in your front window or on your front door. If you – or a neighbor – have been injured and are going into shock, time is critical. This signals your status to your neighbors and helps prioritize your response activity. (See ***Neighborhood Preparedness - Map Your Neighborhood***, or simply write OK or Help in a paper and post it.)
6. Place your fire extinguishers outside on the sidewalk or street edge so they are visible and available for immediate use should anyone in the neighborhood experience fire. Time is critical. In a disaster, 9-1-1 fire responders will likely be unavailable.

See ***Neighborhood Preparedness*** for programs and resources that will help your neighbors organize and prepare for a timely and safe response to disasters.

Tsunami

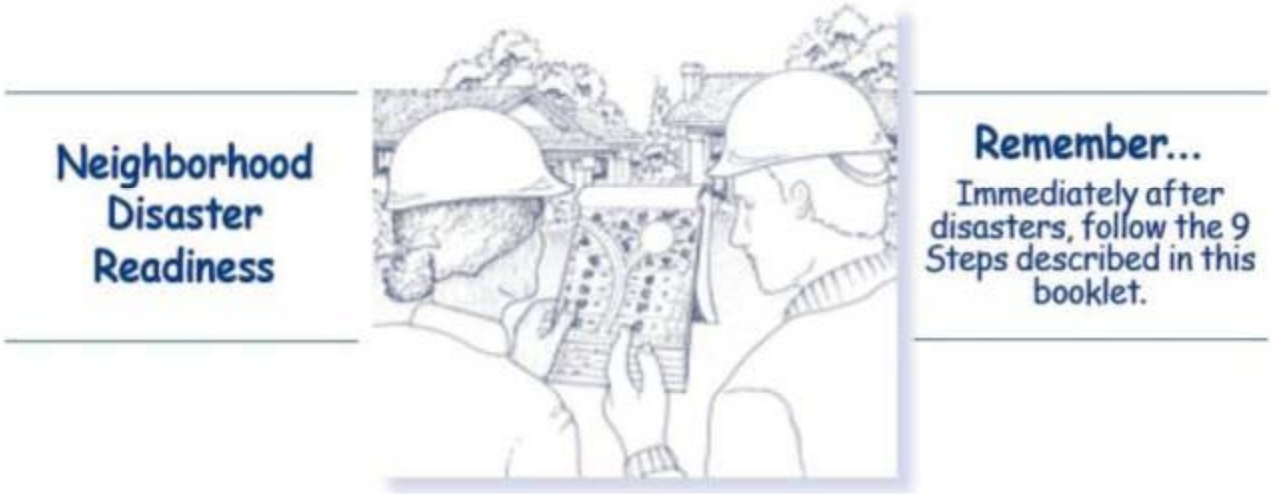
- Tsunamis that strike the Washington Coast are most often caused by earthquakes. These earthquakes might occur far away or near where you live.
- Some tsunamis can be very large. In coastal areas their height can be as great as 30 feet or more (100 feet in extreme cases), and they can move inland several hundred feet.
- A tsunami consists of a series of waves. Often the first wave may not be the largest. The danger from a tsunami can last for several hours after the arrival of the first wave.
- Tsunamis move faster than a person can run.
- Sometimes a tsunami causes the water near the shore to recede, exposing the ocean floor.
- The force of some tsunamis is enormous. Large rocks weighing several tons along with boats and other debris can be moved inland hundreds of feet by tsunami wave activity. Homes and other buildings are destroyed. All this material and water move with great force and can kill or injure people.

✔ ❑ **What To Do:**

- If you are at home and hear there is a tsunami warning, make sure your entire family is aware of the warning. Evacuate immediately.
- If you are at the beach or near the ocean and you feel the earth shake, move immediately to higher ground. DO NOT wait for a tsunami warning to be announced.

Free download at:
http://www.emd.wa.gov/preparedness/documents/2011_PIY_Booklet.pdf

How You Can Prepare
Your Neighborhood



- An easy 9-step program to get yourself and your neighbors prepared for disaster.
- More info at http://www.preporegon.org/MYN_overview

How You Can Prepare
Join your local CERT group!

- Educates people about disaster preparedness for hazards
- Training in basic disaster response skills, such as fire safety, light search and rescue, team organization, and disaster medical operations.
- CERT members can assist others in their neighborhood or workplace following an event when professional responders are not immediately available to help.

How You Can Help

- Prepare at home, work, and school
- Talk to your friends, family, and neighbors
- Do the Map Your Neighborhood exercise with your immediate neighbors
- Get emergency notifications via phone, cell, email, text, etc. Sign up at your county government's website via emergency management department

Thank you!

Shake Out. Don't Freak Out.

October 17, 10:17 a.m.

The Great Oregon ShakeOut™

Register at www.ShakeOut.org/oregon

Join Us

for the Largest Earthquake Drill in Oregon History.

More Information

www.OregonTsunami.org
Oregon Dept. of Geology and Mineral Industries (DOGAMI)
(971) 673-1543

Or from your local fire station or city hall