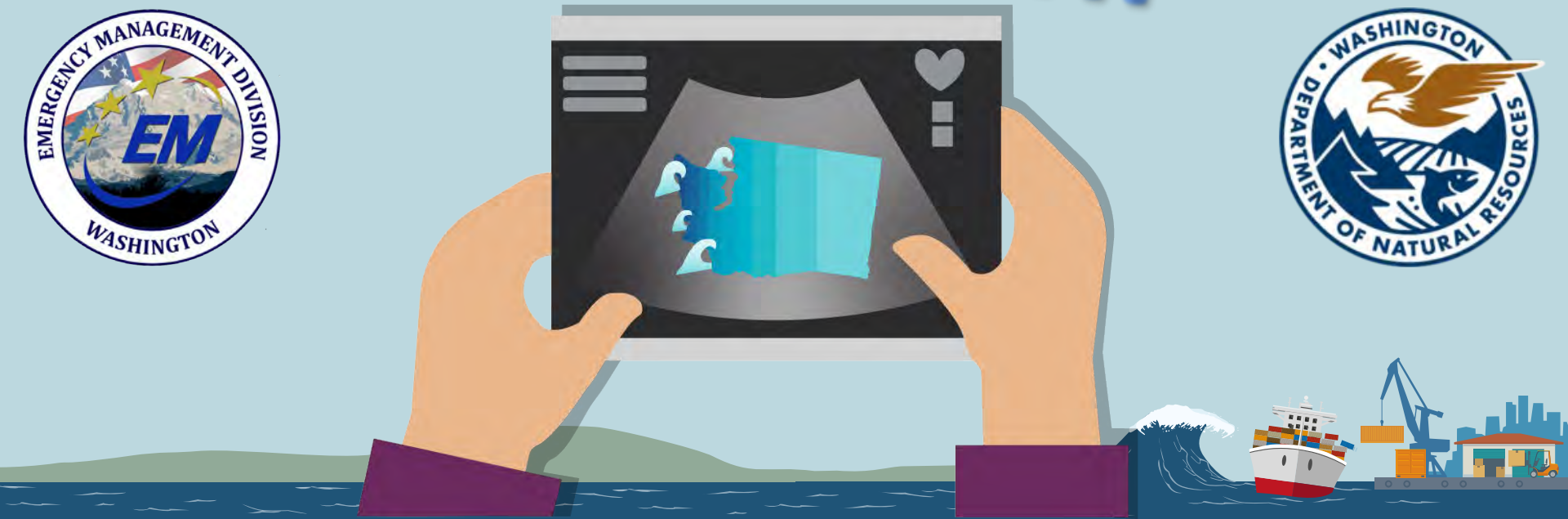
WHAT TO EXPECT WHEN YOU'RE EXPECTING

a TSUNAMI



Tsunami Hazards in Washington State

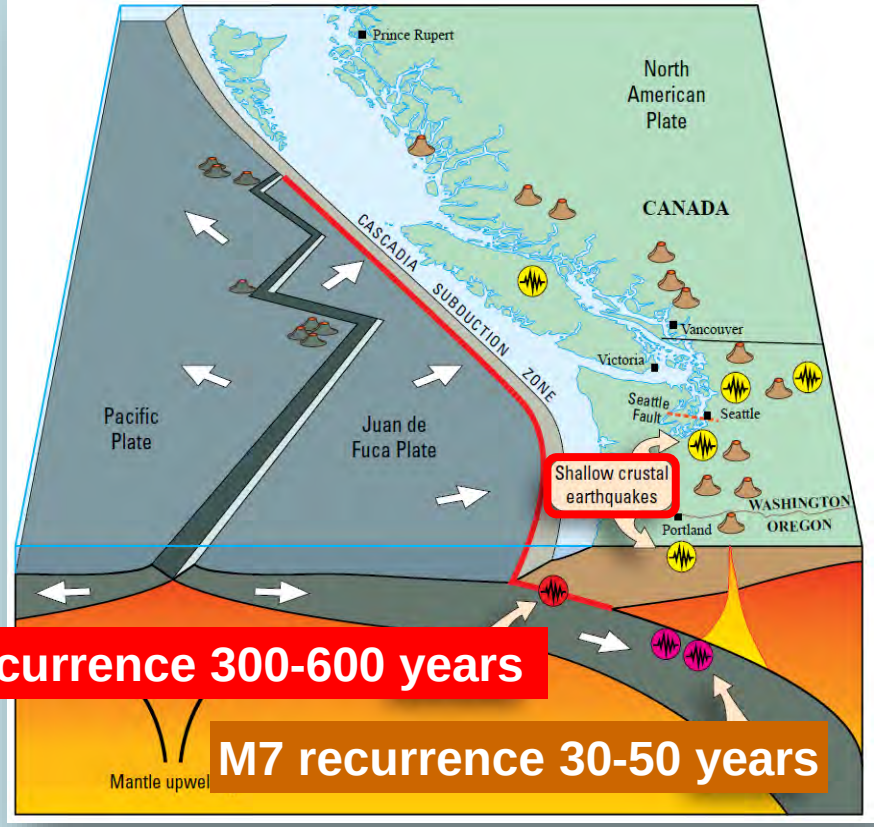
Maximilian Dixon – Washington Emergency Management Division

Geological Hazards in Washington

WA has the 2nd highest earthquake risk in the US

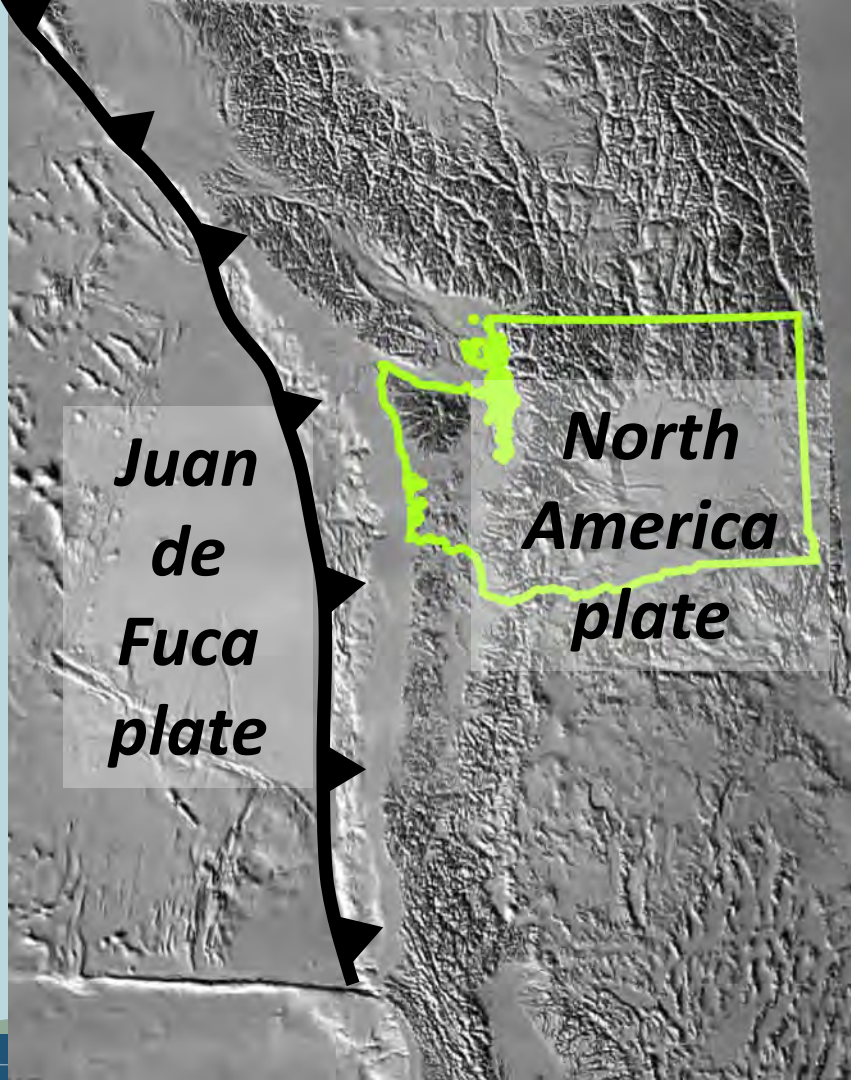
We also have…

- **Tsunamis** - local and distant
- 5 active volcanoes
- Landslides



Cascadia Subduction Zone

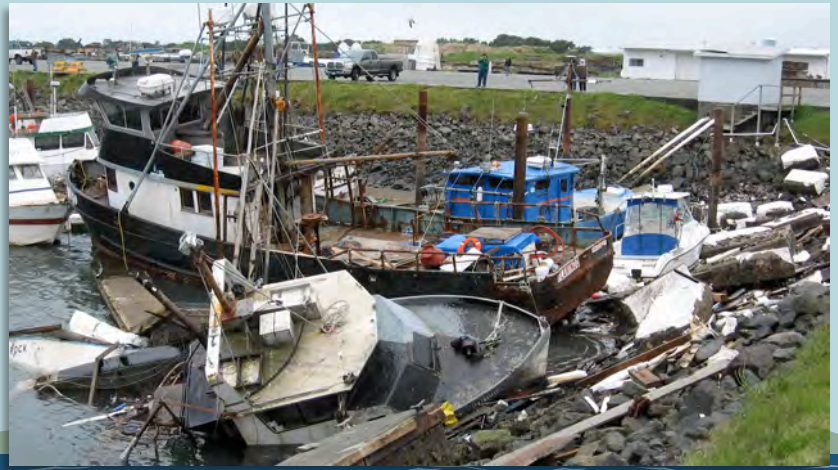
- 700 miles long (1,130 km)
- Breaks 300 – 600 years (~500 years on average)
- Last great rupture in 1700 (320 years ago)
- 10-20% chance within next 50 years
- Magnitude 8.0-9.0+
- Shaking felt region-wide for 3–6 minutes
- Shaking intensity is greatest along coast & where local conditions amplify seismic waves
- Earthquake followed by a **major tsunami hitting WA's outer coast in 15-20 min**
- Many large aftershocks will follow main quake



Distant vs Local Tsunamis

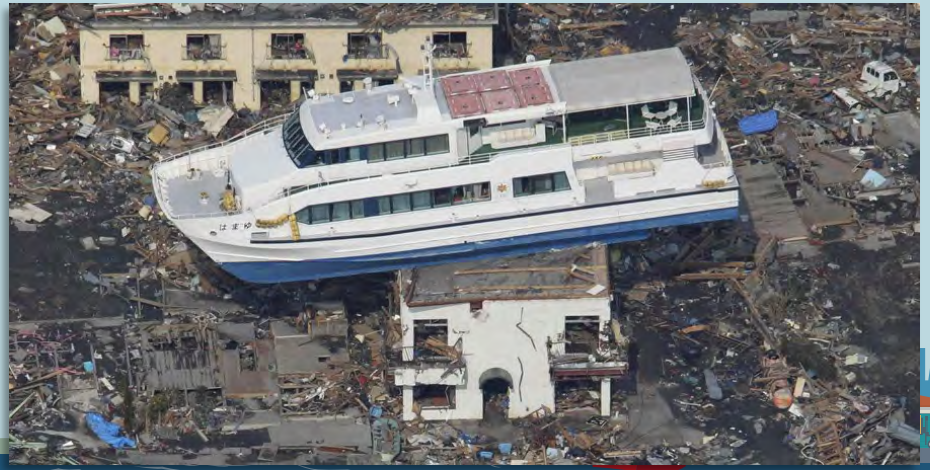
Distant

- No earthquake felt
- > 3 hours until first wave arrives
- Warning must be distributed
- Less inundation/slower currents
- Less severe impact to coast



Local

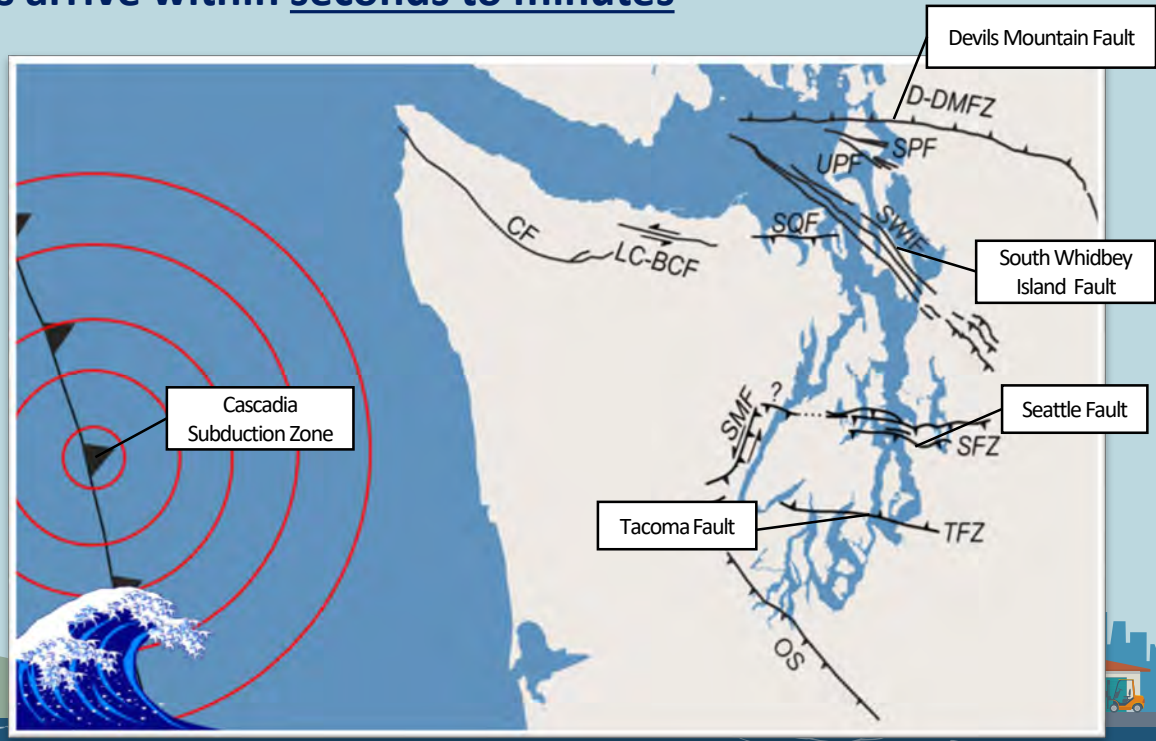
- Event will typically be felt
- < 3 hours until first wave arrives
- Earthquake is primary warning
- More inundation/faster currents
- Significant impact to coast

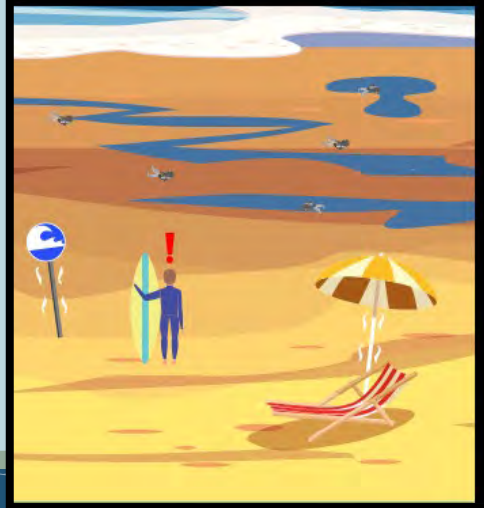


Local Tsunamis

THE SHAKING IS YOUR WARNING!

The first waves arrive within seconds to minutes





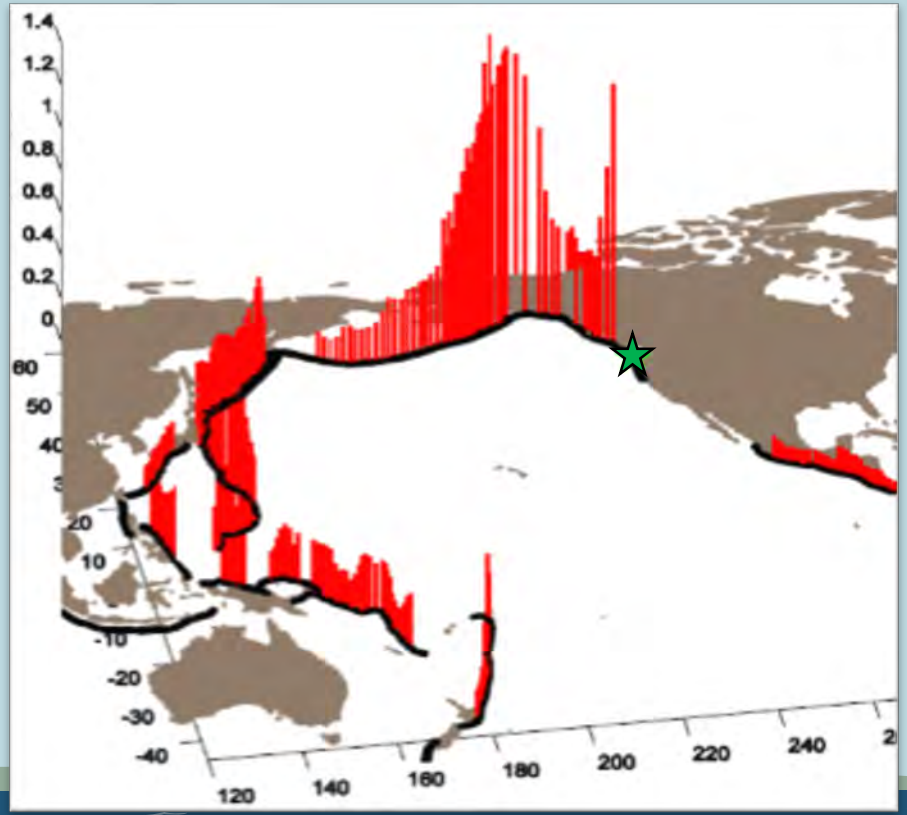
Know the Natural Tsunami Warning Signs

1. Feel a long or strong ground shaking at the coast
2. See a sudden rise or fall of the ocean
3. Hear a loud roaring sound coming from the ocean

If you experience any of these, it's time to **grab your go-bag and head to high ground!**

Distant Tsunami Threats - Alaska

The first waves arrive in <u>less than 4 hours</u>



You will NOT feel ground shaking for a distant tsunami!

Instead, you might be warned through official alerts like…

- EAS
- WEA
- Tsunami sirens

Tsunami Alerts

Alert Name	Actions	Potential Hazards
WARNING	Get to high ground or inland IMMEDIATELY Follow tsunami evacuation signage	DANGER! TSUNAMI IMMINENT! Flooding/powerful currents Wave heights > 3 ft. or unknown
ADVISORY	Stay out of the water and away from the shore	STRONG CURRENTS AND DANGEROUS WAVES in or very near coastal water Wave heights of 1 - 3 ft.
WATCH	Be prepared to take action Stay tuned to local radio/TV/ NOAA “alert” weather radios	TSUNAMI IS POSSIBLE Alert level *will* change once more information is known
INFORMATION STATEMENT	No action needed	NO TSUNAMI IMPACT EXPECTED Alert level may change once more information is known

THREAT Message: Intended to alert international partners only. Not applicable to U.S. coasts

THE NATIONAL TSUNAMI WARNING CENTER ISSUES OFFICIAL TSUNAMI ALERTS FOR WASHINGTON. CHECK TSUNAMI.GOV OR WEATHER.GOV WEBSITES FOR TSUNAMI ALERT DETAILS.

Tsunami Alert Dissemination

- Tsunami alerts occur for any type of tsunami event
- They are MOST important during a DISTANT source event

How do you receive alerts?

How to do you stay informed?

NWS: Tsunami Warning Centers

Pacific Tsunami Warning Center (Honolulu, HI)

International warning center for 26 member countries and Hawaii

National Tsunami Warning Center (Palmer, AK)

Issues all tsunami products for AK, BC, WA, OR, CA – all of North America

Example Messages

NTWC Message #4 (3:41 PM PST)

BULLETIN
Public Tsunami Message Number 4
NWS National Tsunami Warning Center Palmer AK
239 PM AKDT Mon Oct 19 2020

UPDATES
---
 * Updated observations

...THE TSUNAMI WARNING REMAINS IN EFFECT...

Tsunami Warning in Effect for;

 * SOUTH ALASKA AND THE ALASKA PENINSULA, Pacific coasts from Kennedy Entrance, Alaska (40 miles SW of Homer) to Unimak Pass, Alaska (80 miles NE of Unalaska)

For other US and Canadian Pacific coasts in North America, there is no tsunami threat.

PTWC Message #2 (3:11 PM PST)

 * AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 7.5 OCCURRED SOUTH OF ALASKA AT 2055 UTC ON MONDAY OCTOBER 19 2020. NOTE THAT THE MAGNITUDE HAS BEEN UPDATED.

 * BASED ON ALL AVAILABLE DATA... THE TSUNAMI THREAT FROM THIS EARTHQUAKE HAS NOW PASSED.

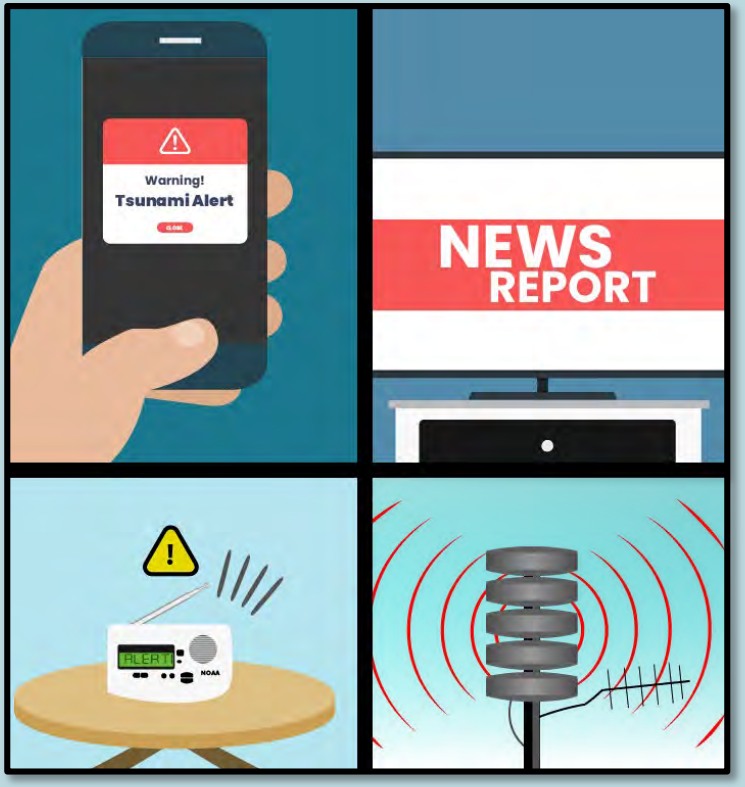
TSUNAMI THREAT FORECAST...UPDATED
---

 * THERE IS NO LONGER A TSUNAMI THREAT FROM THIS EARTHQUAKE, EXCEPT FOR THE IMMEDIATE EPICENTRAL AREA.

* COASTAL REGIONS OF CALIFORNIA... OREGON... WASHINGTON... BRITISH COLUMBIA AND ALASKA SHOULD ONLY REFER TO U.S. NATIONAL TSUNAMI WARNING CENTER MESSAGES THAT CAN BE FOUND AT WWW.TSUNAMI.GOV.

Alert Dissemination

- Emergency Alert System (EAS) - Originally designed for the President to address the nation in times of disaster
  - Life-threatening weather and natural hazards
  - Law enforcement alerts (Amber Alerts, etc)
- NOAA weather radio - broadcasts warning information for all types of hazards
- Wireless Emergency Alerts (WEA) - Used ONLY when a tsunami warning is issued
  - You will only receive ONE message, once!
  - Even if you have a WEA-enabled device, you may not receive a WEA:
    - If your device is roaming
    - In a service area where the provider is not offering WEA

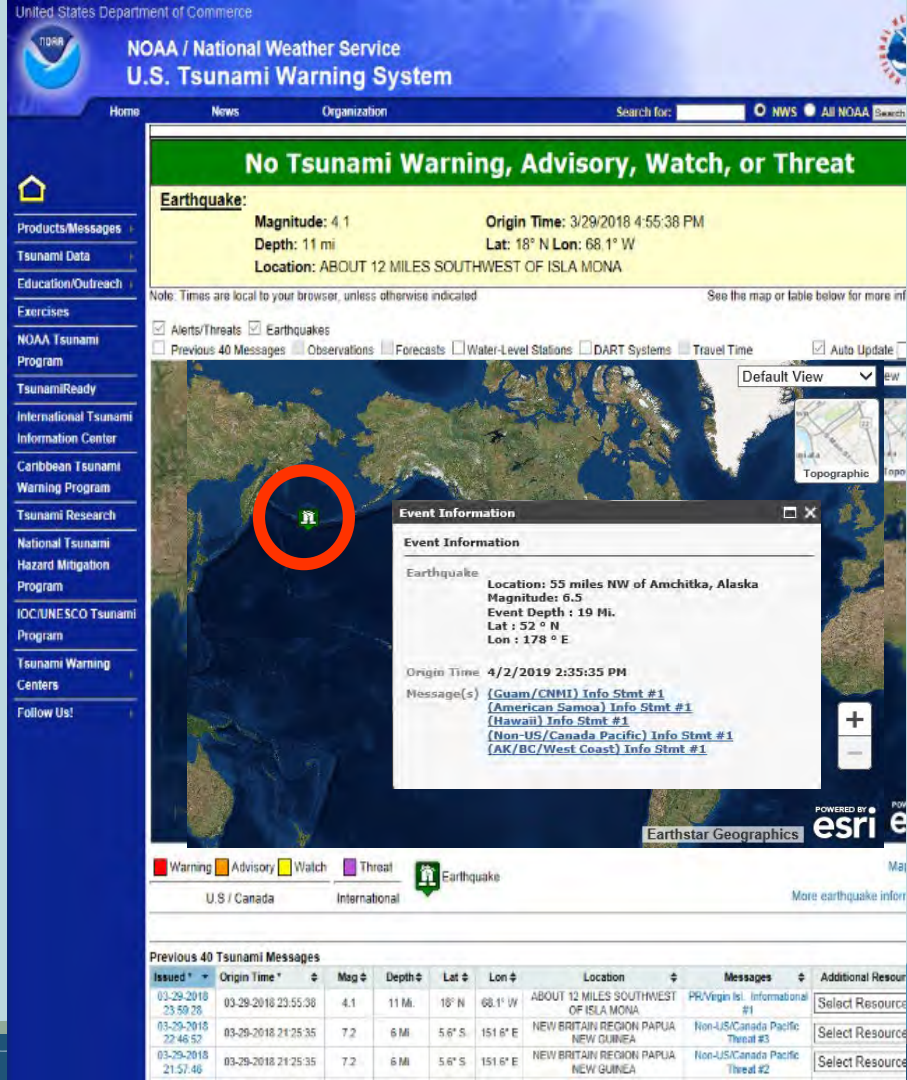


All Hazard Alert Broadcast (AHAB) Tsunami Sirens

- OUTDOOR tsunami warning system intended to warn people on/near the beach
    - Sirens have an approximately 1-mile audible range depending on topography, weather, and barriers
- Currently 95 sirens
- The state Alert and Warning Center activates sirens upon receipt of an official Tsunami warning from the NTWC
- Monthly test: Westminster Chimes
- Tsunami warning: wailing tone followed by verbal instructions in English and Spanish

Tsunami.gov

- Visually displays where earthquakes occur and alert levels
- Look for messages for: AK/BC/US West Coast
- Lists last 40 messages issued at the bottom
- Links to all sorts of additional information
- There will NOT be information for the inner coast for a CSZ earthquake
- Has a history of crashing during big events

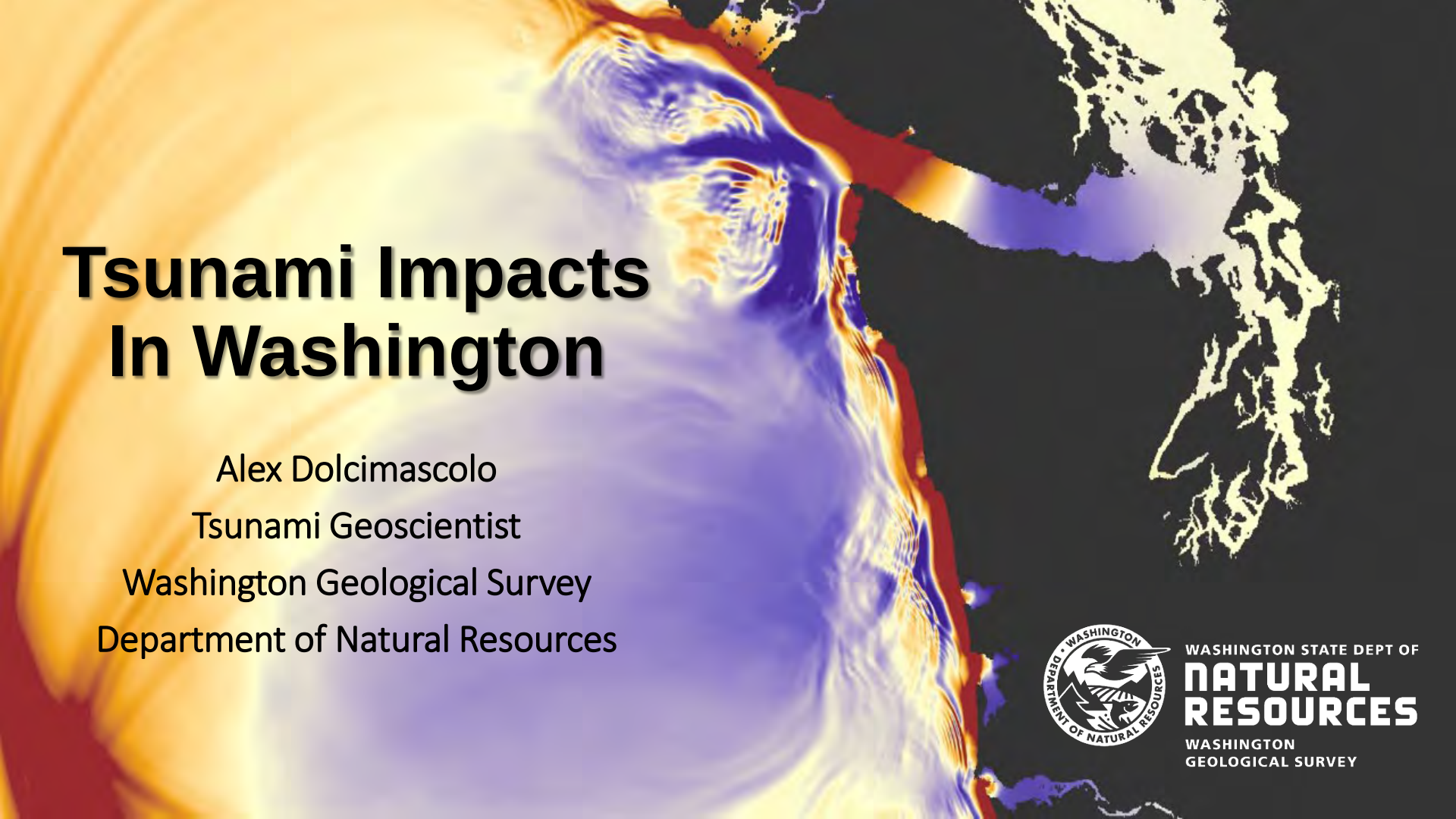


Alerting for the Inner Coast

- Currently the NWS does not have forecasting or alerting capabilities for the inner coast (Puget Sound and Salish Sea) for a Cascadia Subduction Zone earthquake and Distant tsunamis
- This means: NO NOAA Weather Radio, EAS, Tsunami.gov, or forecasted wave arrival times on tsunami bulletins for inner coast locations
- WA EMD will send a WEA message for tsunami warnings to the inner coast

Tsunami Impacts In Washington

Alex Dolcimascolo
Tsunami Geoscientist
Washington Geological Survey
Department of Natural Resources



WASHINGTON STATE DEPT OF
NATURAL RESOURCES
WASHINGTON GEOLOGICAL SURVEY

Learning From History

- 2011 Japan Earthquake (Magnitude 9.1) and tsunami (125 feet high in places)
- An estimated **20,000 people were dead or missing** and close to 500,000 people were forced to evacuate.
- The total economic cost could reach up to $235 billion, the World Bank estimated, making it the costliest natural disaster in world history.

- The 2004 magnitude 9.1 Banda Aceh earthquake and tsunami in Sumatra **killed more than 230,000 people**

Photo credits unknown

Tsunamis occur when large quantities of water are displaced, most commonly because of earthquakes, landslides, or volcanic eruptions. Tsunamis can also be produced by atmospheric disturbances or meteorite impacts, but these are rare.

Tsunamis

- Tsunamis involve **multiple waves**—the first tsunami wave may not be the biggest in the series.
- Tsunami waves are **huge** in width, length, and depth
- The tsunami **may not cease for hours to days**.
- Tsunamis create **powerful currents** that cause damage and carry large, hidden objects within them. You cannot swim through a tsunami.
- Tsunamis **cannot be predicted**. We know what types of earthquakes can cause them but not when they will happen.

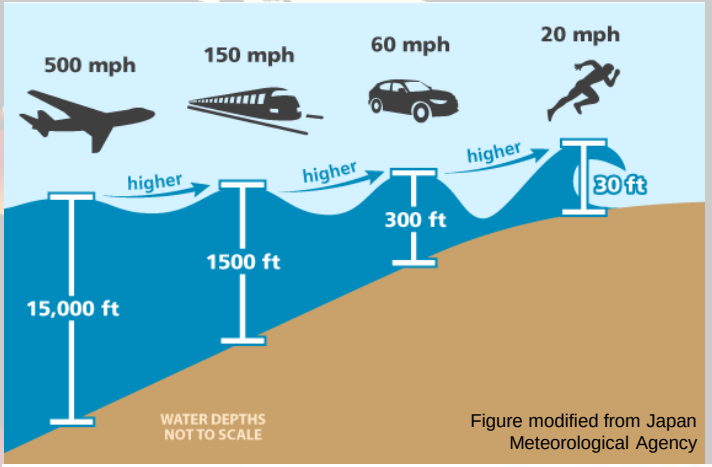
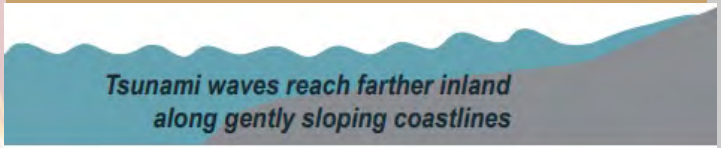


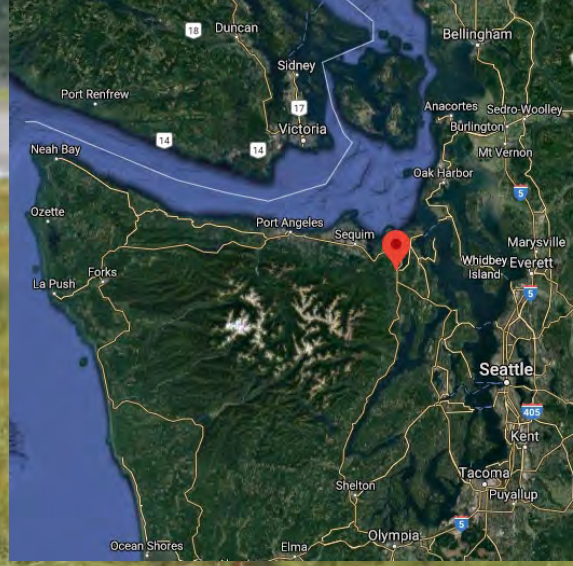
Figure modified from Japan Meteorological Agency



Local Tsunami Sources: Crustal Faults- Seattle Fault

(Last ruptured in ~ 1,100 years ago)


Tsunami deposits
Sea Grant
Washington



Sea Grant
Washington

Tsunami Modeling Can Estimate:

- Wave arrival times
- Tsunami wave amplitude (height of wave offshore)
- Tsunami inundation depth (height of water over previously dry land)
- Tsunami extent (distance tsunami wave will travel inland)
- Duration of tsunami wave action
- Tsunami current velocity

Modeling earthquakes and tsunami inundation

Use models of fault ruptures to simulate ground displacement and wave propagation across ocean and within Puget Sound

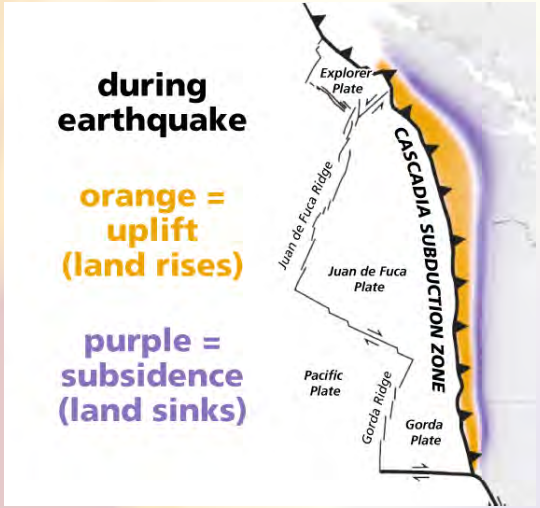


Figure from Washington Sea Grant

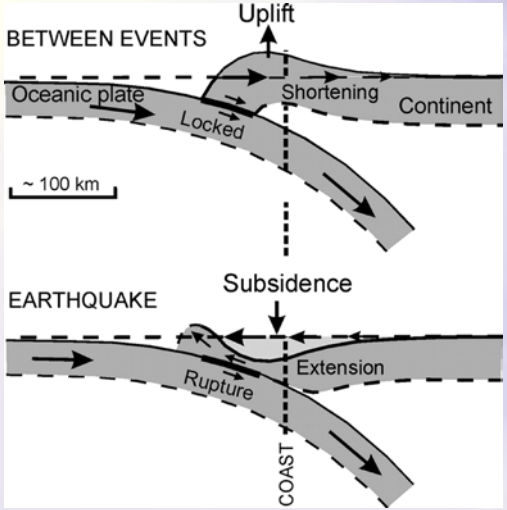


Figure from Leonard et al., 2003

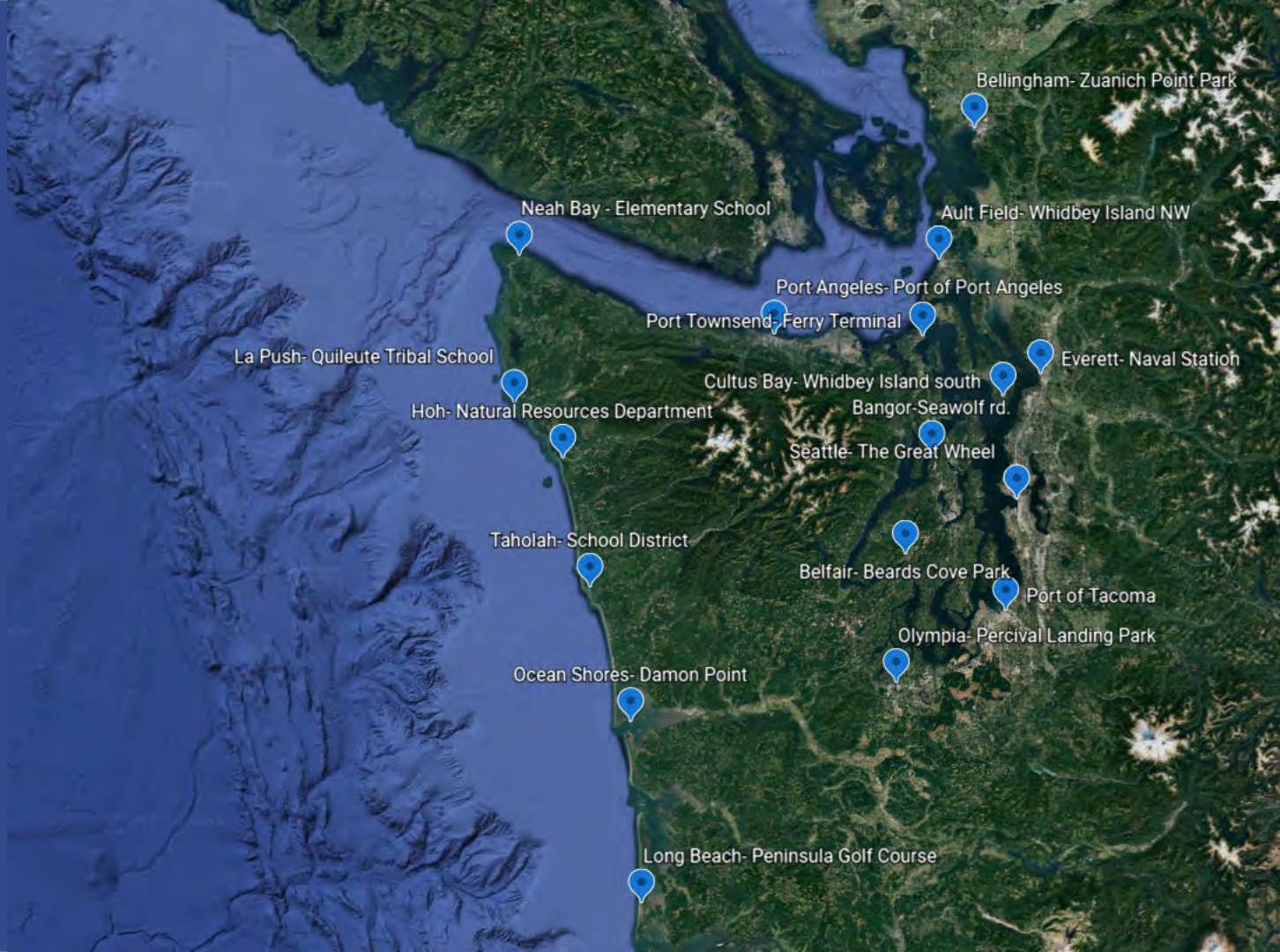
Tsunami inundation models show the amount of water that is expected to travel inland

Tsunami Modeling Assumptions:

- Simplified fault models (uniform slip, full rupture, etc.)
- Results are referenced to mean high water (waves could be higher or lower if it is a king tide or low tide
- Waves are not interacting with the buildings, vegetation, or built environment (bare earth models)
- Do not account for seismically induced landslides

Tsunami Inundation and Approximate Wave Arrival Times

Locations where estimated wave arrival and inundation depths will be shown

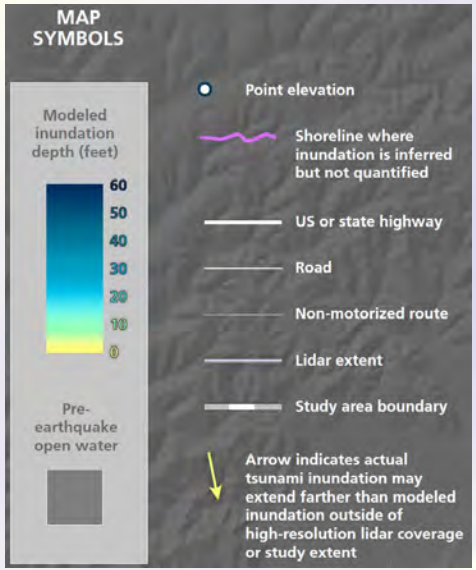


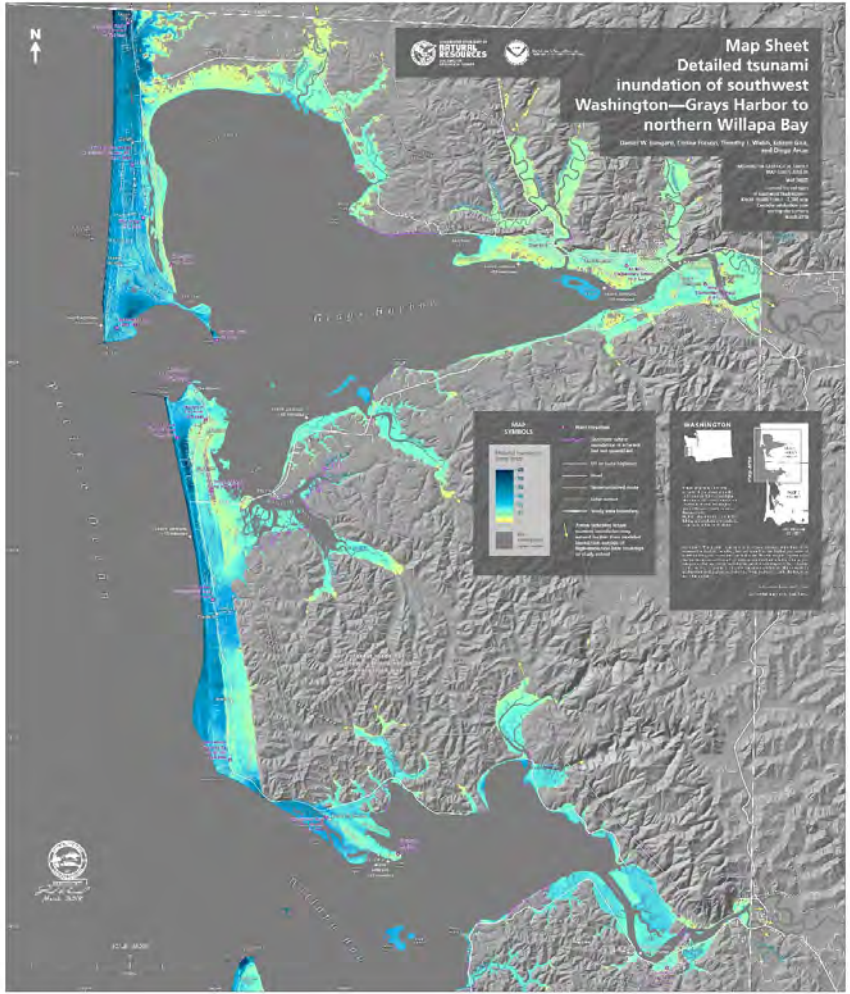
LOCATION	CSZ ESTIMATED WAVE ARRIVAL	CSZ APPROX. INUNDATION	SF ESTIMATED WAVE ARRIVAL	SF APPROX. INUNDATION
LONG BEACH- PENINSULA GOLF COURSE	~15 MINUTES	~17 FT	Not Available	Not Available
LA PUSH- QUILEUTE TRIBAL SCHOOL	~15 MINUTES	~30 FT	Not Available	Not Available
OCEAN SHORES- DAMON POINT	~ 20 MINUTES	~61 FT	Not Available	Not Available
HOH TRIBE NATURAL RESOURCES DEPARTMENT	~ 20 MINUTES	~6 FT	Not Available	Not Available
TAHOLAH SCHOOL DISTRICT	~ 20 MINUTES	~32 FT	Not Available	Not Available
NEAH BAY ELEMENTARY SCHOOL	~ 20 MINUTES	~24 FT	Not Available	Not Available
PORT ANGELES- PORT OF PORT ANGELES	~1 HR	~15 FT	Not Available	Not Available
WHIDBEY ISLAND- AULT FIELD	~1 HR 30 MIN	~4 FT	~1 HR	~<1 FT
PORT TOWNSEND- FERRY TERMINAL	~1 HR 40 MIN	~9 FT	~40 MIN	~3 FT
WHIDBEY ISLAND- CULTUS BAY	~2 HR 10 MIN	~2 FT	~ 25 MIN	~5 FT
EVERETT- NAVAL STATION	~2 HR 15 MIN	~<1 FT	~ 30 MIN	~2 FT
BELLINGHAM-ZUANICH POINT PARK	~2 HR 15 MIN	~5 FT	~1 HR 45 MIN	~<1 FT
SEATTLE- GREAT WHEEL	~2 HR 20 MIN	~2 FT	MINUTES	~27 FT
BANGOR- SEAWOLF RD	~2 HR 30 MIN	~9 FT	~45 MIN	~4 FT
TACOMA- PORT OF TACOMA	~2 HR 40 MIN	~4 FT	~ 20 MIN	~5 FT
BELFAIR- BELFAIR STATE PARK	~ 3 HR 30 MIN	~6 FT	1 HR 40 MIN	~3 FT
OLYMPIA- PERCIVAL LANDING PARK	~4 HR 15 MIN (MAX HEIGHT AT 10 HR)	~2 FT	~ 1 HR 15 MIN	~<1 FT

Tsunami Inundation Map

Detailed inundation maps

- Wave arrival times
- Inundation depths
- Land use planning/mitigation measures

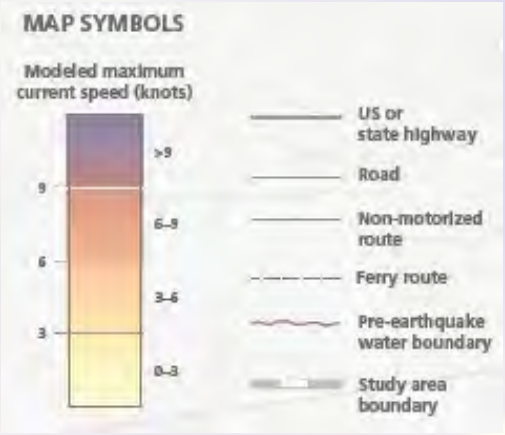


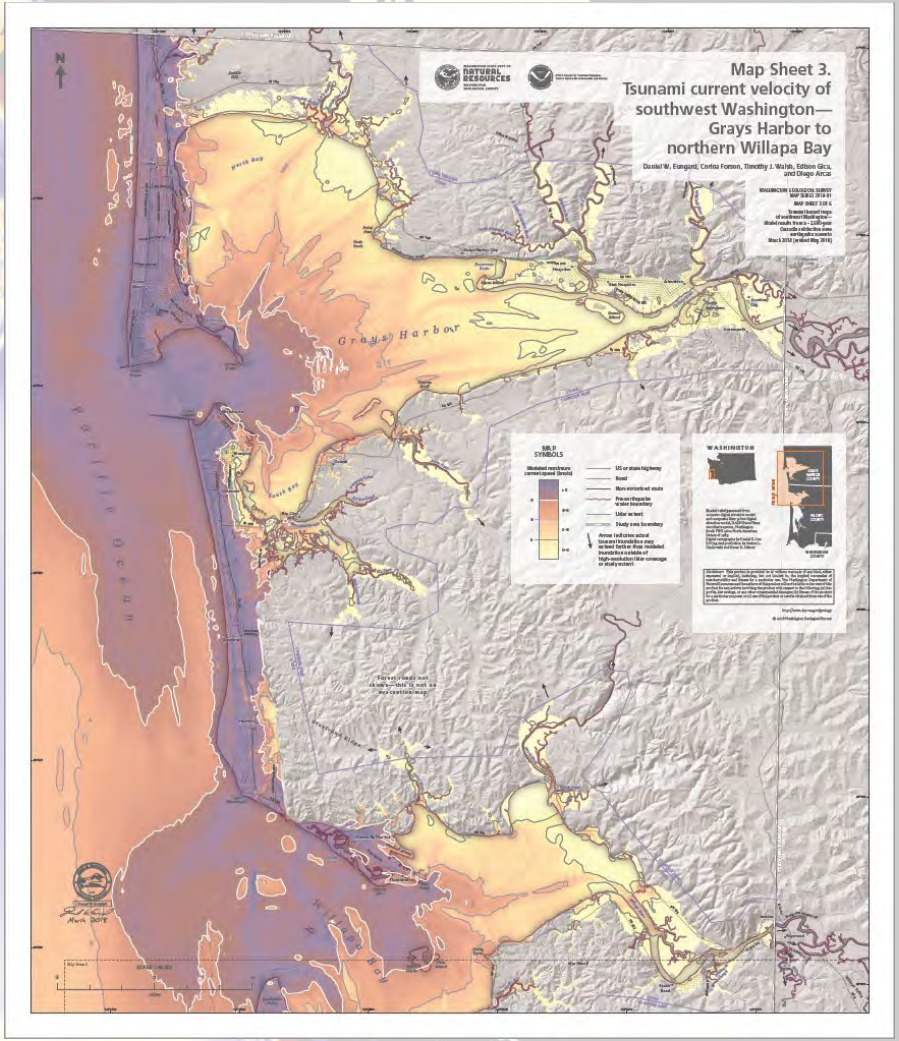


Tsunami Current Velocity Map

Current velocity maps

- Important for maritime guidance
- > 9 knots = extreme risk to ships, port infrastructure unlikely to survive
- < 3 knots = minimal risk
- 3-9 knots = minimal to high risk

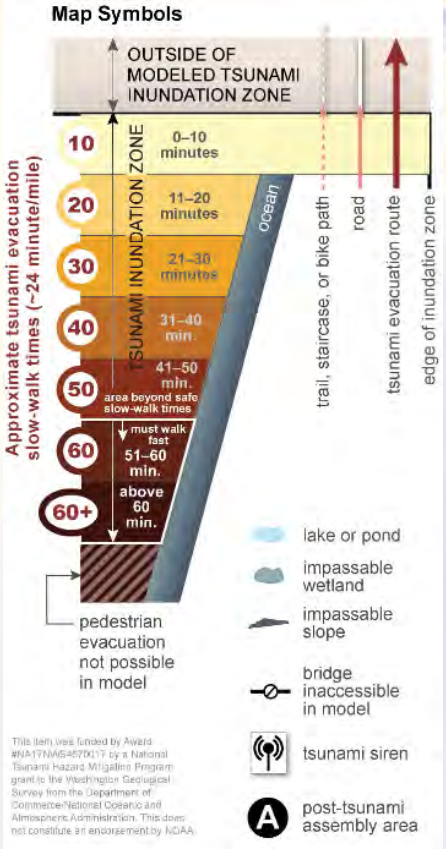


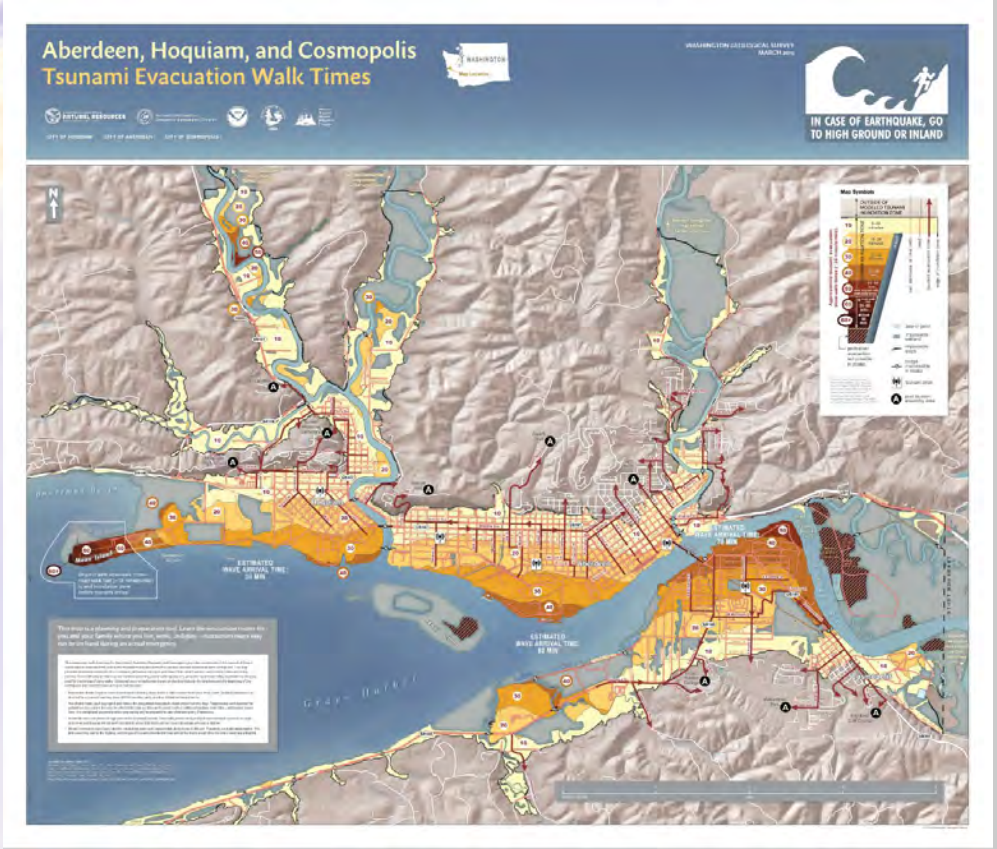


Tsunami Evacuation Walk Times Map

Pedestrian evacuation maps

- Time to evacuate
- Fastest route out of inundation zone

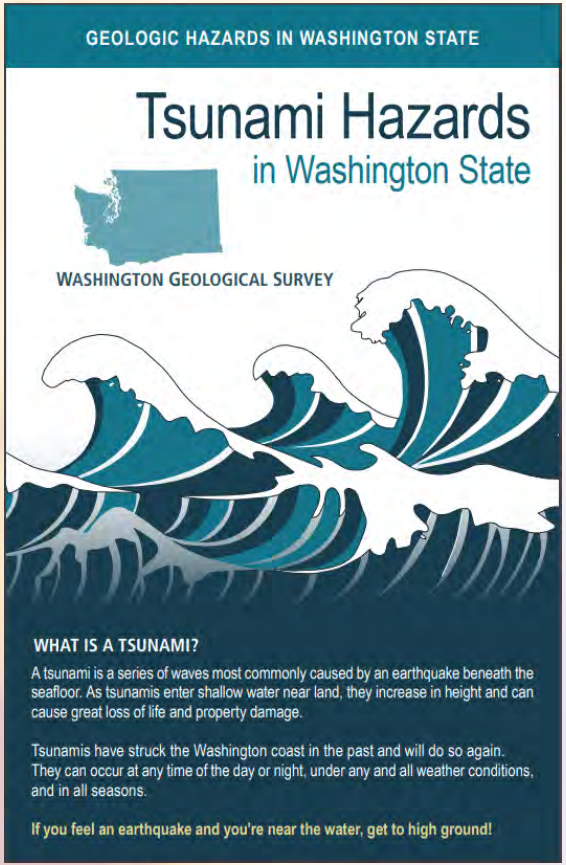


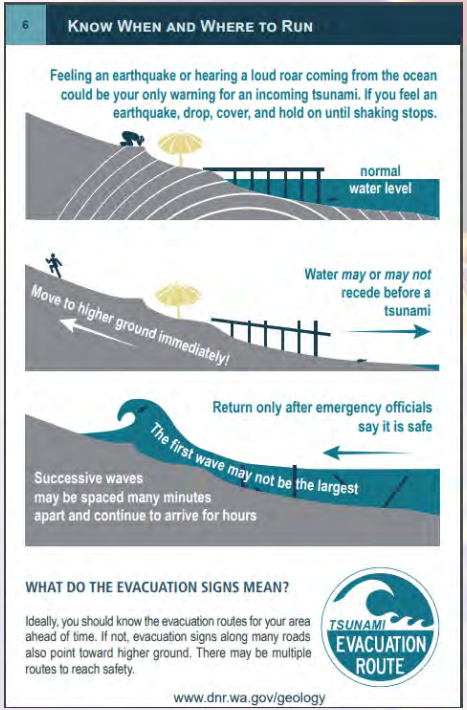


Upcoming Tsunami Hazards Publications for 2021

- CSZ inundation and current velocity for the Puget Sound and adjacent waters (early 2021)
- Seattle fault inundation and current velocity for the Puget Sound and adjacent waters
- CSZ inundation for the northwest outer coast
- Walk maps (4 proposed areas)
- Simulation videos (3 proposed areas)

Tsunami Hazards Brochure

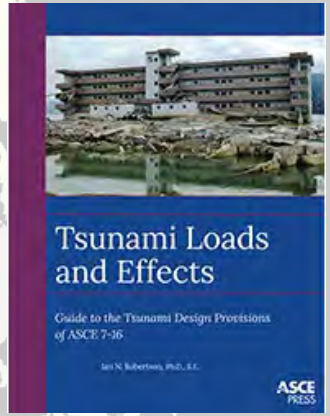


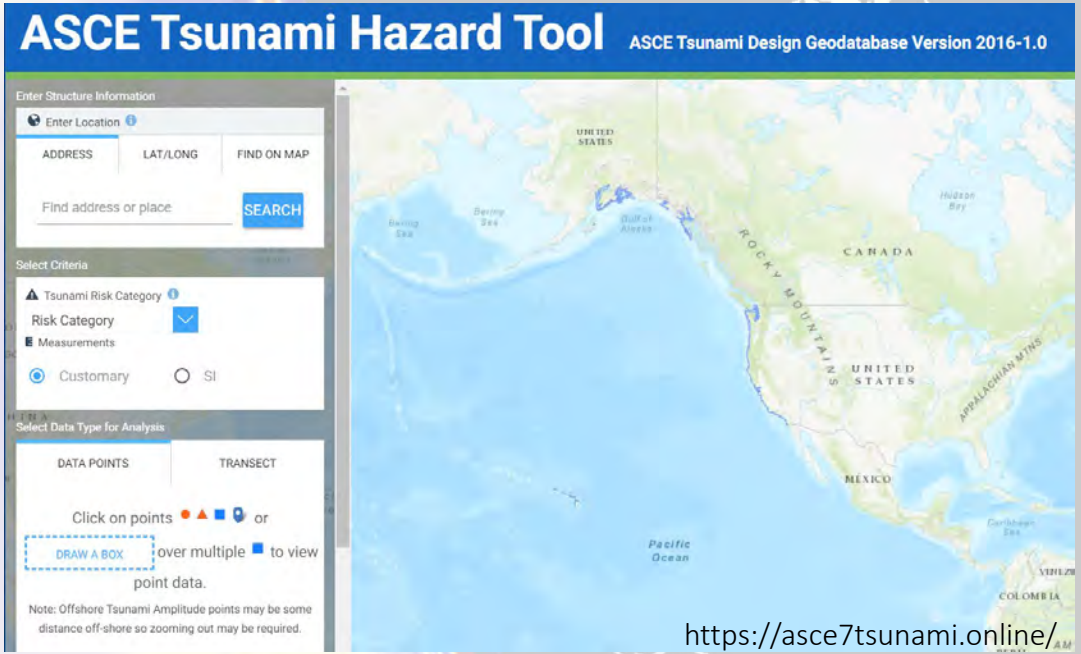


- https://www.dnr.wa.gov/publications/ger_tsunami_hazards_brochure.pdf

Tsunami Design Zones in the State Building Code

- Who: Washington State
- What: Adoption of a new building code focused on tsunami and engineering loads for newly constructed critical facilities and Vertical Evacuation Structures
- Where: Tsunami inundation zones
- When: February 2021





TsuInfo

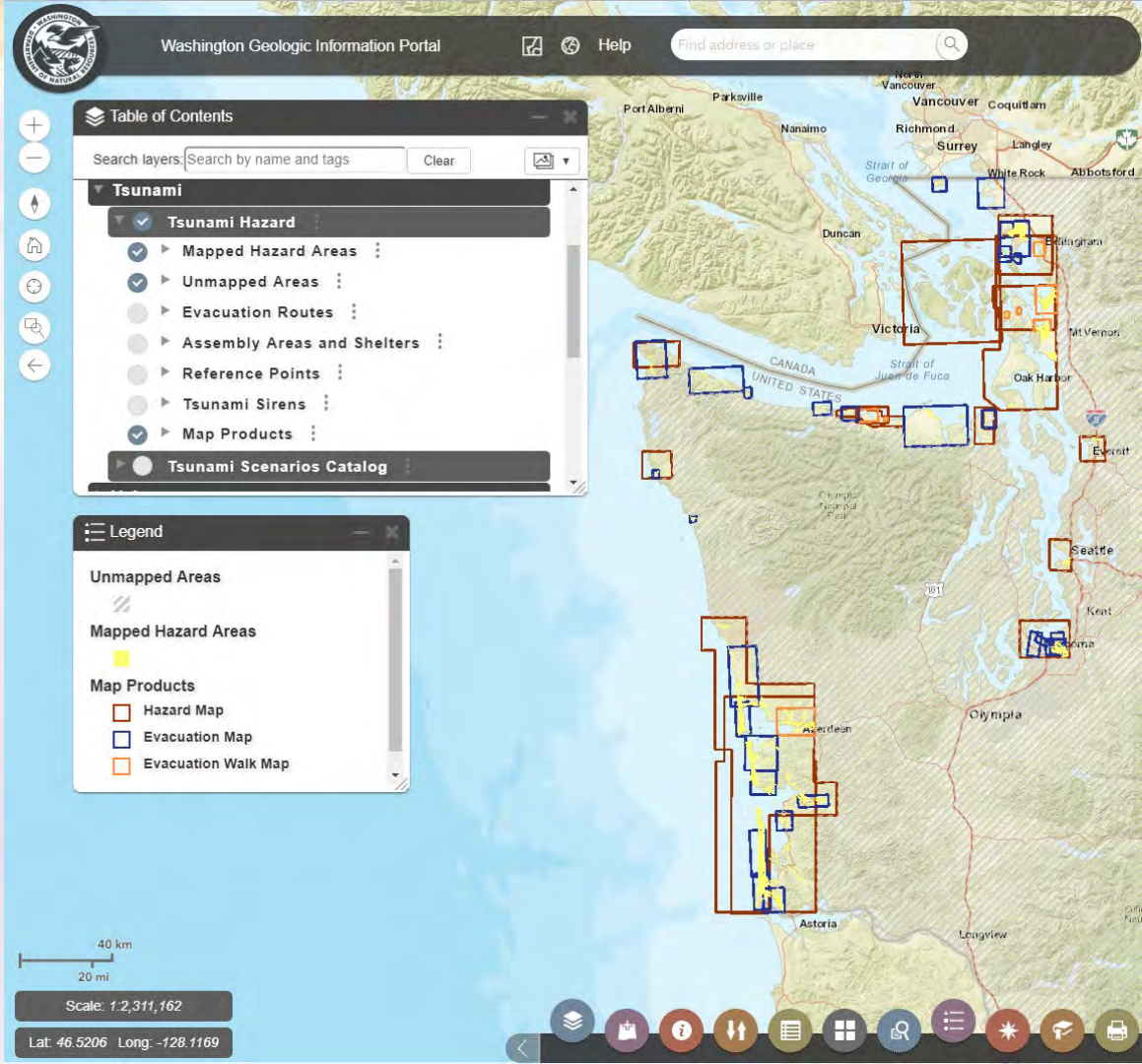
TsuInfo Alert is a bi-monthly newsletter that links scientists, emergency responders, and community planners to the latest tsunami research.

Contact:
Stephanie Earls
Stephanie.earls@dnr.wa.gov
360-902-1473

Geology Portal

https://geologyportal.dnr.wa.gov/

- Published products
- Access to geologic data
- Locational tools
- Print and save functions
- Use link above or type “WA Geology Portal” in your browser



Thank You

alex.dolcimascolo@dnr.wa.gov

360-742-7571

Maritime Tsunami Hazards

Jacob Witcraft – Washington Emergency Management Division

Maritime Impact in Tohoku (2011)

Japan (local)

- 28,000 ships destroyed
- 319 ports destroyed
- Economic loss of $3.9 Billion/day

California (distant)

- $100M in damage to 24+ harbors
- Some closed for up to a year, some have yet to recover

Washington's Maritime Economy

- 31 ports at risk of tsunami damage including the ports of Seattle and Tacoma (4th largest container gateway in the US)
- Largest ferry system in the US
- 7 Coast Guard stations, 4 Navy bases
- 700+ fishing and seafood processing operations
- 400+ private marinas
- $37+ billion maritime industry

Tsunami Hazards for Harbors and Boaters

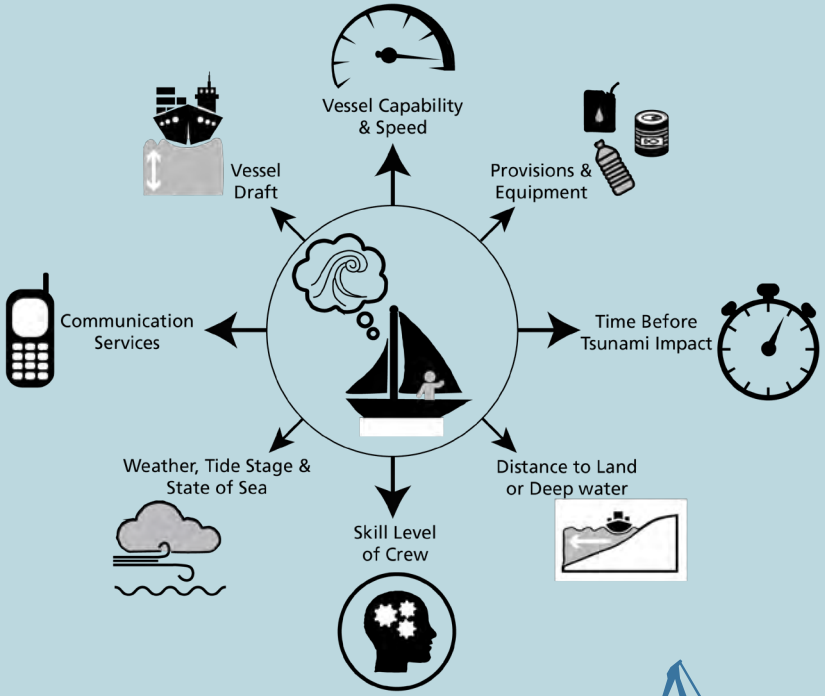
- **Strong and unpredictable currents**
- Sudden **water-level fluctuations** where docks and boats hit bottom, overtop piles, or are pushed on top of docks
- **Eddies/whirlpools**
- **Tsunami bores and amplified waves** swamping boats and damaging docks
- **Debris in the water**
- **Dangerous tsunami conditions can last 12-24+ hours** after first wave arrival, impacting boaters who take their boats offshore

What To Do When a Local Tsunami Strikes

- On the water
  - Cease any activities immediately, free any bottom attachments
  - Dock your vessel and evacuate to high ground if you are able
  - If not, head vessel to beyond 100 fathoms
  - Be aware of other vessels around you
  - Avoid areas with potential for dangerous currents
- On Land
  - Evacuate immediately to high ground - *you do not have time to save your vessel and you could die trying!*

What To Do When a Distant Tsunami Strikes

- On the water
  - Move to a location with a depth of at least 30 fathoms
  - Stay ½ mile from shoreline
  - Avoid areas with potential for strong currents
  - If a suitable location is not reachable in time, dock vessel and evacuate to high ground
- On land or tied to dock
  - Leave vessel and evacuate to high ground
  - Know your evacuation routes
  - Many distant source tsunamis are small enough to leave boat docked safely
  - Congestion in waterways and boat ramp areas can be dangerous



What To Do After a Tsunami

- **Offshore:** Check with USCG for guidance before attempting to return
- **Onshore:** Check with local authorities for guidance before returning to inundation zone
- *Do not return to local ports until you have firm guidance from USCG and local authorities* - local ports/marinas may sustain heavy damage and may not be safe for days, weeks, or months

What Can I Do To Prepare?

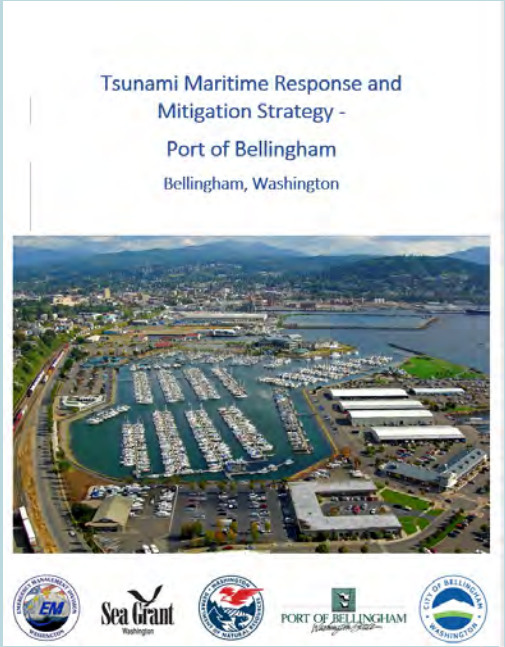
- Know the tsunami alert levels and have a NOAA Weather radio on your boat
- Have enough fuel and emergency supplies on vessel for at least 3 days at sea
- Know areas of dangerous currents to avoid and safe locations in open water

Tsunami Alerts

Alert Name	Actions	Potential Hazards
WARNING	Get to high ground or inland IMMEDIATELY Follow tsunami evacuation signage	DANGER! TSUNAMI IMMINENT! Flooding/powerful currents Wave heights > 3 ft. or unknown
ADVISORY	Stay out of the water and away from the shore	STRONG CURRENTS AND DANGEROUS WAVES in or very near coastal water Wave heights of 1 - 3 ft.
WATCH	Be prepared to take action Stay tuned to local radio/TV/ NOAA "alert" weather radios	TSUNAMI IS POSSIBLE Alert level *will* change once more information is known

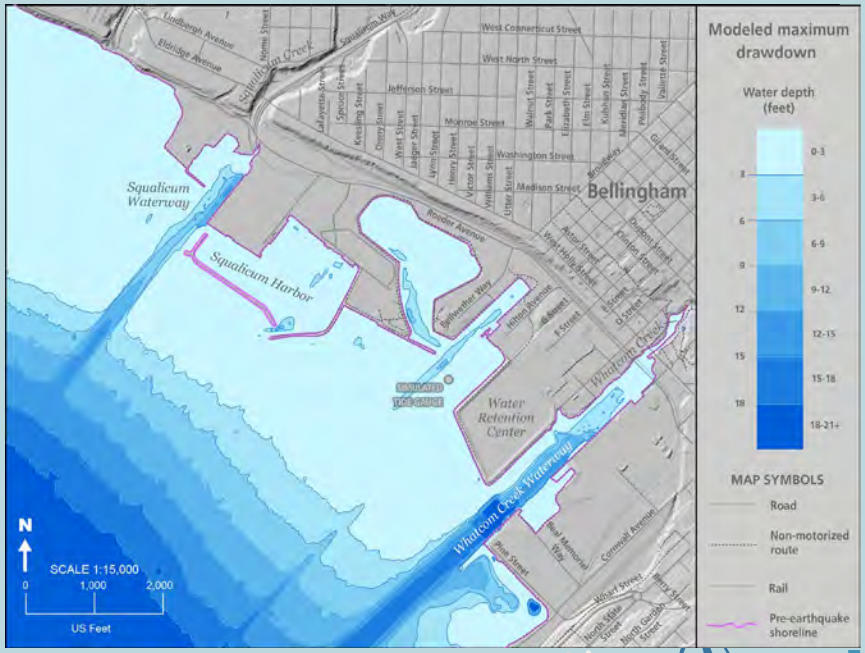
What Can Ports and The Maritime Community Do To Prepare?

- Development of Maritime focused Response and Mitigation strategies
- Provides framework for Port/Harbor scale decision making
- Focuses on maritime infrastructure mitigation and response guidance for boaters and mariners



What Does a Maritime Response And Mitigation Strategy Entail?

- Targeted port-area specific tsunami modeling
- Development of suite of maps detailing:
  - Inundation
  - Current velocity
  - Sea level drawdown
  - Evacuation routes
- Defining specific response roles to ensure appropriate and timely actions are undertaken when necessary



Tsunami Preparedness

Elyssa Tappero – Washington Emergency Management Division

Are YOU Prepared?

Can you answer these questions?

- How will I know a tsunami is coming?
- Do I know my evacuation routes, and have I practiced walking them?
- Do I have a family emergency plan?
- Do I have a go-bag ready?
- How will I communicate and reunite with my family?
- Am I involved in neighborhood and community preparedness?


Plan to be on your own for a while

Supplies and Go-Bags

At home (shelter-in-place)

- At least 2 weeks' worth of non-perishable food and water
- 1 gallon of water per person per day (for drinking, cooking, and cleaning)

Go-bags (anywhere you spend time)

- Intended for immediate evacuation to high ground or a shelter
- One for each member of the family
- Have one at home, work, school, and in your vehicle

What's In Your Go-Bag?

The usual (food, flashlight, batteries, first aid kit, warm clothes, etc) but also…

- Water purification kit or tablets
- Portable NOAA radio
- Essential medications and medical equipment
- Copies of all important documents
- Cash
- Essentials for infants, the elderly, or pets
- Comfort items

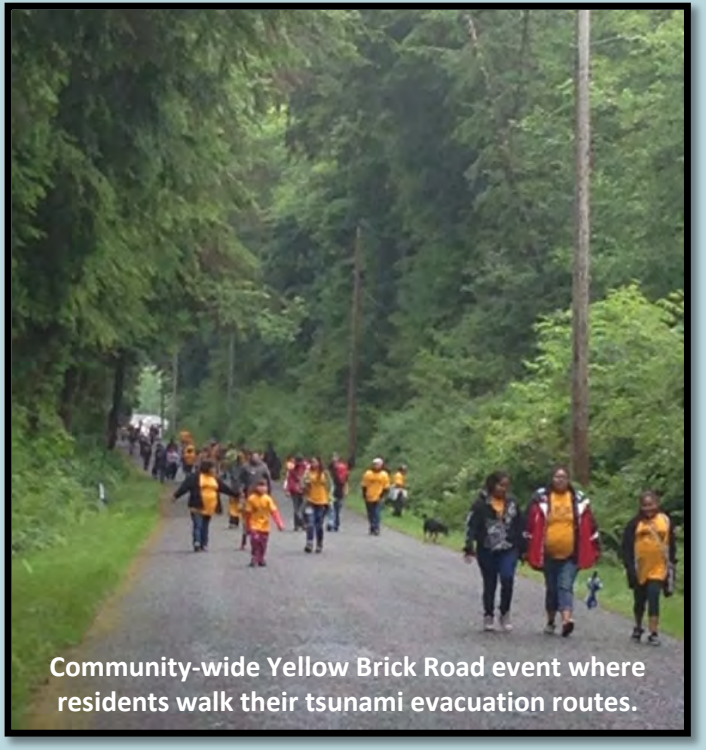
Think of Your Feet!

- After a nighttime earthquake, the #1 injury at emergency rooms is feet cut by broken glass and debris
- Keep the following in a bag tied to your bed:
  - Shoes
  - Flashlight with spare batteries
  - Warm jacket
  - Extra pair of glasses (if necessary)

Find more tips like this at DisasterReadyWashington.com!

Evacuations

- Evacuating will take longer than you think!
  - Have your go-bag already packed and stored in an easily accessible place
  - Don’t waste time confirming alerts with secondary sources or social media
  - Have a plan and *practice, practice, PRACTICE!*
- Washington laws
  - House Bill 1279 requires public schools to practice 1 earthquake drill per year
  - House Bill 1216 requires public schools in mapped tsunami inundation zones to practice 1 tsunami drill per year



Community-wide Yellow Brick Road event where residents walk their tsunami evacuation routes.

Stay Informed – Social Media & Apps

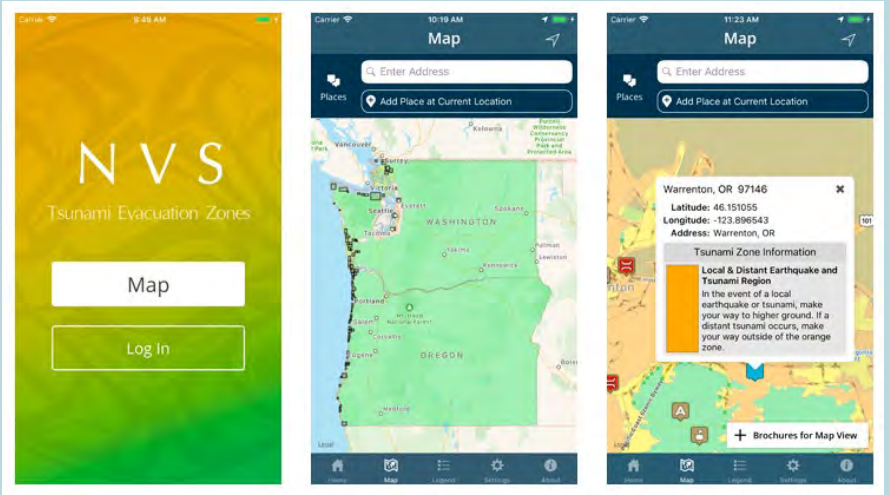
National Tsunami Warning Center
- NWS_NTWC
- NWSNTWC

National Weather Service Seattle:
- NWSSeattle
- NWSSeattle

National Weather Service Portland:
- NWSPortland
- NWSPortland

WA Emergency Management Division:
- WaEMD
- WashEMD

NVS Tsunami Evacuation app for WA and OR (Apple & Android)

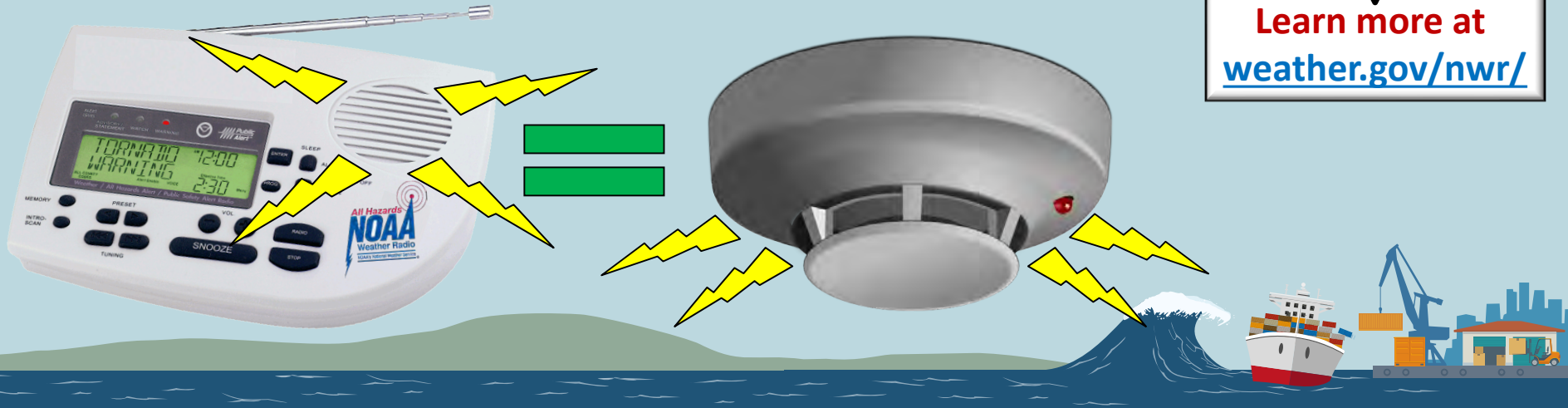


Stay Informed – NOAA Weather Radio

- NOAA Weather Radio: nationwide network of radio stations broadcasting continuous weather information directly from NWS
- NOT just for tsunami alerts (e.g. winter storms, high winds)
- 16 Stations in Washington, must program the radio to your area
- Warning alarm feature acts just like a fire alarm
    - New models are programed to only sound an alarm for a WARNING

All Hazards NOAA Weather Radio
NOAA's National Weather Service

Learn more at
weather.gov/nwr/



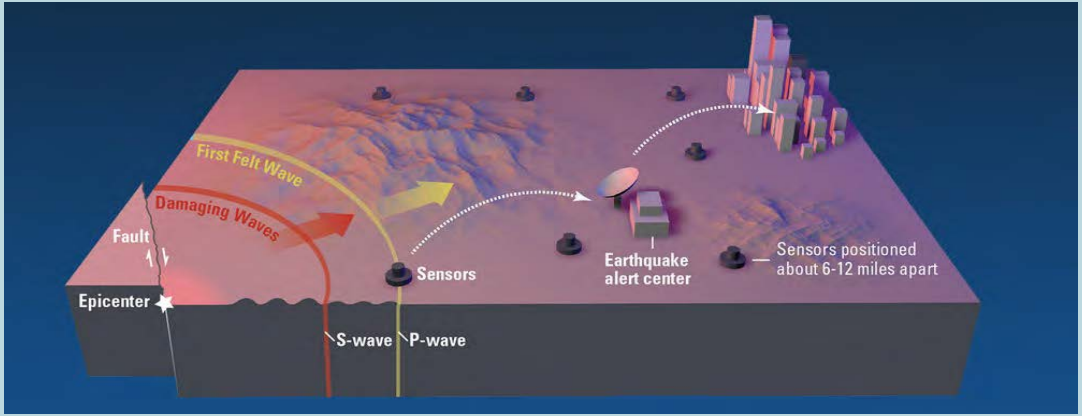
Stay Informed – Local Alerts

What if you were alerted when an earthquake occurred…

<u>BEFORE</u> the shaking reached you?

Earthquake Early Warning is Coming!

The Earthquake Early Warning (EEW) System detects damaging earthquakes and rapidly disseminates alerts to people to warn them of imminent shaking.



WA state's goal is for EEW alerting to be available to the public starting in **2021** via WEA and mobile phone apps.

“Re-Preparing” During the Covid-19 Pandemic

Since March, have you had to…	If so, it might be time to…
…use any of your emergency supplies?	…review and restock!
…dip into your emergency savings fund?	…plan for replenishing it!
…change any of your financial, medical, or insurance information?	…save updated copies of your important documents!
…spend long amounts of time in new locations?	…make new go-bags to store there!

youtube.com/user/EMDprepare

You CAN survive IF you get prepared!

mil.wa.gov/alerts

dnr.wa.gov/geologyportal

mil.wa.gov/preparedness

youtube.com/user/EMDprepare

If you have additional questions, please reach out to ***public.education@mil.wa.gov***