MAPPING THE WAVE
Depicting Tsunami Hazards in Washington State

Image modified from: The Great Wave (Kanagawa Oki Nami Ura) by Hokusai Katsushika
MISSION: To collect, develop, use, distribute, and preserve geologic information to promote the safety, health, and welfare of the residents of Washington, protect the environment, and support its economy.
Tsunamis in the Pacific Northwest

- Distant and Local Sources
- Local Cascadia-induced tsunami
  - < 15 minutes before tsunami reaches coast
  - potential for inundation up to 60 feet
Tsunamis in the Pacific Northwest

- Many communities in tsunami inundation zones
- 31,000 WA students attend schools in tsunami inundation zones  
  *(Doughton and Gilbert, 2016)*
- Summer tourism greatly increases coastal population
Cascadia Subduction Zone (CSZ)

- Average interval between earthquakes: 240 years
- Average interval between large (>8.5 $M_w$) earthquakes: 500–600 years
- Last large CSZ earthquake: January 26, 1700
CSZ Earthquake and Tsunami

A. The Juan de Fuca Plate moves slowly and is locked between the Pacific and North American Plates.

B. The locked zone ruptures, releasing energy as an earthquake.

C. The locked zone ruptures, releasing energy as an earthquake that starts the tsunami.

D. Tsunami waves spread from the epicenter.

E. Local coastal inundation occurs.

Source: DOGAMI
CSZ Earthquake and Tsunami

Images: Carrie Garrison-Laney (WA SeaGrant)
2011 Tōhoku Earthquake and Tsunami

- Magnitude 9.0–9.1 ($M_w$) earthquake
- Massive tsunami inundation multiple stories high
- Hundreds of billions of dollars in damage
- Over 15,000 deaths
Tsunami Mapping Challenges

• Multiple earthquake scenarios
**Tsunami Mapping Challenges**

- Multiple earthquake scenarios
- Data inconsistencies / updates
Tsunami Mapping Challenges

• Multiple earthquake scenarios
• Data inconsistencies / updates
• Earthquake uplift and subsidence

Map modified from Carrie Garrison-Laney (WA SeaGrant)
Tsunami Mapping Challenges

• Multiple earthquake scenarios
• Data inconsistencies / updates
• Earthquake uplift and subsidence
• Long and complicated coastline (3,026 miles)
Tsunami Mapping Challenges

- Multiple earthquake scenarios
- Data inconsistencies / updates
- Earthquake uplift and subsidence
- Long and complicated coastline (3,026 miles)
- Bureaucracy

Data
- National Oceanic and Atmospheric Administration
- Federal Emergency Management Agency
- University of Washington
- Washington Geological Survey
- Washington Emergency Management Division
- County Emergency Managers
- Local Officials (Police, Fire)
- Residents and Visitors

Authority
- Policy
- Budgets
- Grants
- Communication
WGS Tsunami Team

- Chief Hazards Geologist—Corina Forson
- Tsunami Hazards Geologist—Daniel Eungard
- Tsunami Hazards Geologist—Alex Dolcimascolo
Recent WGS Tsunami Mapping

- Inundation and current velocity
Recent WGS Tsunami Mapping

- Inundation and current velocity
- Evacuation walk times
Recent WGS Tsunami Mapping

- Inundation and current velocity
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- WGS website—interpretive graphics and data
Recent WGS Tsunami Mapping

- Inundation and current velocity
- Evacuation walk times
- WGS website—interpretive graphics and data
- Amplitude and velocity simulations
Inundation and Current Velocity

- Modeled magnitude 9.0 Cascadia-induced tsunami
- 2 inundation maps (binned / continuous data) and current velocity (speed)
- 6 coastal regions mapped thus far
- Modeling Software, ArcGIS Desktop and Adobe Photoshop/Illustrator
Evacuation Walk Time Modeling

- Modeled slow walk pace (~2.5 mph) to exit tsunami zone
- 10 communities mapped thus far
- Vertical evacuation structures needed for several locations
- ArcGIS Desktop, Pedestrian Evacuation Analyst Toolkit (PEAT), Adobe Photoshop and Illustrator
Ocosta School vertical evacuation structure
Community Events

• Tsunami Road Show
• Stakeholder workgroup meetings ~10 times per year
• Presentations on request to various community groups
Tsunamis have hit Washington in the past, and they will happen again in the future. Click on the icons below to learn about how and where tsunamis occur, how to recognize a tsunami, how to evacuate before a tsunami arrives, and what geologists at the Washington Geological Survey are doing to learn more about these natural hazards.

Understanding tsunamis
Tsunamis in Washington
Tsunami hazard maps
Preparation and evacuation
Tsunami alerts
Historical tsunamis worldwide

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LINKS
For more Information about tsunamis and emergency preparation:
- Washington Emergency Management
- National Tsunami Warning Center
- The US site that monitors for tsunamis and issues warnings

Information on preparation for emergencies and disasters in our state
Website Maps and Graphics

Tsunamis in Washington
- Port Island, 1890: Tsunami liquefied soil and sediment, forming a delta.
- Lake Roosevelt, 1942: Wave generated by an earthquake, traveled 1,800 miles and led to flooding.
- Crescent Beach, 1946: Wave generated by fault rupture, reached 100 feet high.
- Tsunami Warning, April 15, 1989: Preparedness for future events.

COASTAL EARTHQUAKE SUBSIDENCE
- Before earthquake: Land above sea level.
- One year after earthquake: Land subsidence.
- Decades to centuries later: Cedar snags.
- Tides: Calm sea level.
- Land above sea level:
  - Wave frequency: The number of wave crests passing point A.
  - Wave period: The time required for the wave crest at point A to reach point B.

TSUNAMI GENERATION SOURCES
- Earthquakes: Induced by underwater fault rupture.
- Volcanic explosions: Induced by underwater eruptions.
- Landslides: Induced by submarine landslides.

During earthquake:
- Orange = uplift (land rises).
- Purple = subsidence (land sinks).
Washington Geologic Information Portal

- Publication and data downloads
- Tsunami hazard areas
- Evacuation routes
- Assembly areas
- Tsunami sirens
Amplitude and Velocity Simulations

- 9 simulations
- Wave amplitude (peaks and troughs)
- Current velocity (speed)
- YouTube and direct MP4 download
- Modeling Software (M.O.S.T.)—NetCDF files, ArcGIS Pro, Adobe After Effects and Illustrator
- More in the next month
Tsunami wave simulation
for Washington State from a hypothetical magnitude 9.0 earthquake (L1) scenario on the Cascadia subduction zone

Link to tsunami simulations: https://bit.ly/2BxfXqM
Thanks!

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