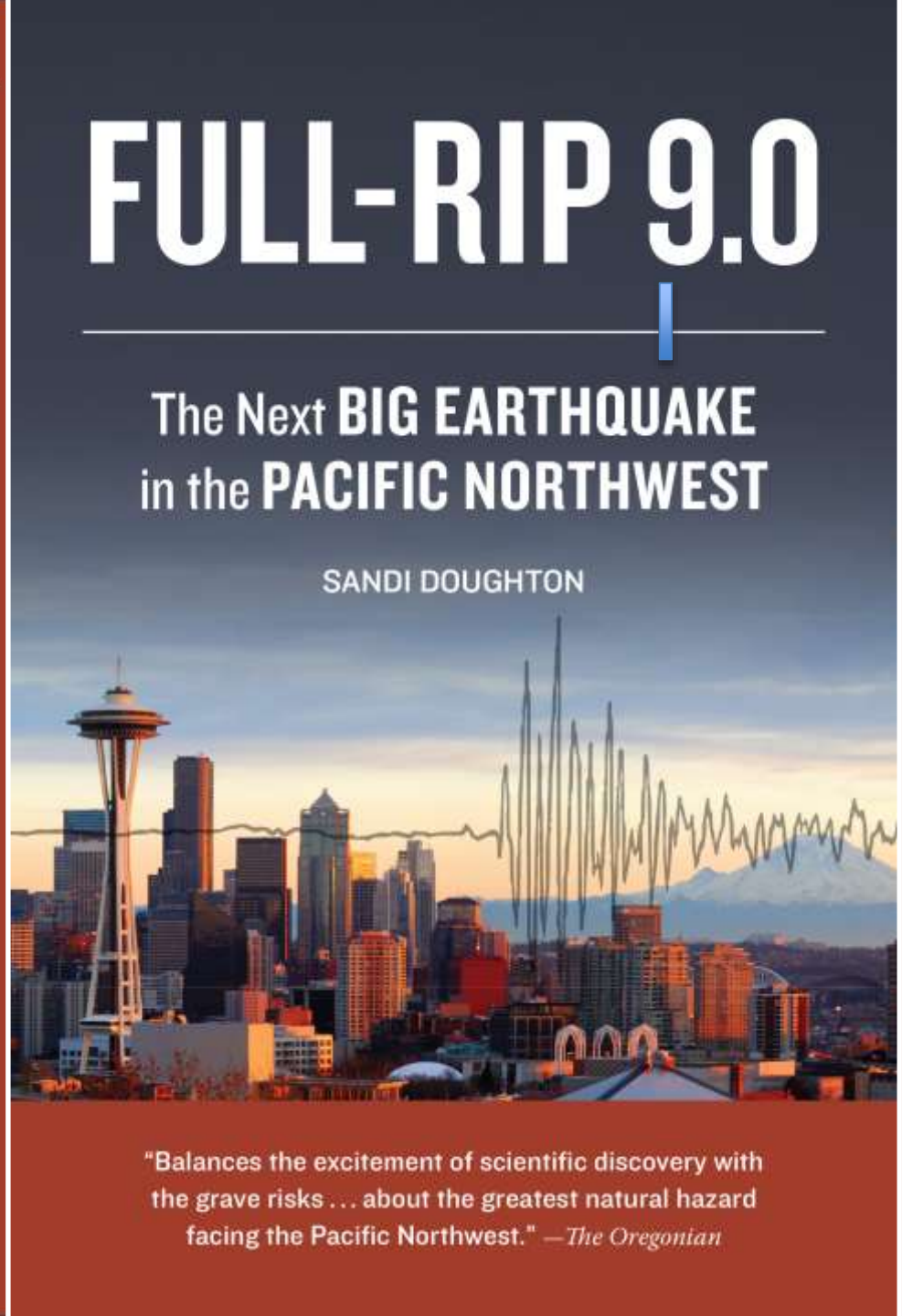
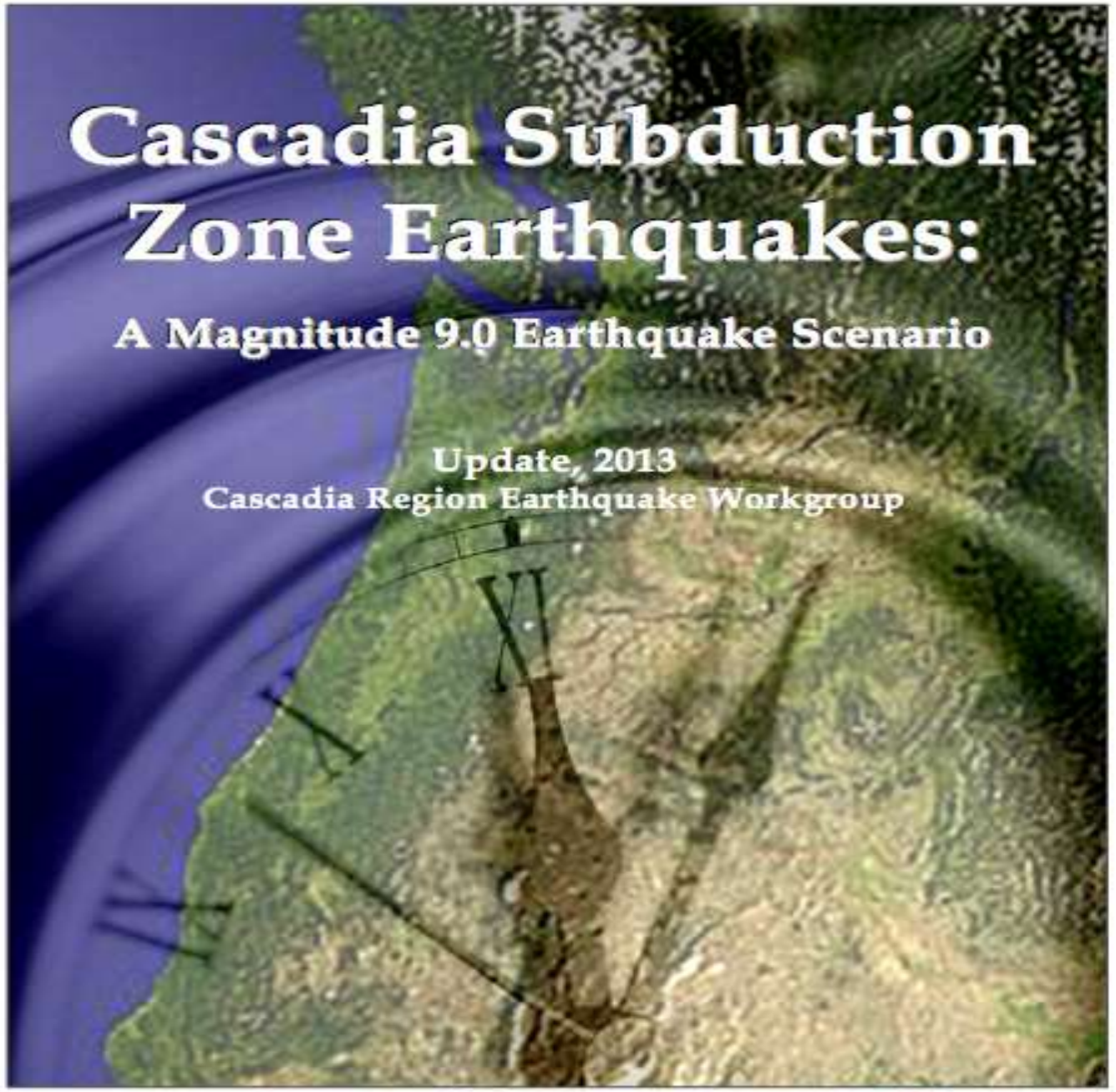


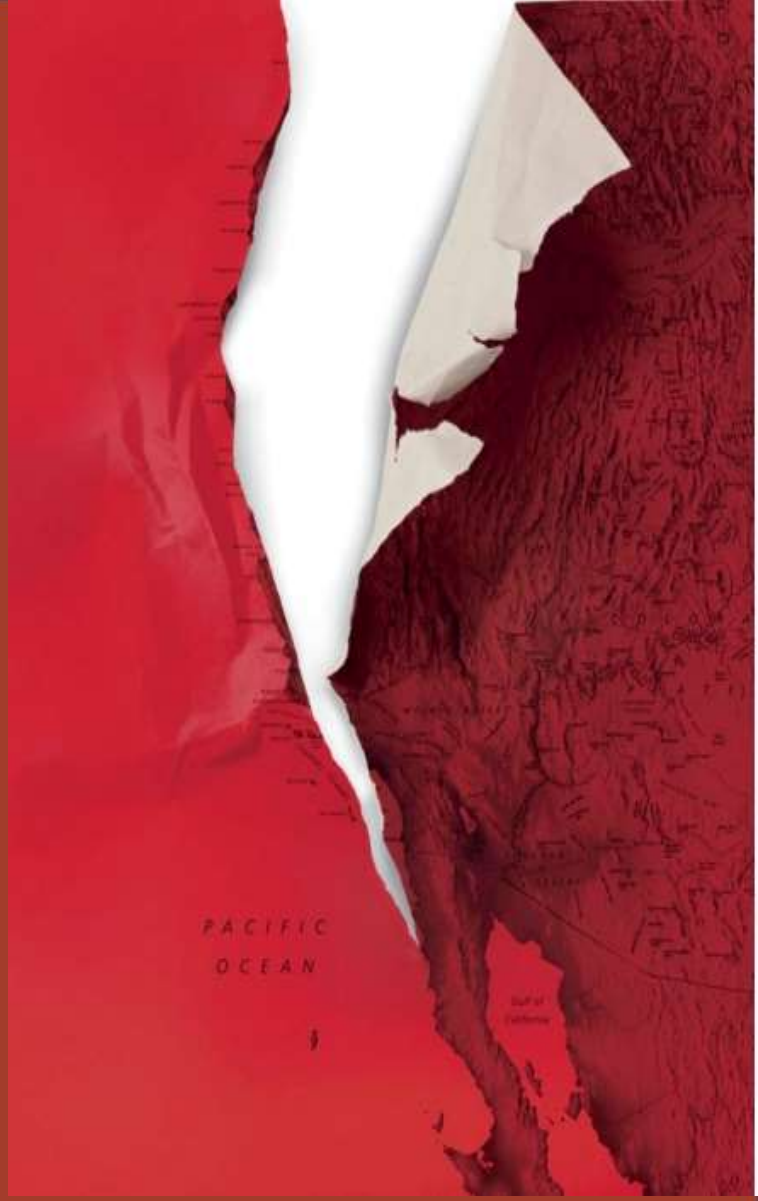
Shake, Rattle & Rebound

Sandi Doughton


Cascadia Subduction Zone Earthquakes:
A Magnitude 9.0 Earthquake Scenario
Update, 2013
Cascadia Region Earthquake Workgroup
CASCADIA REGION EARTHQUAKE WORKGROUP
CREW
AHEAD OF THE WAVE
FEMA
nehrp

THE NEW YORKER

THE REALLY BIG ONE

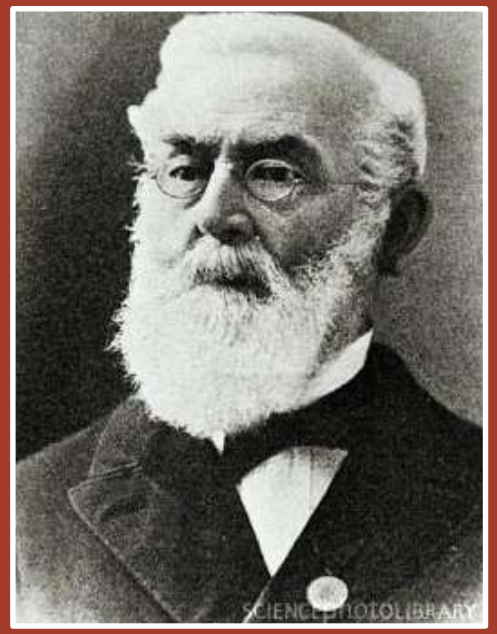


An earthquake will destroy a sizable portion of the Northwest coast

The question is when

July 20, 2015

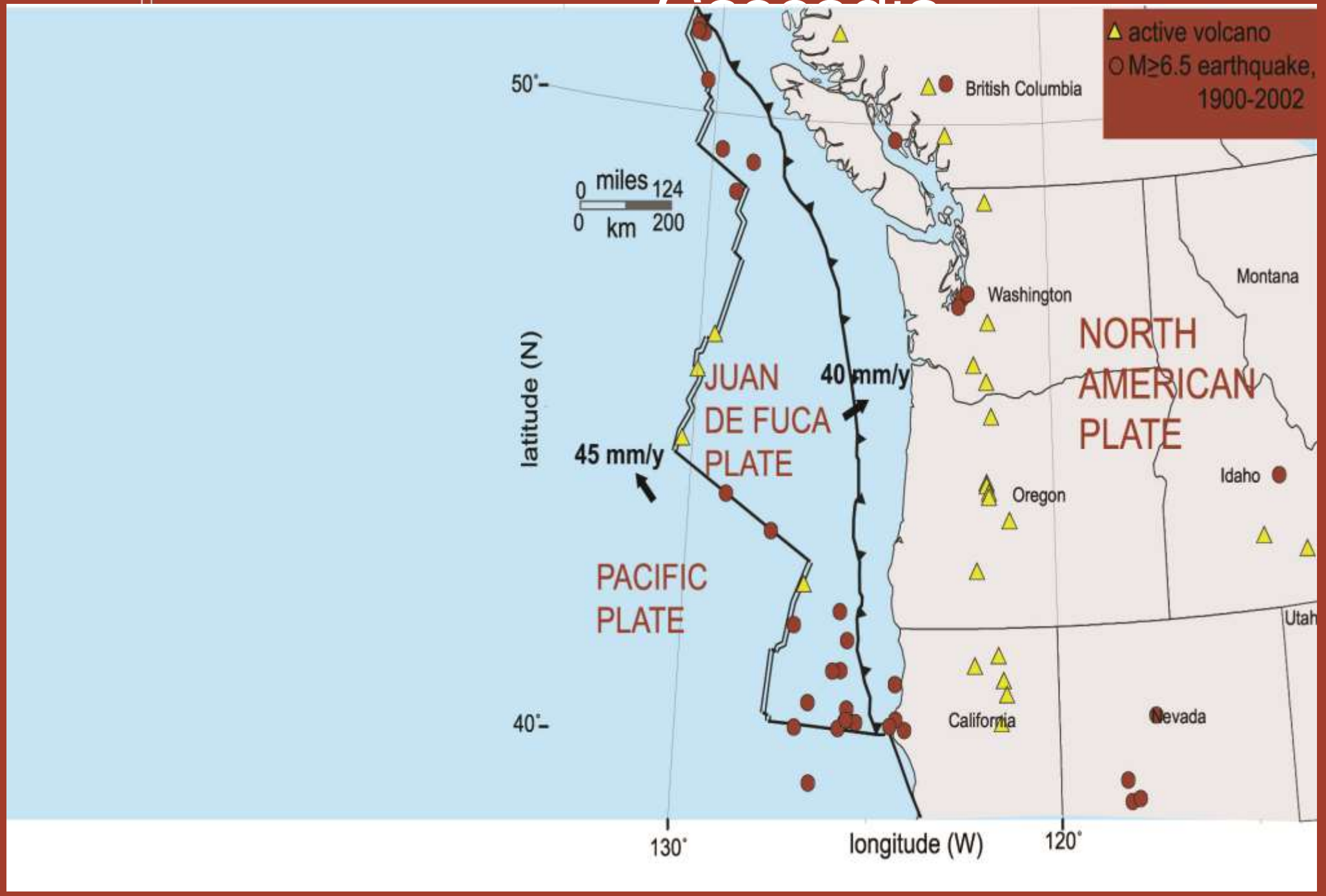
It can't happen *HERE*

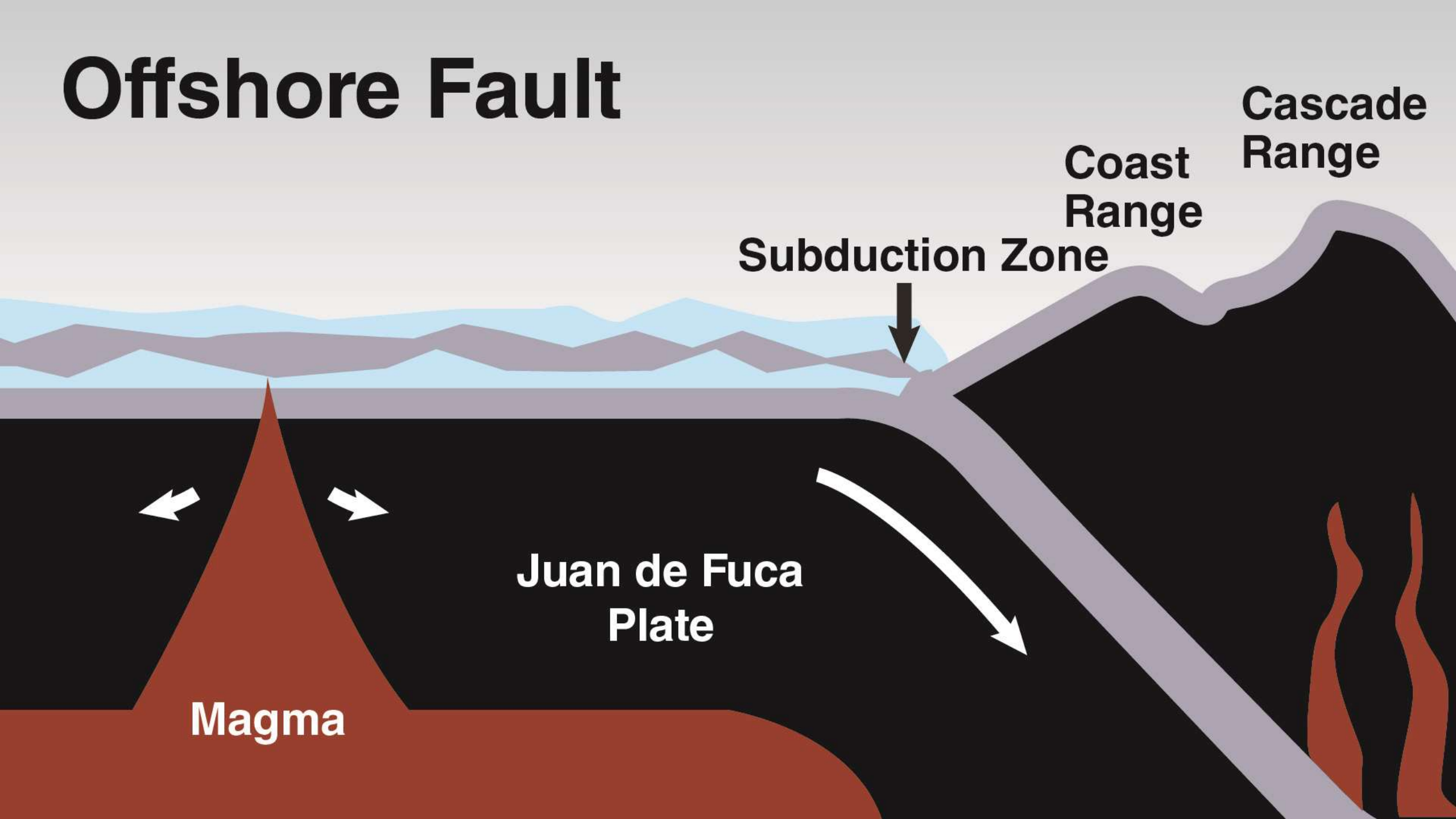


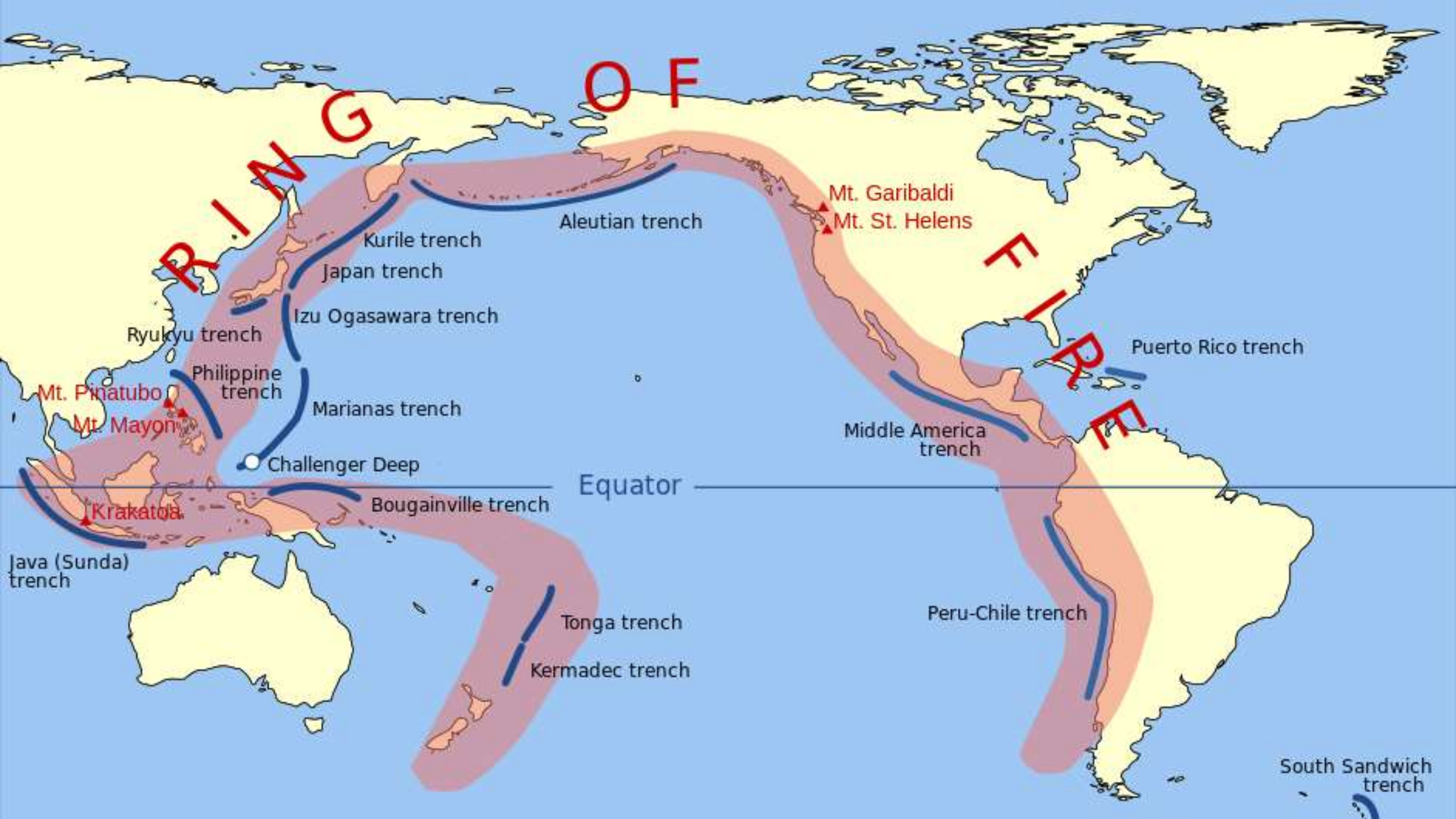
"Los Angeles may shimmy with earthquakes and San Francisco may get another one, but Seattle, set on the deepest glacial drift yet discovered, has a shock absorber that makes the city immune for all time."

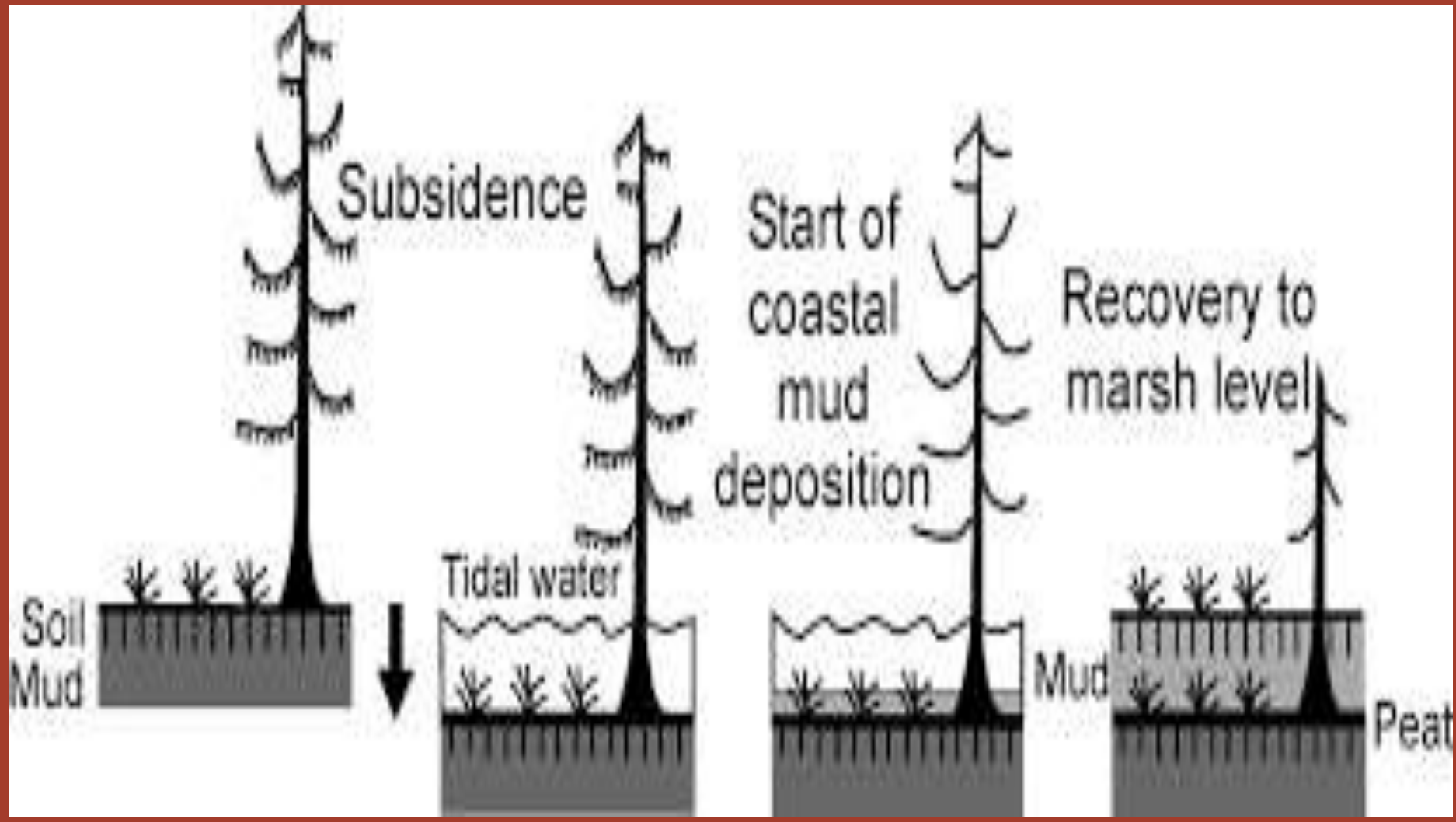
Professor Collier Cobb, 1920

Remember WPPSS?


active volcano
M≥6.5 earthquake, 1900-2002
British Columbia
Washington
Montana
Idaho
Oregon
Utah
California
Nevada
NORTH AMERICAN PLATE
JUAN DE FUCA PLATE
PACIFIC PLATE
40 mm/y
45 mm/y
0 miles 124
0 km 200
50°
40°
130°
120°
latitude (N)
longitude (W)


Offshore Fault
Cascade Range
Coast Range
Subduction Zone
Juan de Fuca Plate
Magma

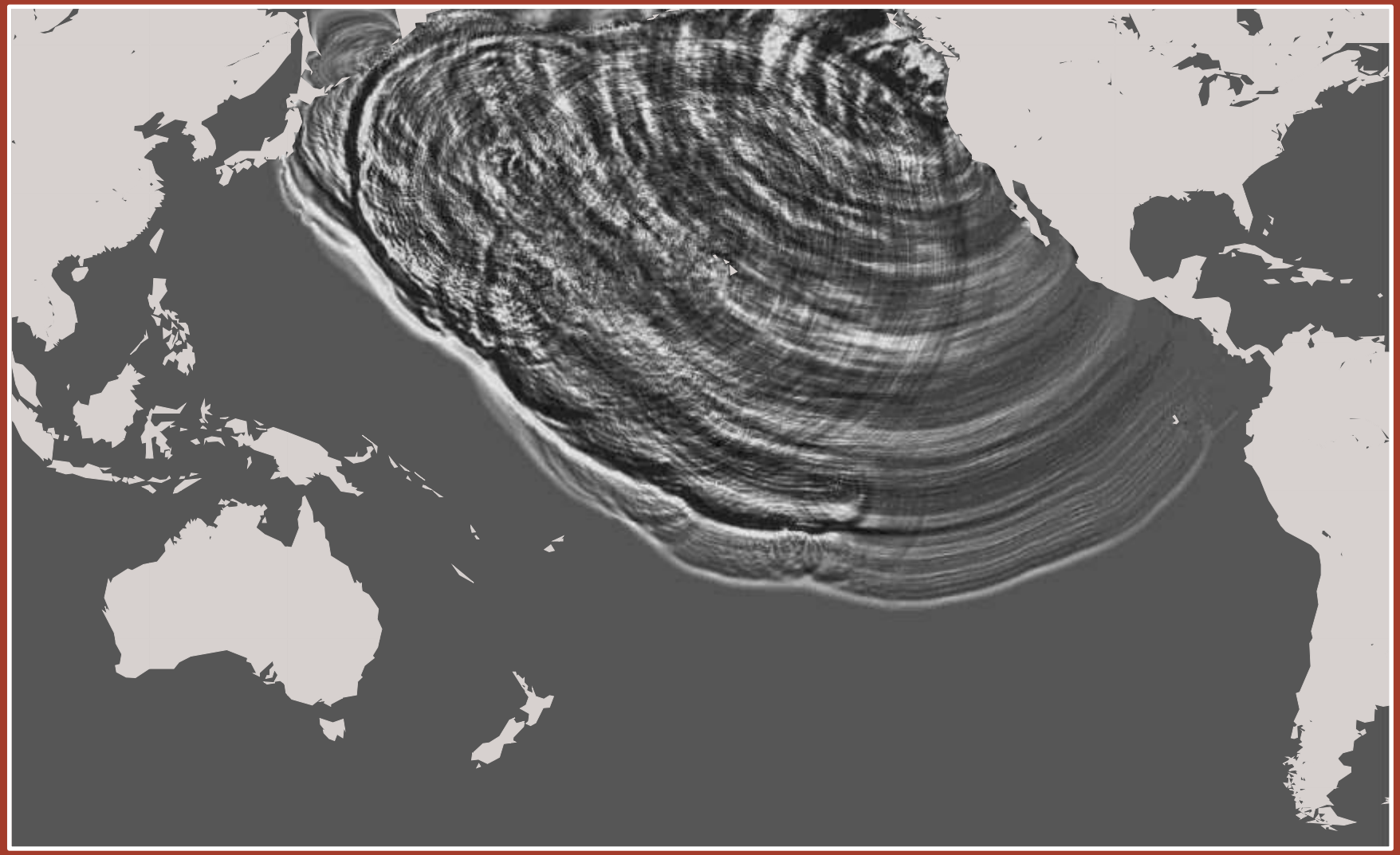

RING OF FIRE
Aleutian trench
Kurile trench
Japan trench
Izu Ogasawara trench
Ryukyu trench
Philippine trench
Marianas trench
Challenger Deep
Mt. Pinatubo
Mt. Mayon
Krakatoa
Java (Sunda) trench
Bougainville trench
Tonga trench
Kermadec trench
Mt. Garibaldi
Mt. St. Helens
Middle America trench
Puerto Rico trench
Peru-Chile trench
South Sandwich trench
Equator


Subsidence
Start of coastal mud deposition
Recovery to marsh level
Soil
Mud
Tidal water
Mud
Peat


要石

The Ghost Forest of the Copalis

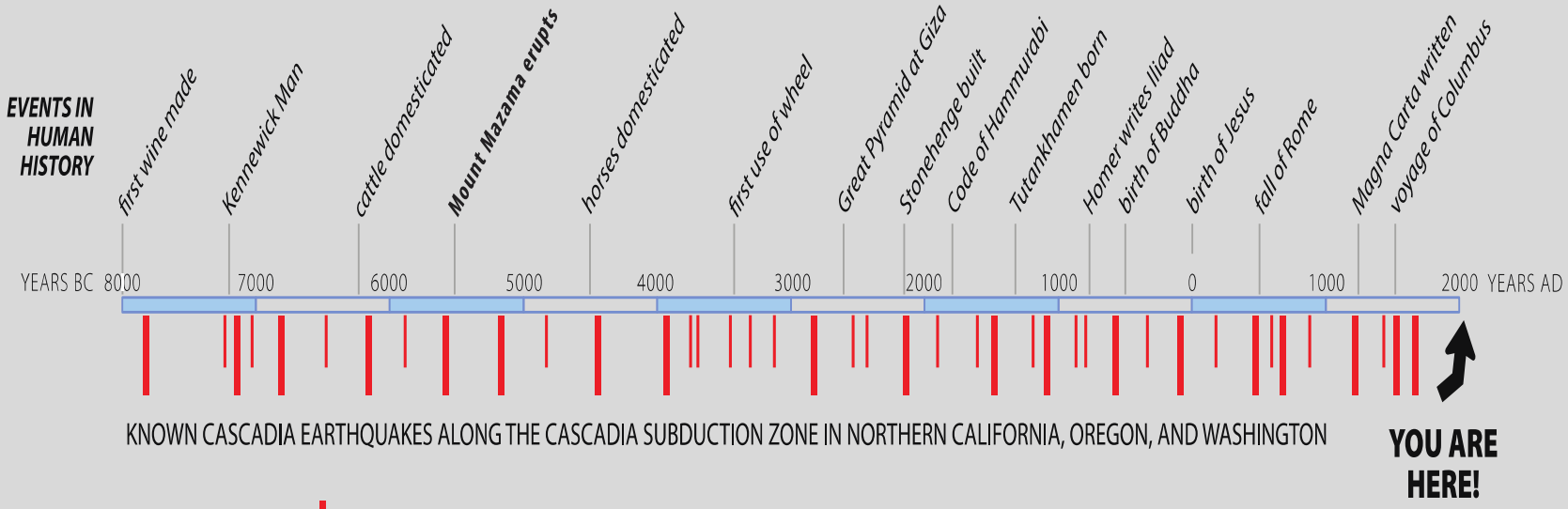
Samurai records, tree rings & tsunami models date the NW's last megaquake



In the last 10,000 years there have been:

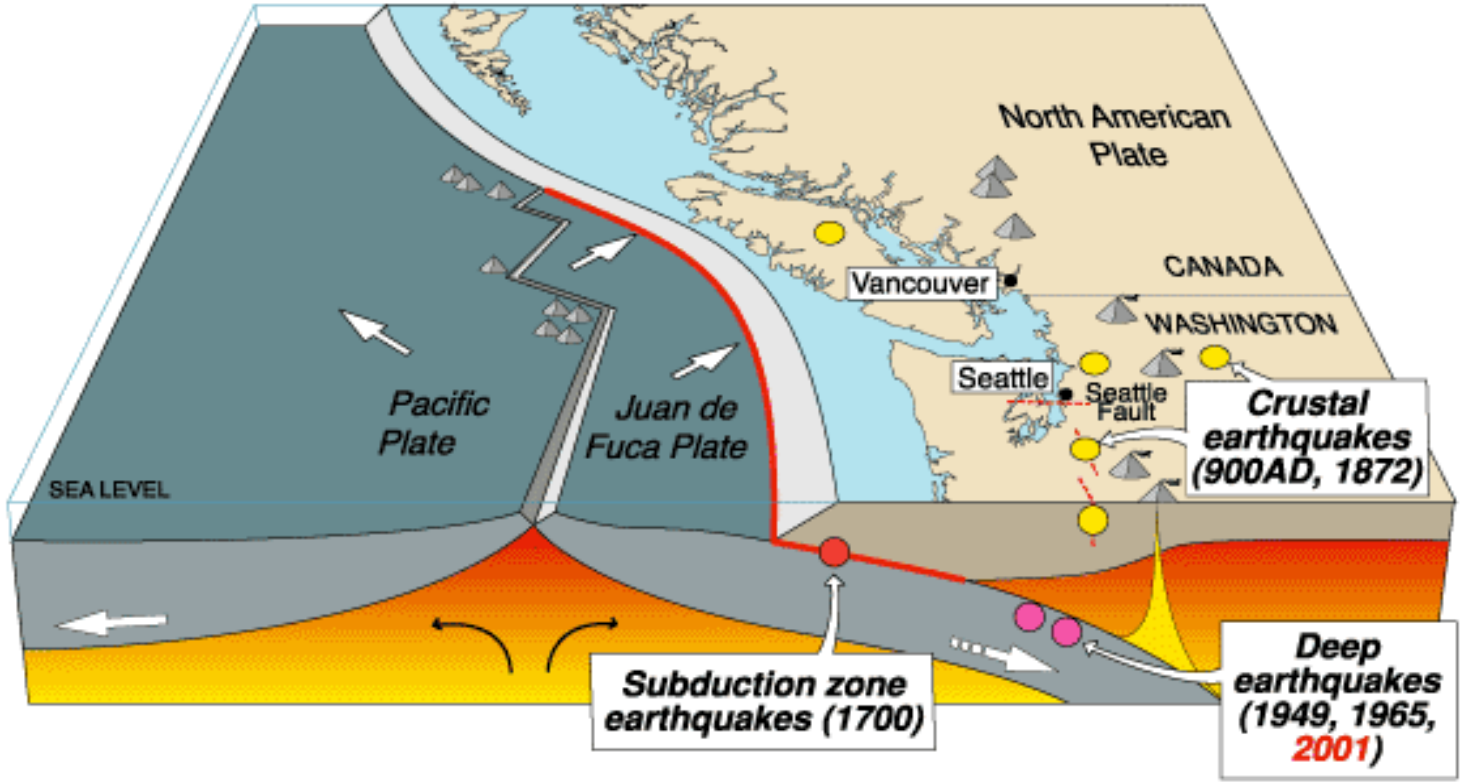
- 20 Full Rip M 9.0s
- 20 Partial Rip M 8-8.5

CASCADIA EARTHQUAKE TIME LINE



Comparison of the history of subduction zone earthquakes along the Cascadia Subduction Zone in northern California, Oregon, and Washington, with events from human history. Ages of earthquakes are derived from study and dating of submarine landslides triggered by the earthquakes. Earthquake data provided by Chris Goldfinger, Oregon State University; time line by Ian P. Madin, DOGAMI.

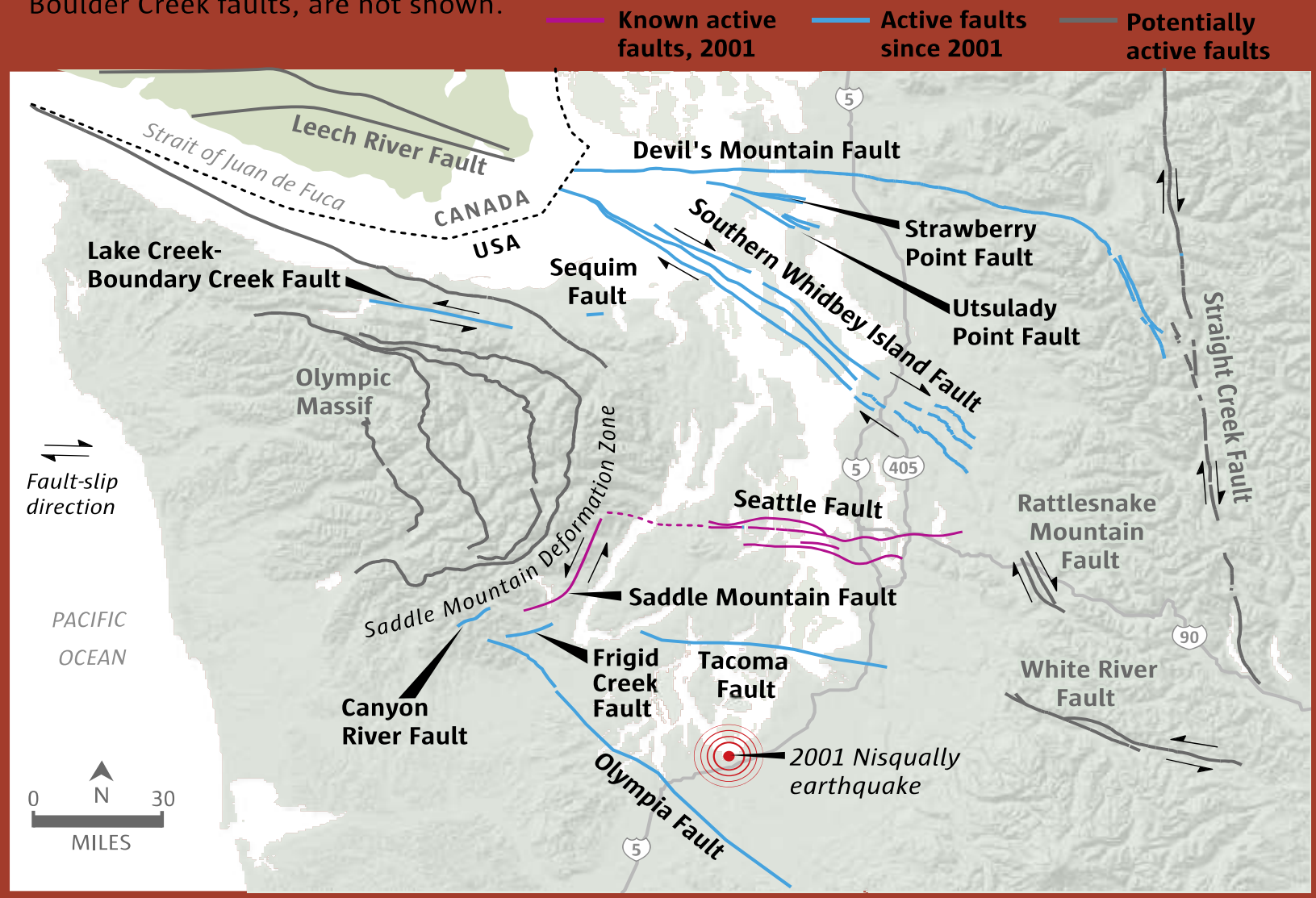
Cascadia earthquake sources



Source	Affected area	Max. Size	Recurrence
Subduction Zone	W.WA, OR, CA	M 9	500-600 yr
Deep Juan de Fuca plate	W.WA, OR,	M 7+	30-50 yr
Crustal faults	WA, OR, CA	M 7+	Hundreds of yr?

New faults detected

Since the 2001 Nisqually earthquake, scientists have discovered more than 10 faults criss-crossing the region. Two recently discovered faults in Whatcom County, the Birch Bay and Boulder Creek faults, are not shown.



Source: U.S. Geological Survey

MARK NOWLIN / THE SEATTLE TIMES



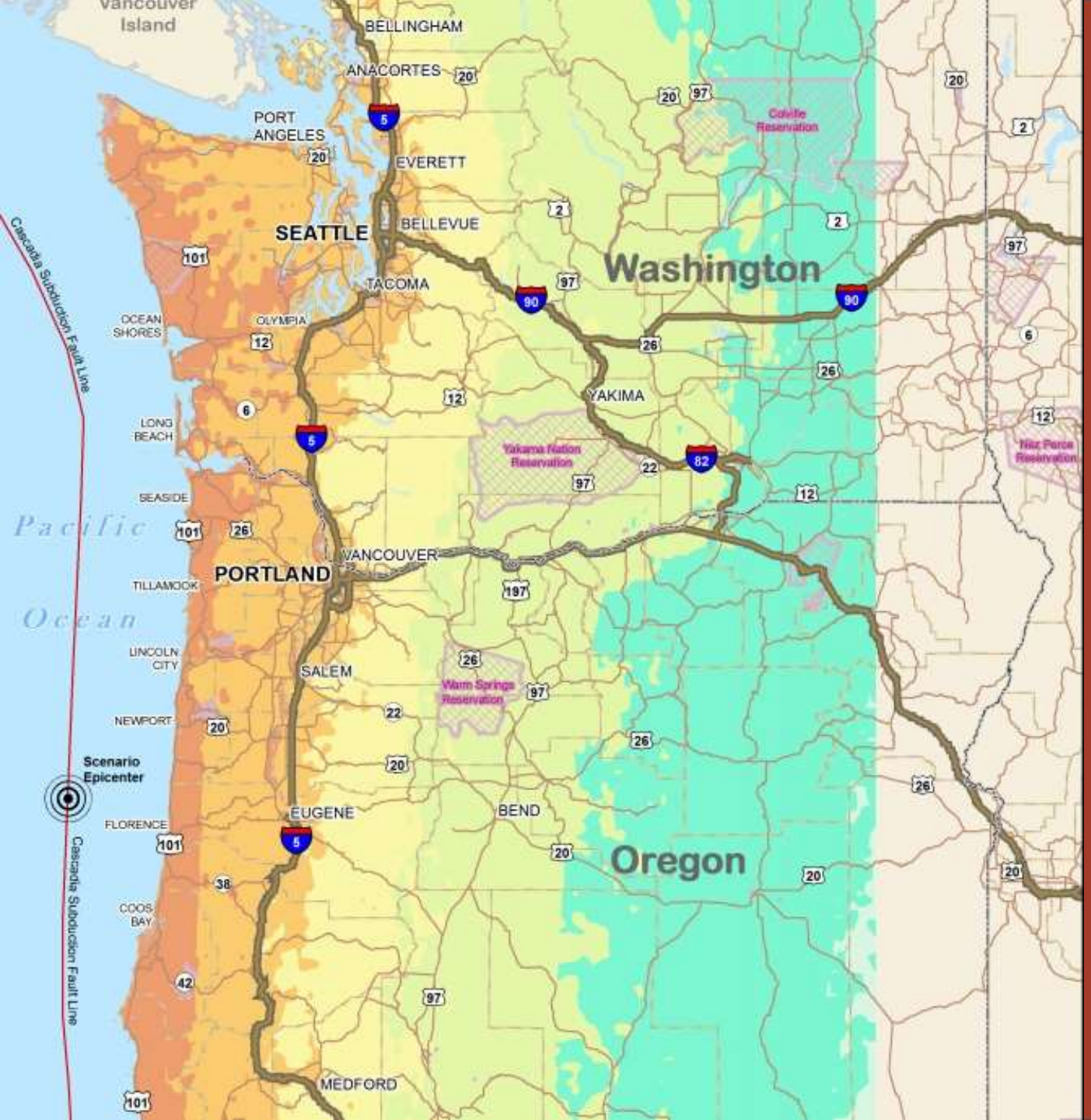
CASCADIA RISING

Cascadia Subduction Zone (CSZ)
Catastrophic Earthquake and Tsunami Functional Exercise 2016

FEMA

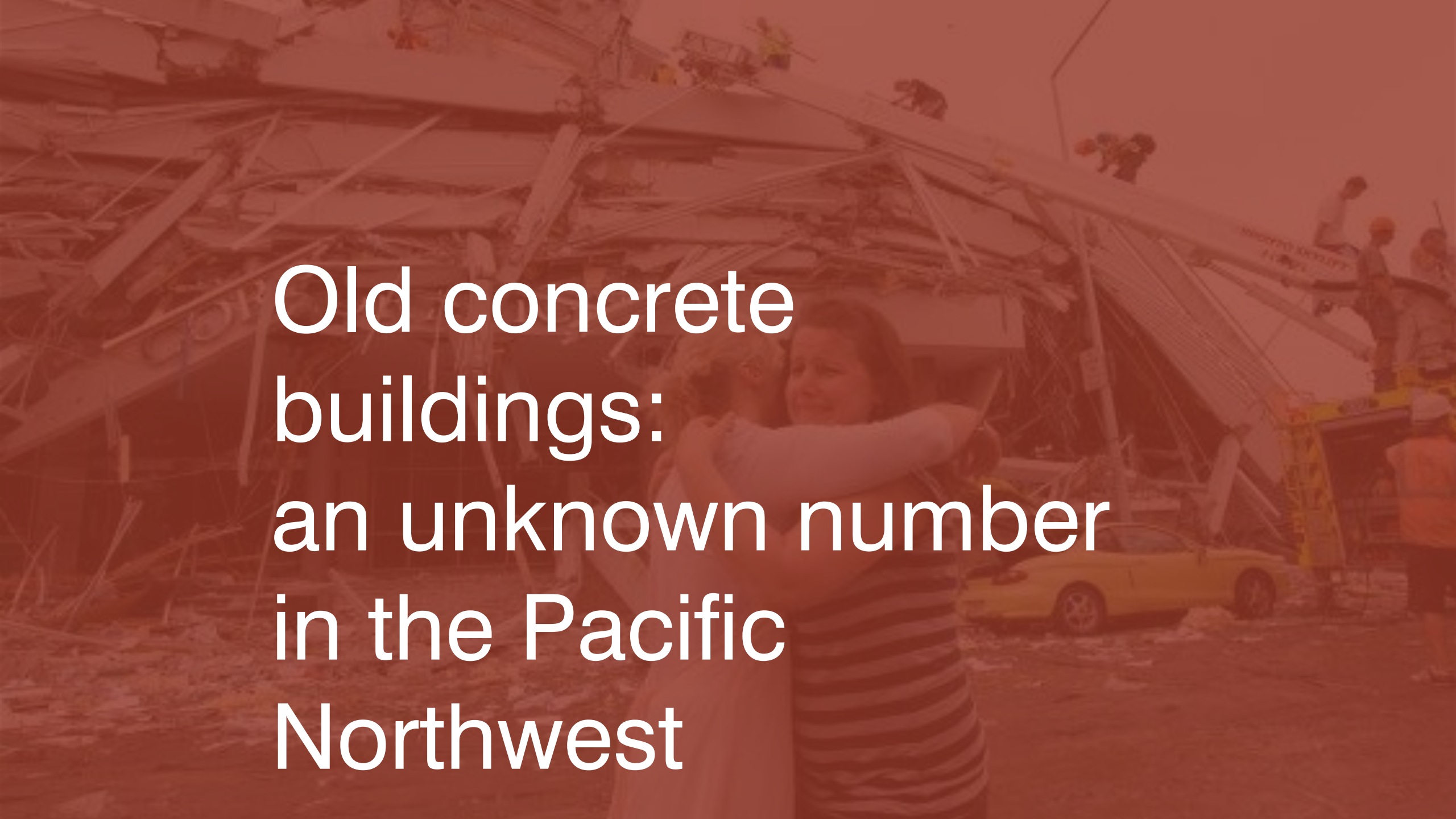
Cascadia Fault

- 10,000+ deaths
- 30,000 injuries
- 1 million people displaced
- More than $80 billion in damages
- Impacts 140,000 square miles; 8 million people

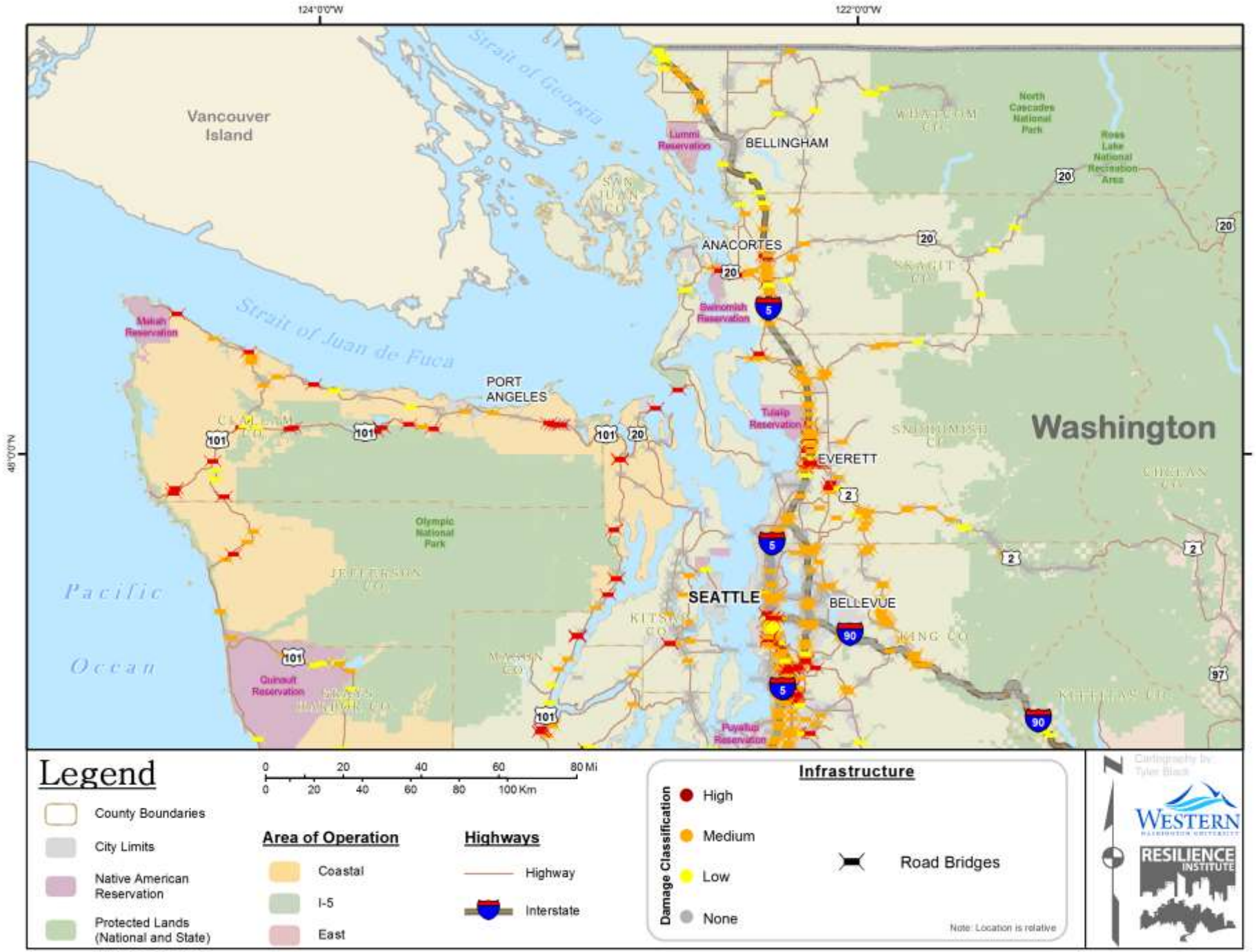

Vancouver Island
BELLINGHAM
ANACORTES
PORT ANGELES
EVERETT
SEATTLE
BELLEVUE
TACOMA
OLYMPIA
OCEAN SHORES
LONG BEACH
SEASIDE
TILLAMOOK
PORTLAND
VANCOUVER
LINCOLN CITY
SALEM
NEWPORT
Scenario Epicenter
FLORENCE
EUGENE
COOS BAY
MEDFORD
BEND
YAKIMA
Washington
Oregon
Colville Reservation
Yakama Nation Reservation
Warm Springs Reservation
Nez Perce Reservation
Cascadia Subduction Fault Line
Cascadia Subduction Fault Line
Pacific
Ocean

Unreinforced Masonry Buildings:

- 800-1,000 in Seattle
- 2,000 in Portland
- 8,000 in Vancouver, BC



Old concrete buildings: an unknown number in the Pacific Northwest


124°0'0"W
122°0'0"W
48°0'0"N
Vancouver Island
Strait of Georgia
Strait of Juan de Fuca
Pacific Ocean
Lummi Reservation
BELLINGHAM
North Cascades National Park
Ross Lake National Recreation Area
ANACORTES
Swinomish Reservation
Makah Reservation
PORT ANGELES
Tulalip Reservation
EVERETT
Washington
Olympic National Park
SEATTLE
BELLEVUE
Quinault Reservation
Puyallup Reservation
Legend
County Boundaries
City Limits
Native American Reservation
Protected Lands (National and State)
0 20 40 60 80 Mi
0 20 40 60 80 100 Km
Area of Operation
Coastal
I-5
East
Highways
Highway
Interstate
Infrastructure
Damage Classification
High
Medium
Low
None
Road Bridges
Note: Location is relative
N
Cartography by: Tyler Black
WESTERN WASHINGTON UNIVERSITY
RESILIENCE INSTITUTE


25

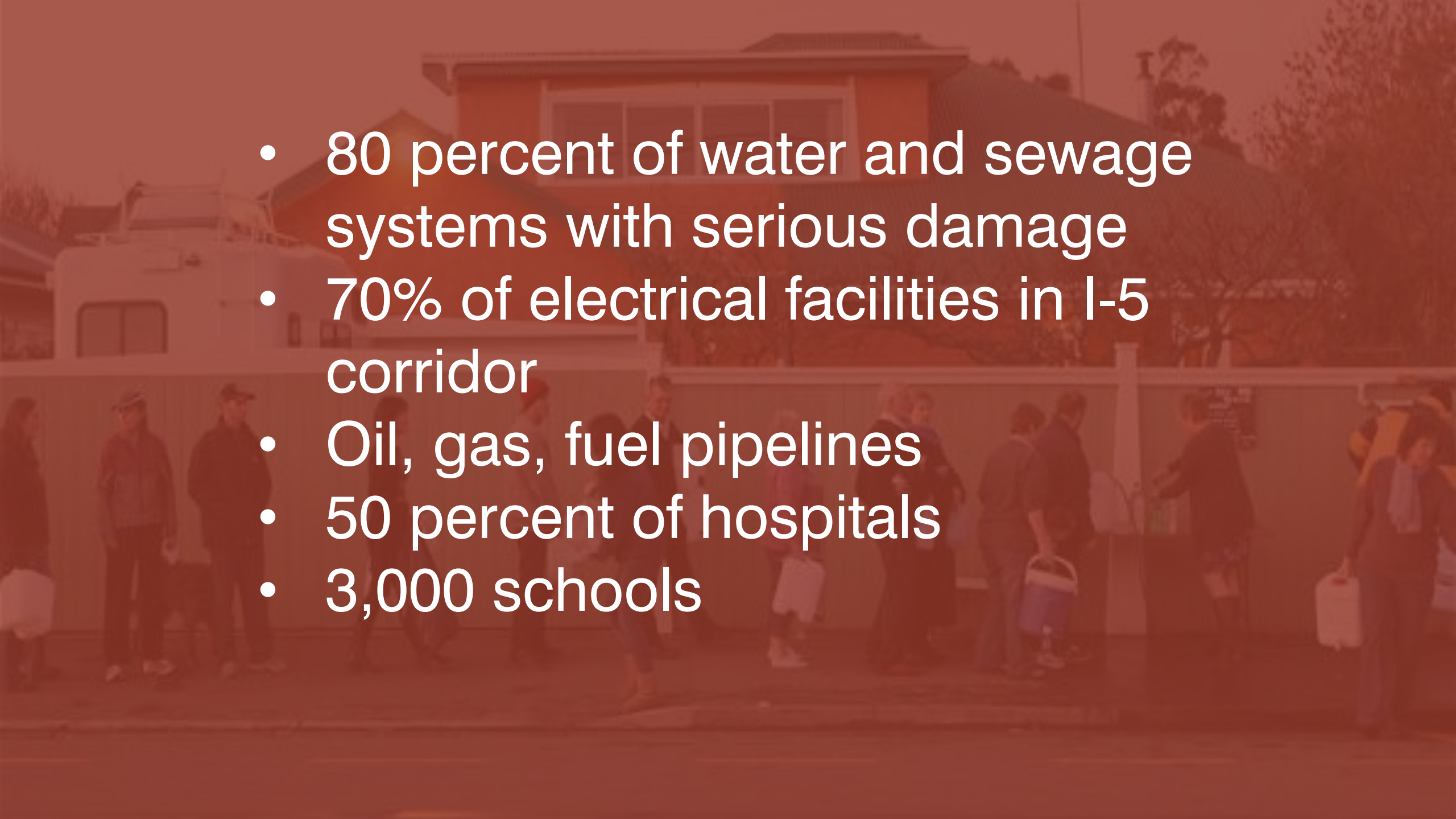
Moderate to severe damage to:

- 16,000 miles of highway – including much of the I-5 corridor
- 7,000 highway bridges
- East-West traffic disrupted by landslides
- 6,000 miles of railways
- 2/3 of airports
- Most port facilities

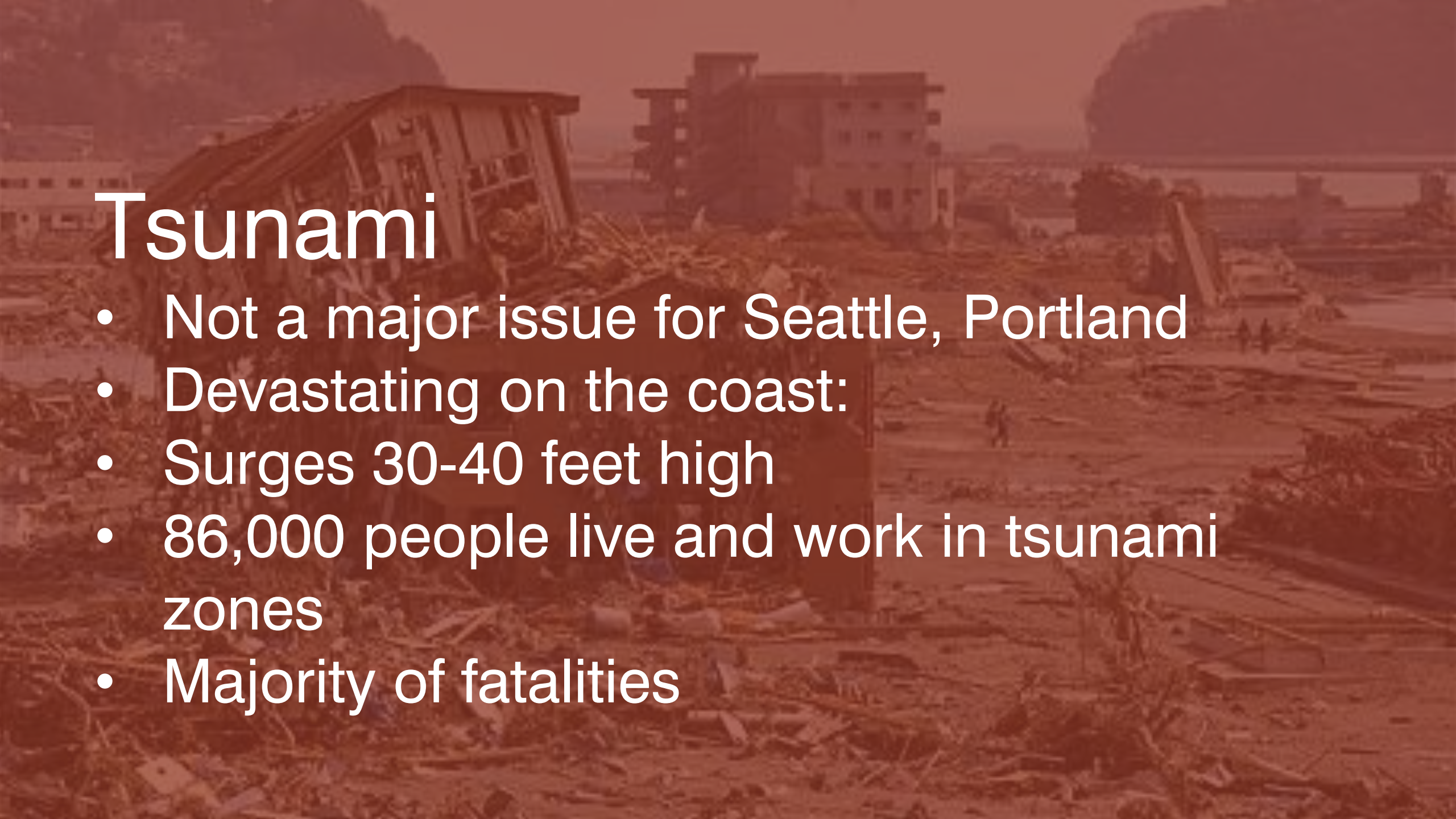

TOYOTA
IK 4351
www.yayateahouse.co.nz

Liquefaction

- Seattle's SoDo area
- Duwamish Valley
- Ports of Seattle, Tacoma, Vancouver
- Kent Valley



- 80 percent of water and sewage systems with serious damage
- 70% of electrical facilities in I-5 corridor
- Oil, gas, fuel pipelines
- 50 percent of hospitals
- 3,000 schools



Tsunami

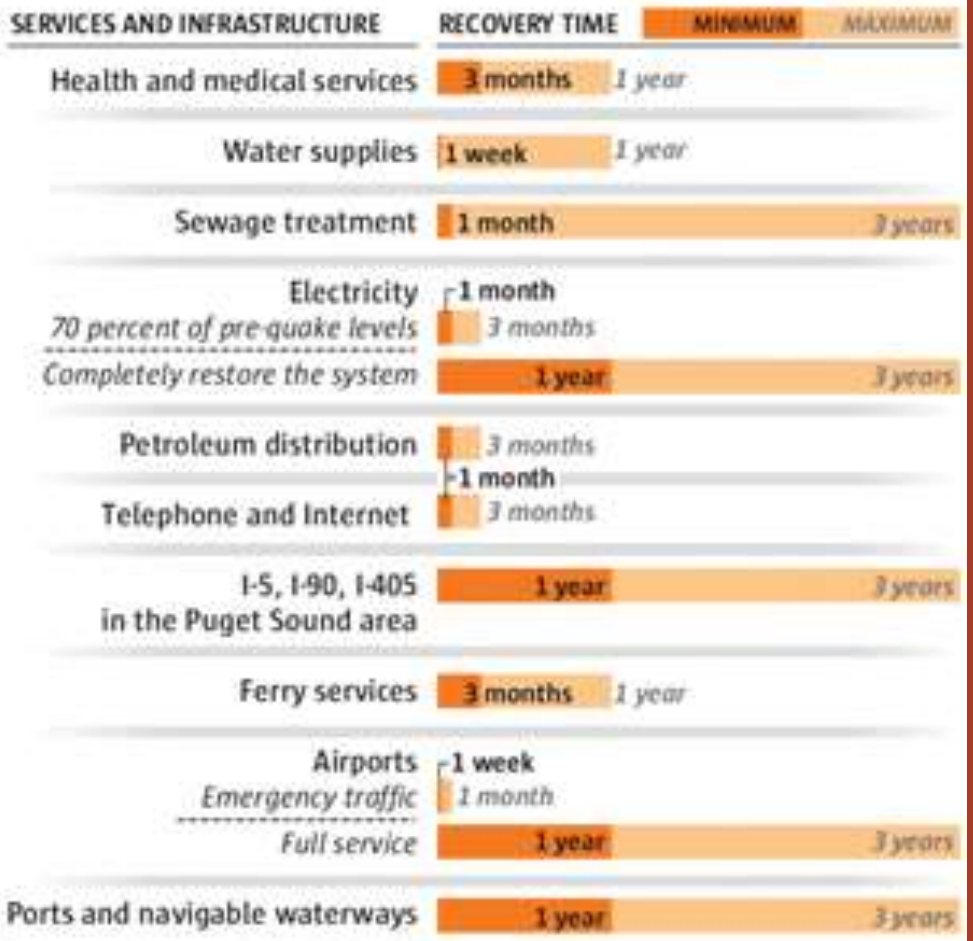
- Not a major issue for Seattle, Portland
- Devastating on the coast:
- Surges 30-40 feet high
- 86,000 people live and work in tsunami zones
- Majority of fatalities

East of the Cascades

* Hospitals overwhelmed
* East-West transportation disrupted
* Supply lines disrupted
* Potential damage to dams, bridges
* Short-term power, communication outages
* Airports become transport hubs

Disruption from a Northwest megaquake and tsunami will last for years

Estimates of the minimum and maximum times it will take to get back to normal after a major earthquake in Washington, such as a magnitude 9.0 coastal megaquake and tsunami or a powerful quake on the Seattle Fault or other shallow faults.

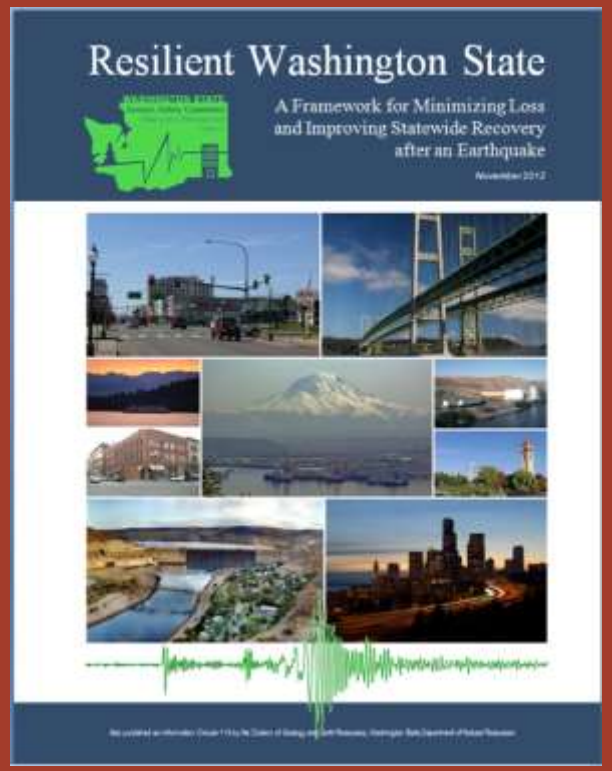


Source: Washington Seismic Safety Committee

MARK NOWLIN / THE SEATTLE TIMES

The Resilient Washington State:

A 50-Year Plan for Improving Earthquake Recovery

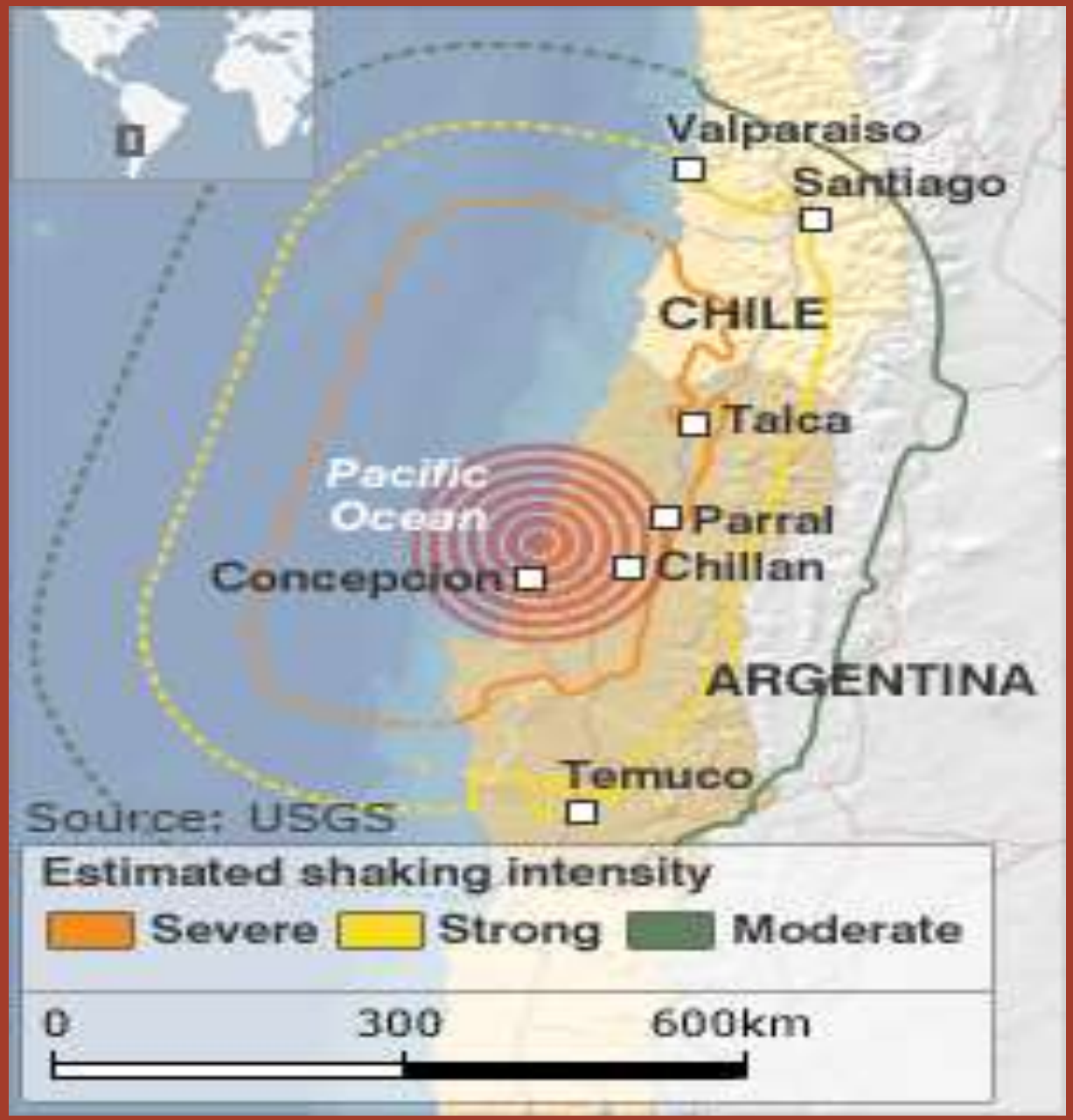


"A resilient state is one that maintains services and livelihoods after an earthquake. In the event that services and livelihoods are disrupted, recovery occurs rapidly, with minimal social disruption, and results in a new and better condition."

- RWS Subcommittee

[Report Accessible at: http://www.emd.wa.gov/about/SeismicSafetyCommittee.shtml](http://www.emd.wa.gov/about/SeismicSafetyCommittee.shtml)

WASHINGTON STATE Seismic Safety Committee Emergency Management Council

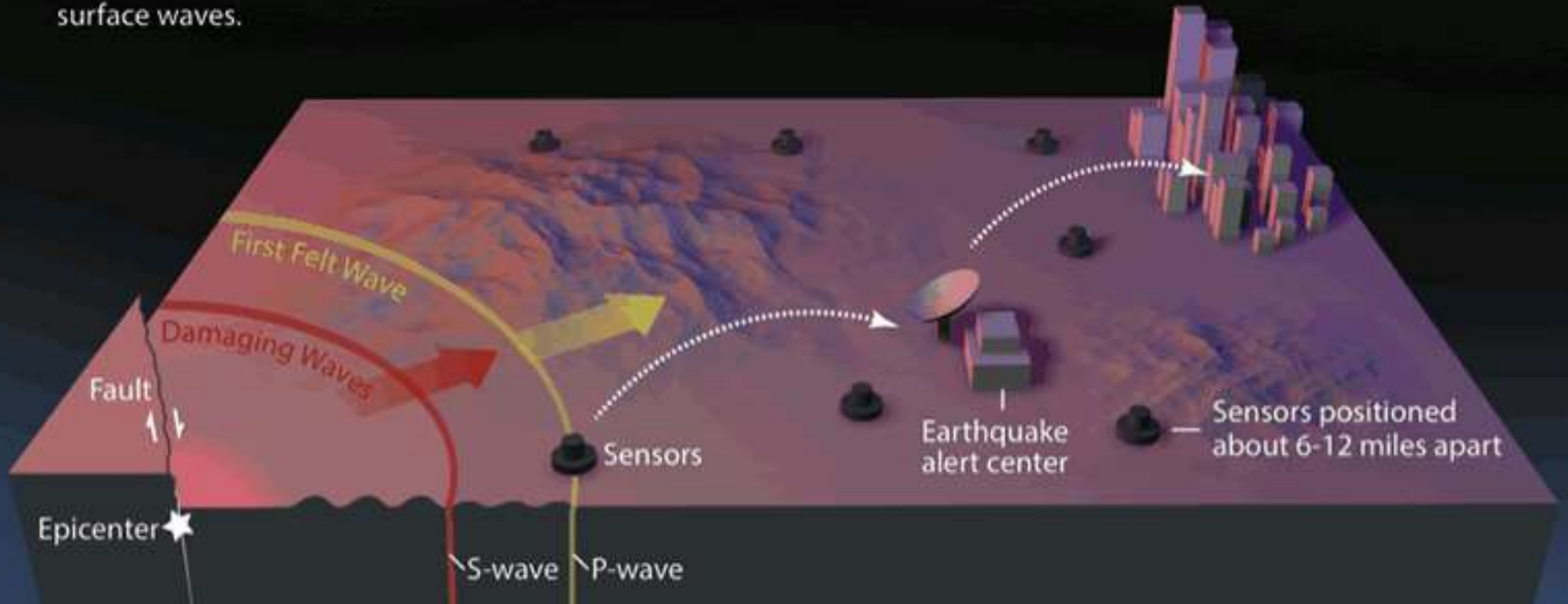

Valparaiso
Santiago
CHILE
Talca
Pacific
Ocean
Parral
Chillan
Concepcion
ARGENTINA
Temuco
Source: USGS
Estimated shaking intensity
Severe
Strong
Moderate
0
300
600km

Earthquake Early Warning Basics

1 In an earthquake, a rupturing fault sends out different types of waves. The fast-moving P-wave is first to arrive, but damage is caused by the slower S-waves and later-arriving surface waves.

2 Sensors detect the P-wave and immediately transmit data to an earthquake alert center where the location and size of the quake are determined and updated as more data become available.

3 A message from the alert center is immediately transmitted to your computer or mobile phone, which calculates the expected intensity and arrival time of shaking at your location.



Earthquake Early Warning

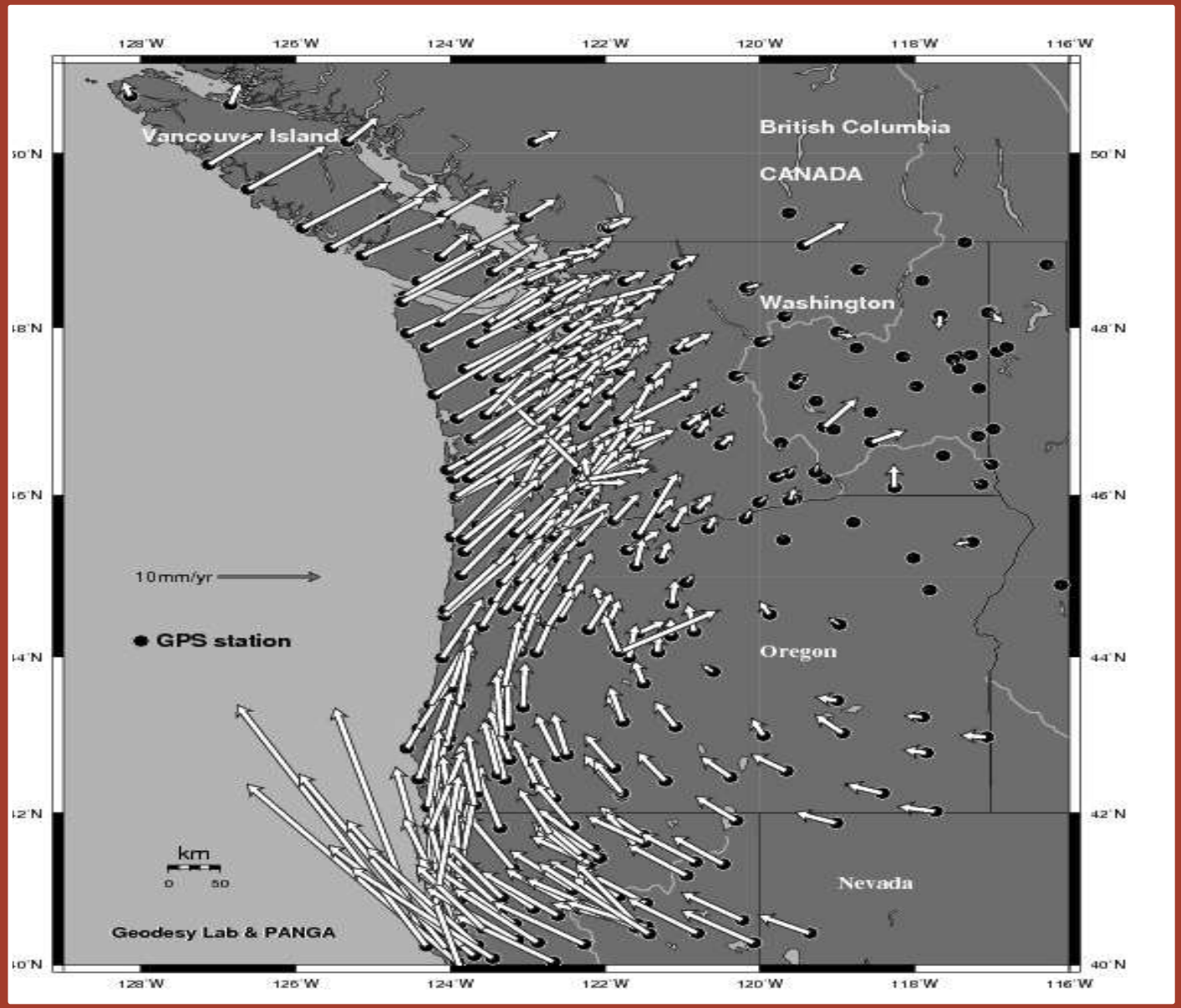
- Seconds-Minutes
- Take cover
- Shut down:
  - Trains
  - Elevators
  - Industrial Processes

On your screen: ShakeAlert

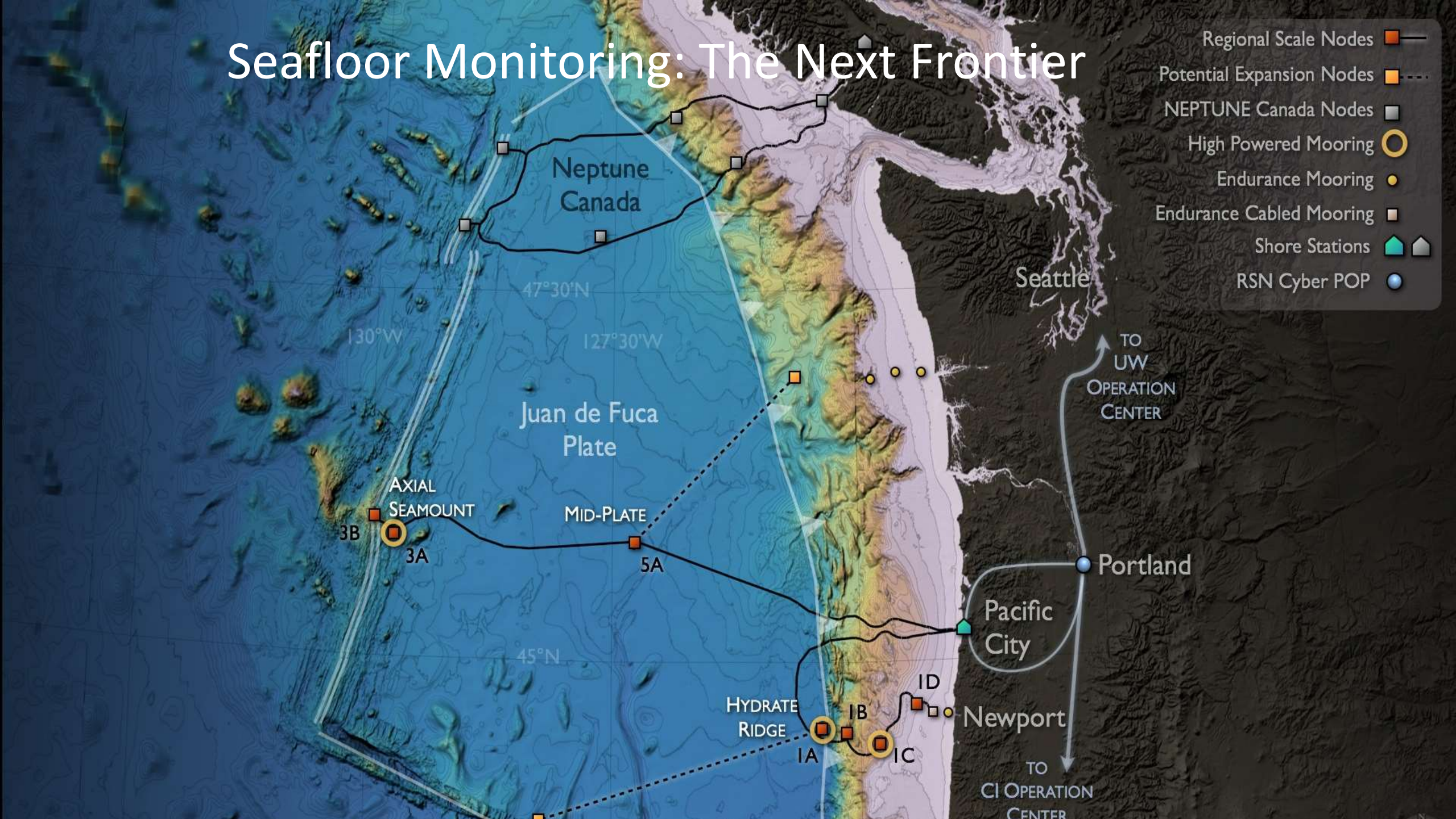
1. Real-time tracking of seismic waves from quake's epicenter.
2. Real-time tracking of the fault rupture (updates intensity).
3. Your current location tracked by GPS.
4. Seconds remaining before seismic waves reach you.
5. Expected intensity of quake at your current location.
6. Estimated magnitude of quake.
7. Intensity scale.


OCOSTA ELEMENTARY SCHOOL

100 percent chance of earthquakes



Seafloor Monitoring: The Next Frontier



Seafloor Monitoring

- Long-term search for possible precursory motion
- Better tsunami warning