

Cascadia Subduction Zone Earthquake and Tsunami Modeling in Washington

by

Timothy J. Walsh

Washington Department of Natural Resources

Division of Geology and Earth Resources

February 1, 2016



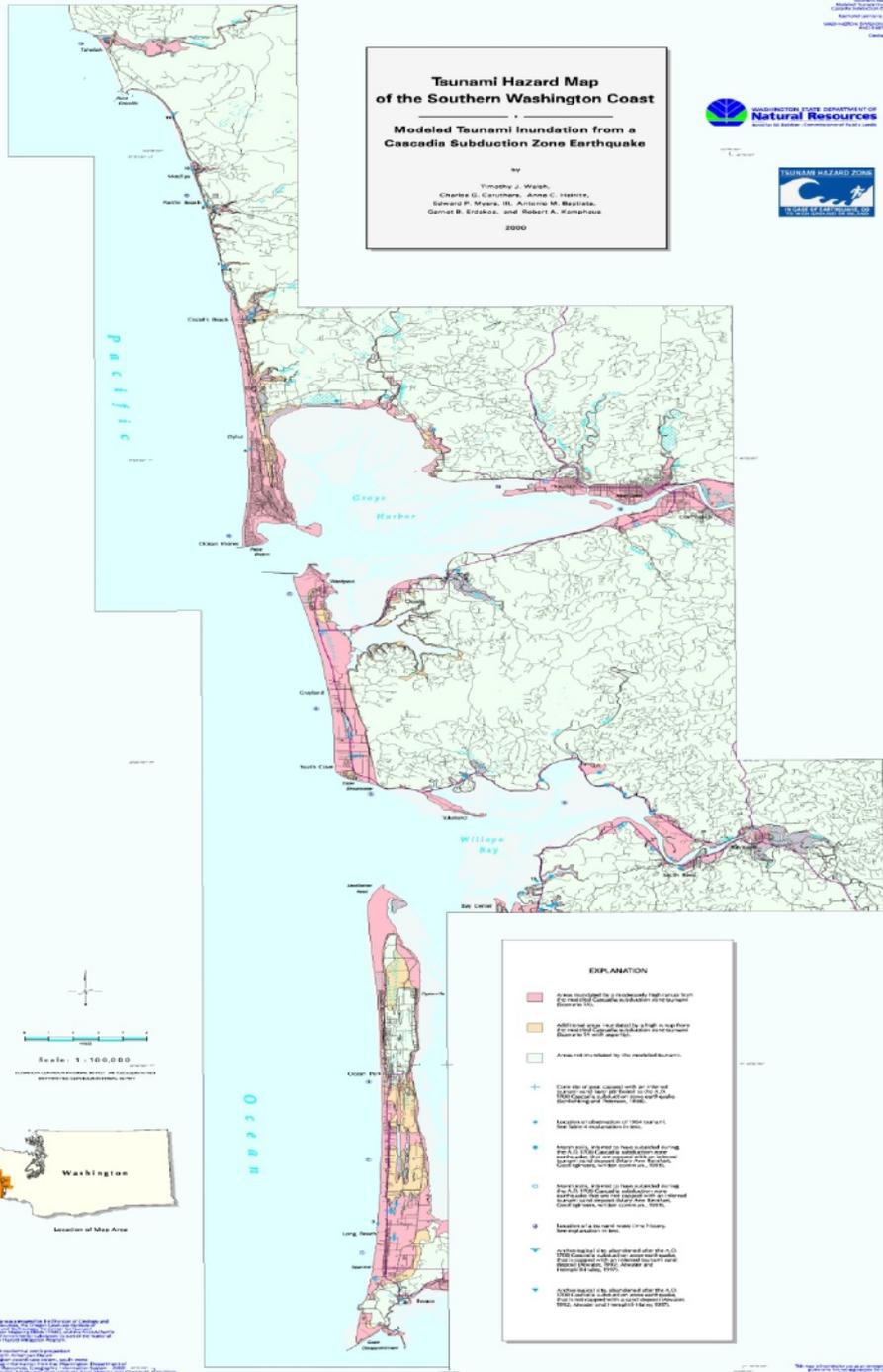
EXPLANATION

**Tsunami Hazard Map
of the Southern Washington Coast**

**Modeled Tsunami Inundation from a
Cascadia Subduction Zone Earthquake**

by
Timothy J. Walsh,
Charles G. Conchares, Anne C. Hester,
Edward P. Moore, III, Anthony M. Rosato,
Gerrit B. Erskos, and Robert A. Komphos

2000



-  Areas inundated by a moderately high runup from the modeled Cascadia subduction zone tsunami (Scenario 1A).
-  Additional areas inundated by a high runup from the modeled Cascadia subduction zone tsunami (Scenario 1A with asperity).
-  Areas not inundated by the modeled tsunami.
-  Core site of peat capped with an inferred tsunami sand layer attributed to the A.D. 1700 Cascadia subduction zone earthquake (Schlichting and Peterson, 1998).
-  Location of observation of 1964 tsunami. See Table 4 explanation in text.
-  Marsh soils, inferred to have subsided during the A.D. 1700 Cascadia subduction zone earthquake, that are capped with an inferred tsunami sand deposit (Mary Ann Reinhart, GeoEngineers, written commun., 1999).
-  Marsh soils, inferred to have subsided during the A.D. 1700 Cascadia subduction zone earthquake that are not capped with an inferred tsunami sand deposit (Mary Ann Reinhart, GeoEngineers, written commun., 1999).
-  Location of a tsunami wave time history. See explanation in text.
-  Archeological site, abandoned after the A.D. 1700 Cascadia subduction zone earthquake, that is capped with an inferred tsunami sand deposit (Atwater, 1992; Atwater and Hemphill-Haley, 1997).
-  Archeological site, abandoned after the A.D. 1700 Cascadia subduction zone earthquake, that is not capped with a sand deposit (Atwater, 1992; Atwater and Hemphill-Haley, 1997).



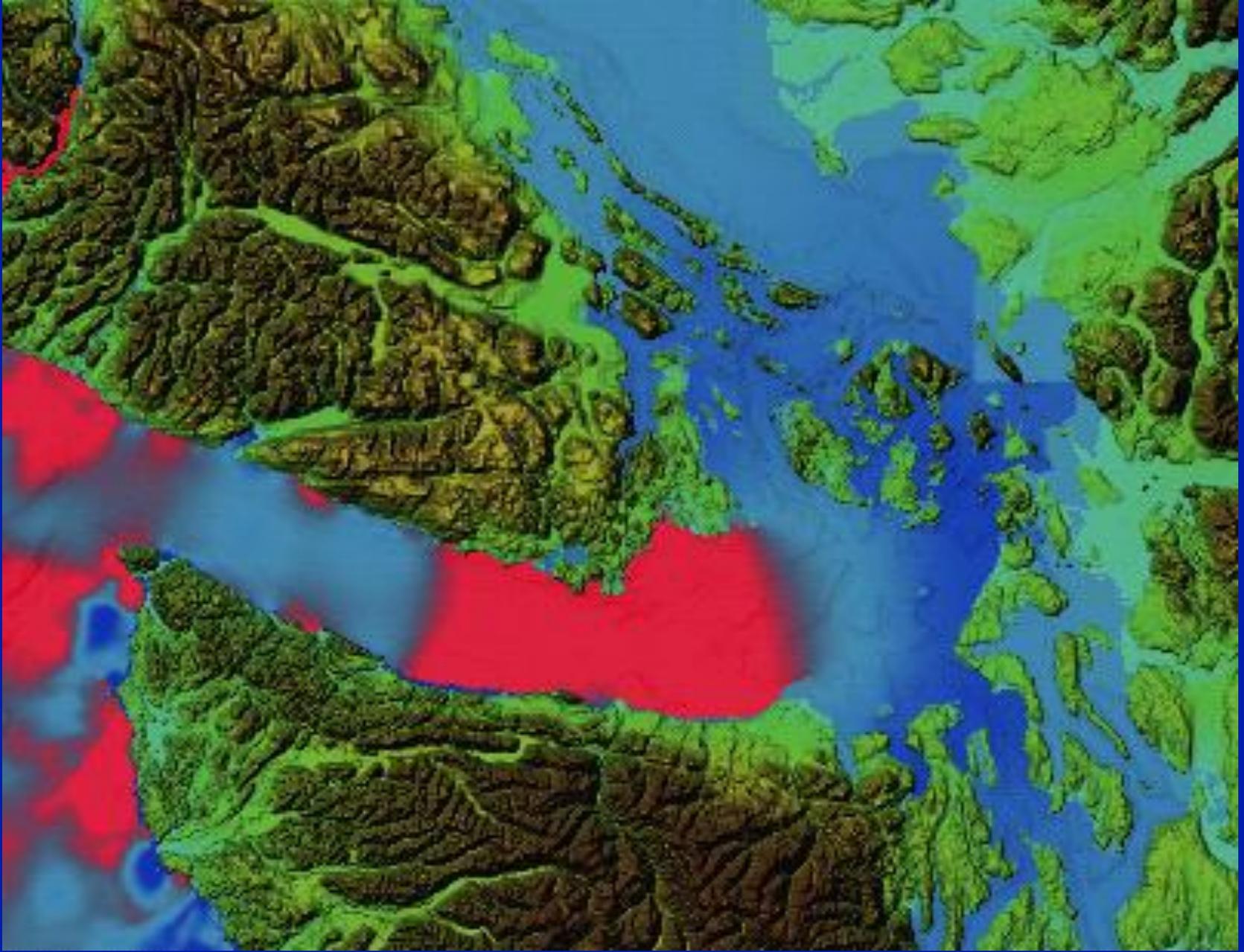
WASHINGTON STATE DEPARTMENT OF
Natural Resources

SJDF propagation (0:30)



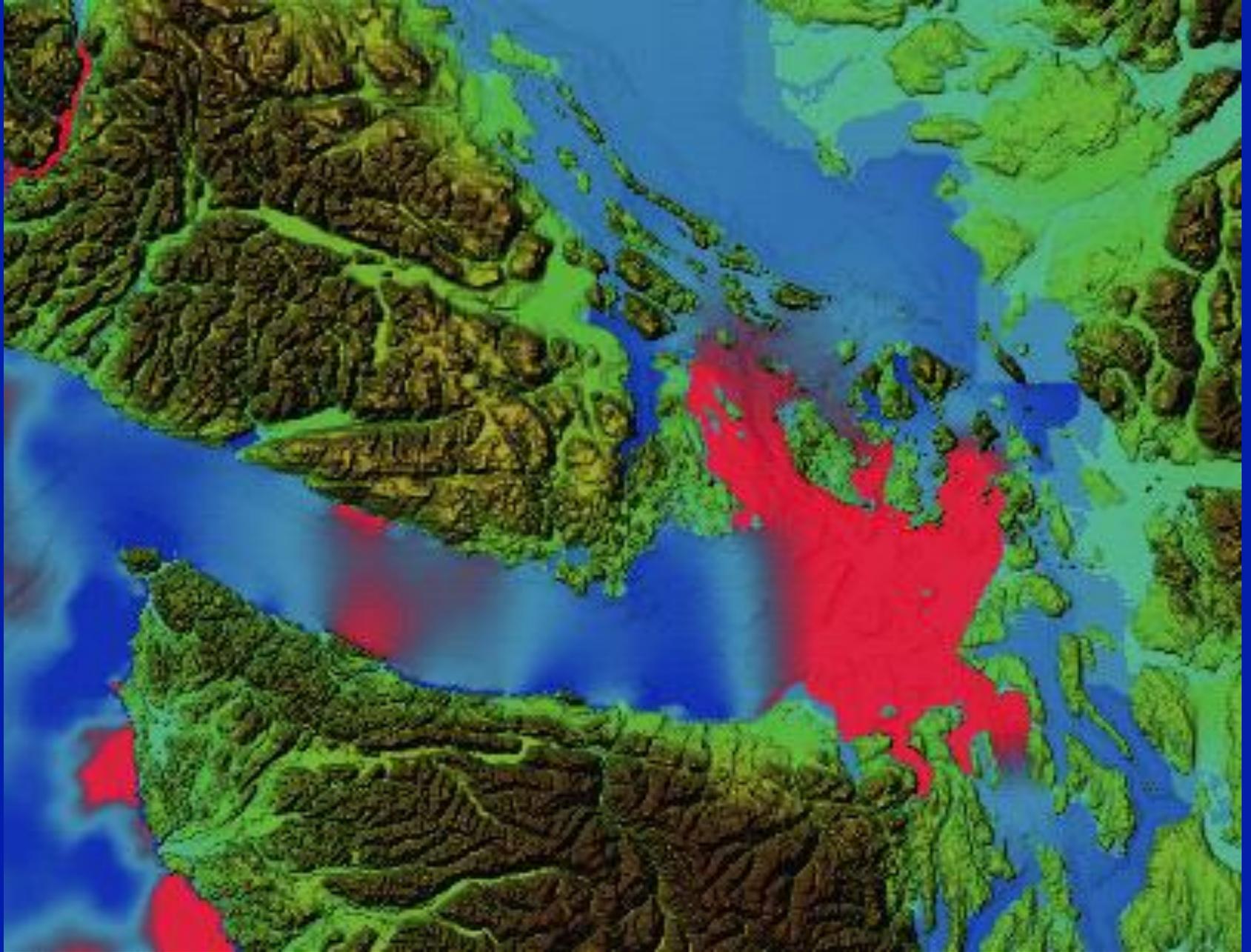
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SJDF propagation (1:00)



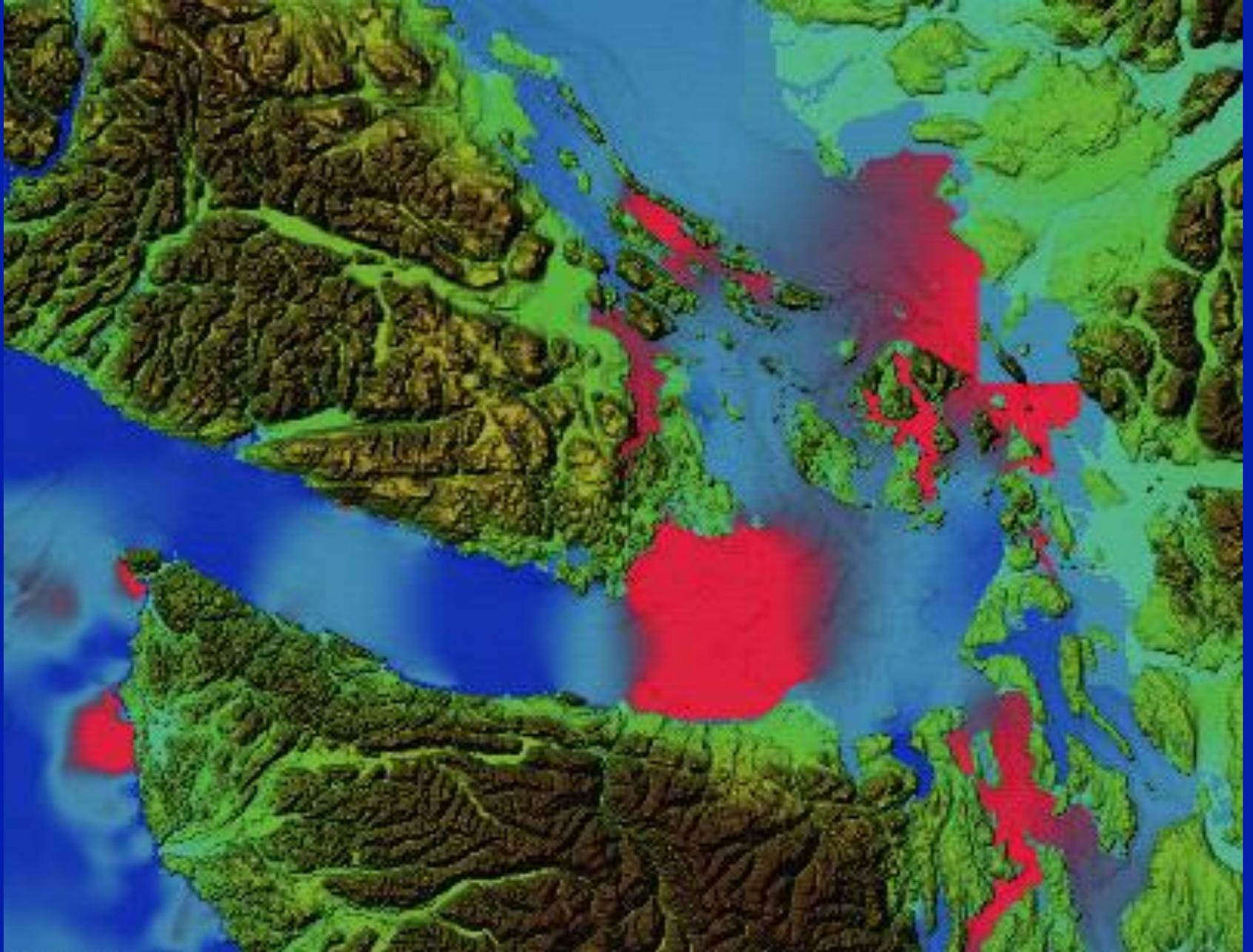
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SJDF propagation (1:30)



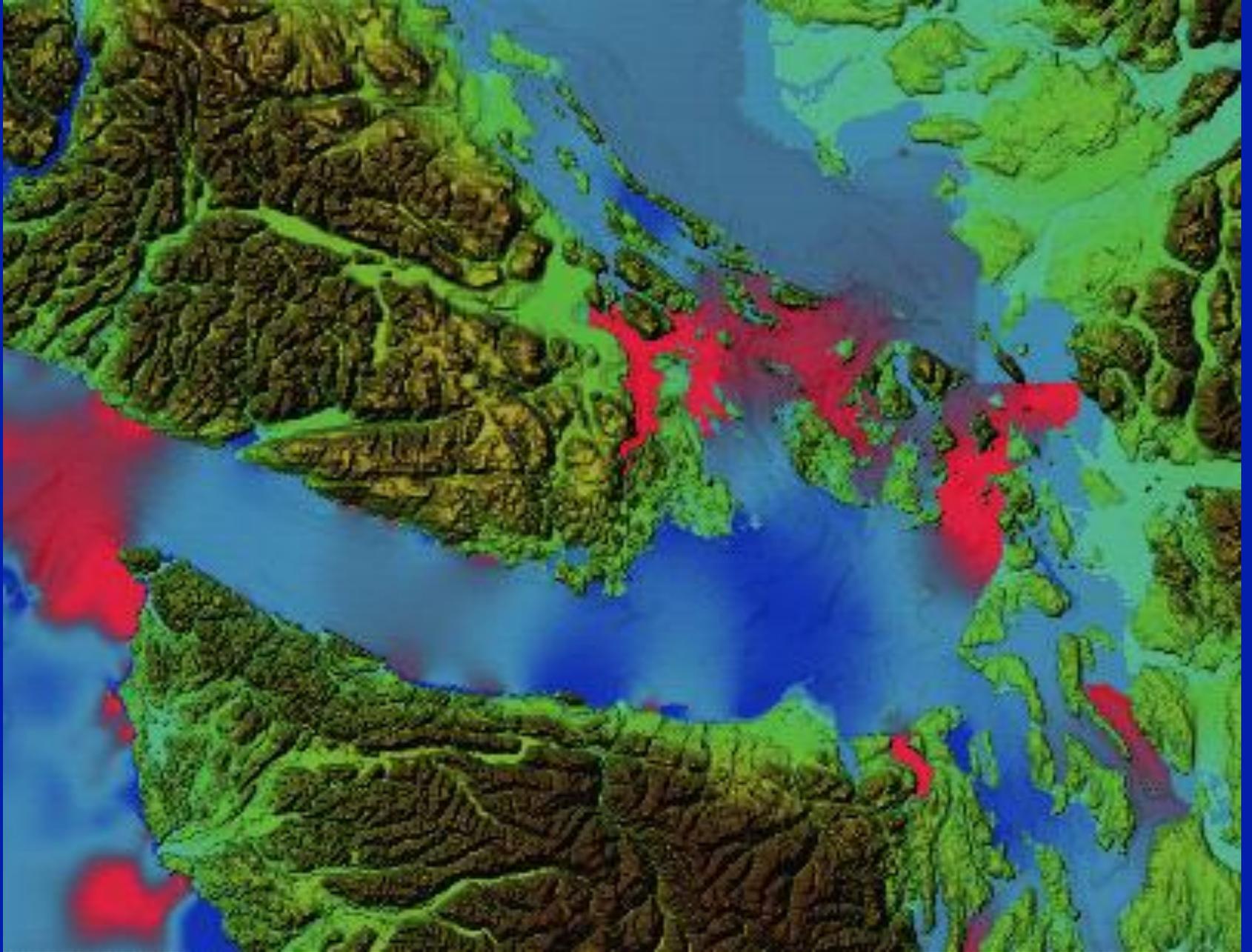
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SJDF propagation (2:00)



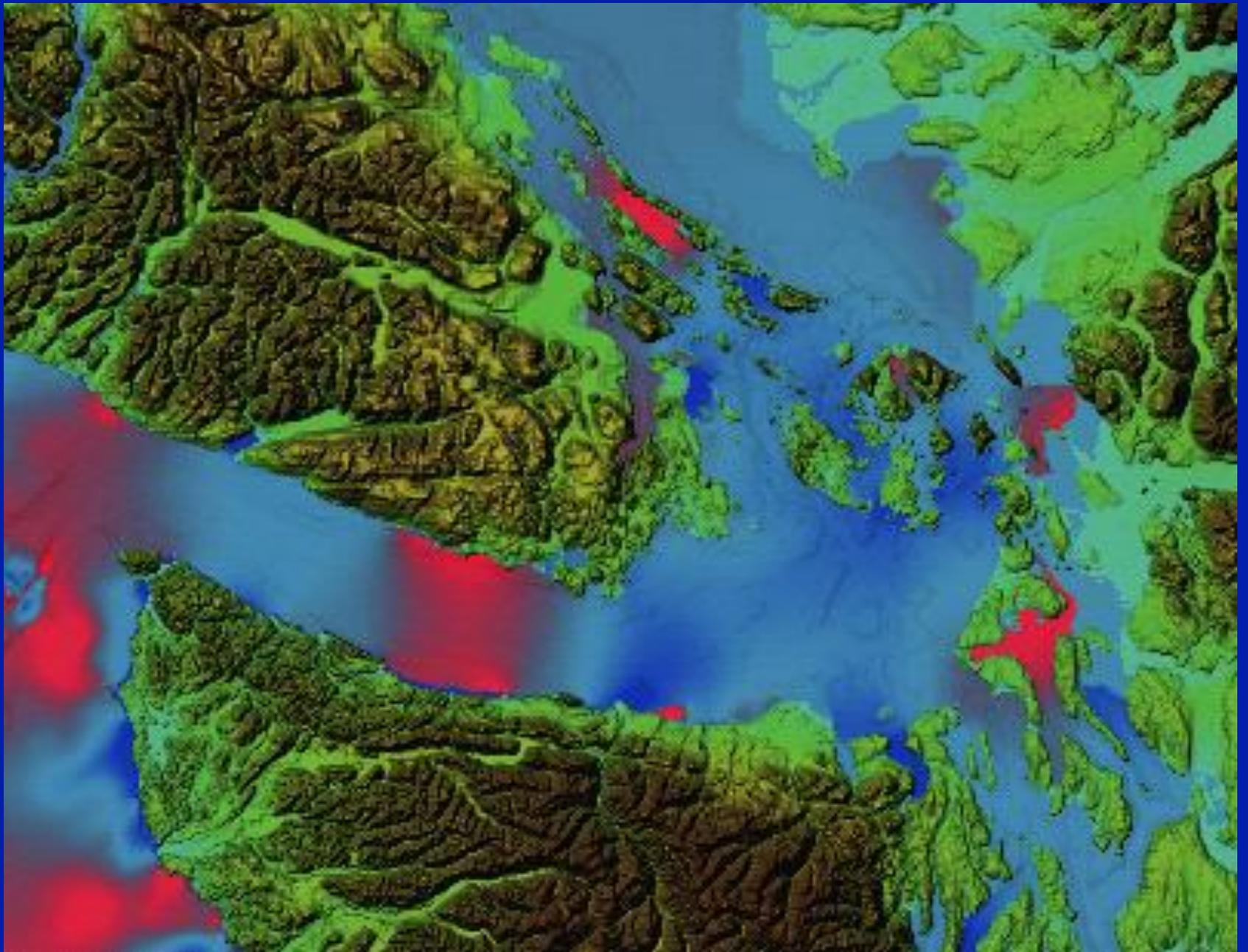
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Natural Resources

SJDF propagation (2:30)



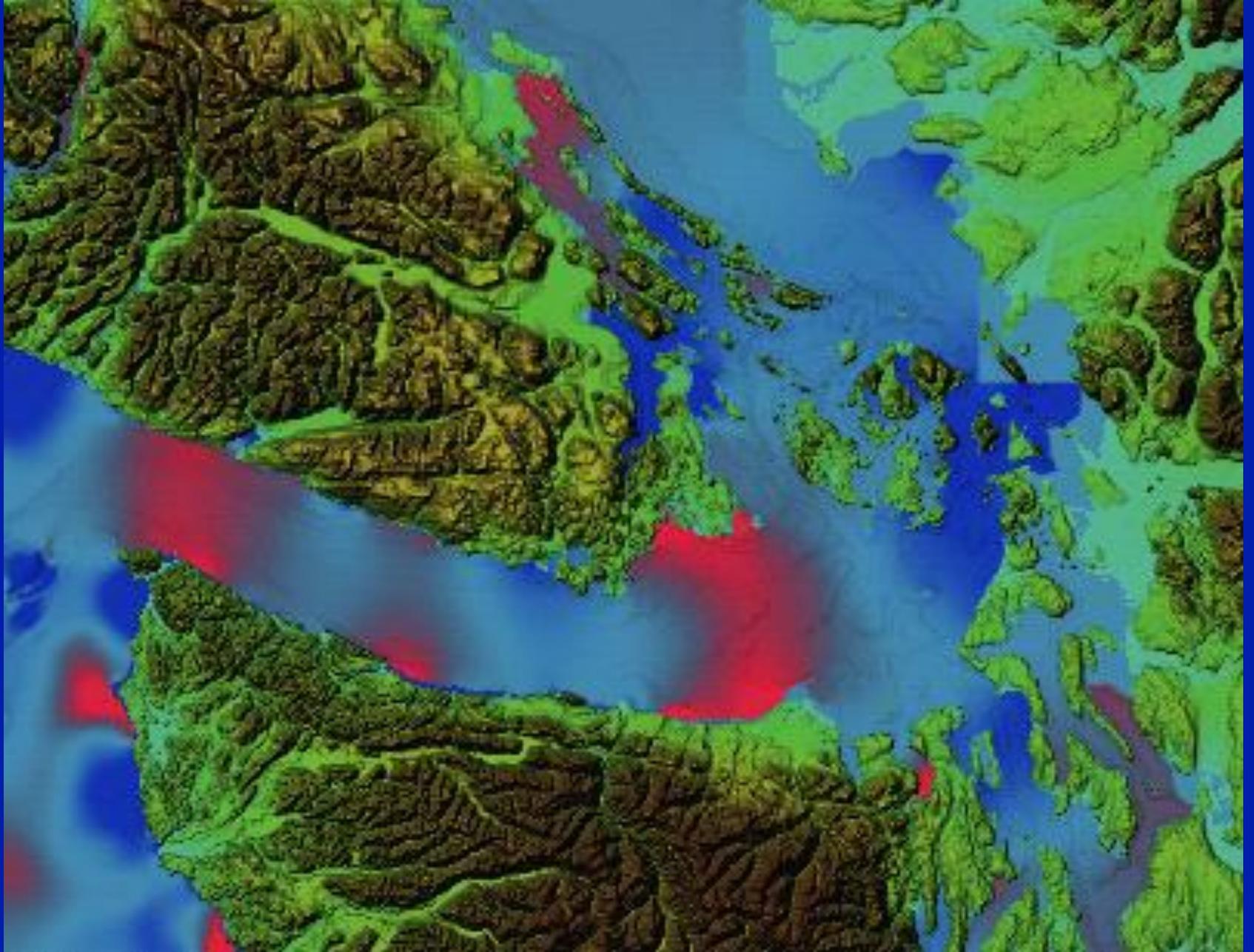
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SJDF propagation (3:00)



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SJDF propagation (3:30)



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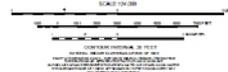
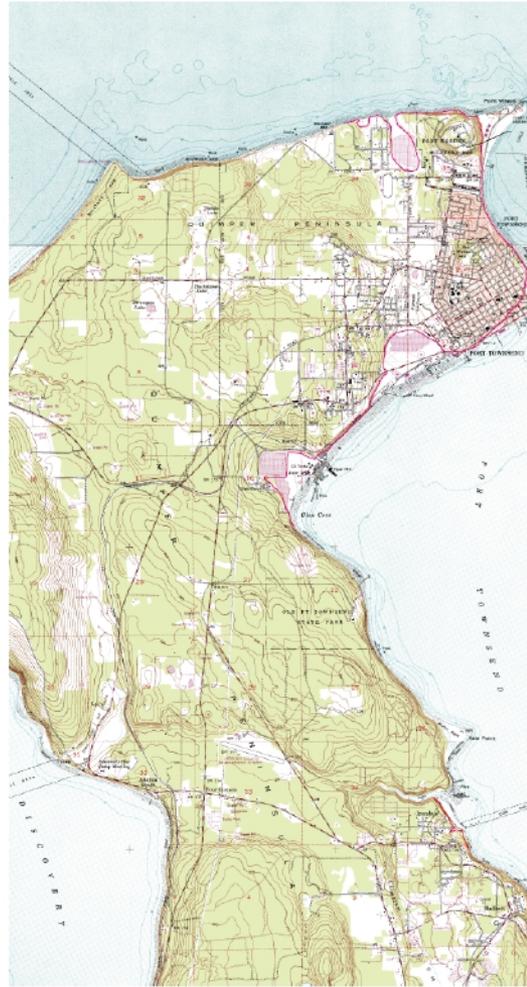
SJDF propagation (4:00)

Tsunami Inundation Map of the Port Townsend, Washington, Area

by
Timothy J. Walsh, Edward P. Myers III, and Antonio M. Baptista

August 2002

We made a number of these hazard maps, including this one of the Port Townsend area



Landward limit of expected inundation

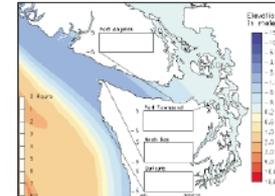


Figure 5. Total tsunami inundation for scenario 1A. Areas within an area of uplift and landslides are an addition.

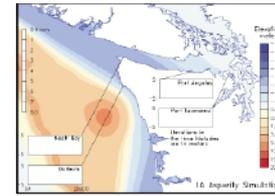


Figure 6. Bathymetric map for scenario 1A. Areas within an area of uplift and landslides are an addition.

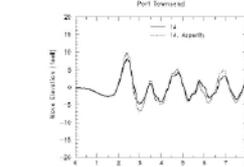


Figure 7. Inundation time history of tsunami wave for scenario 1A. Areas within an area of uplift and landslides are an addition.

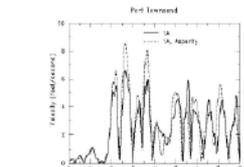


Figure 8. Current velocity with time off Port Townsend. Areas within an area of uplift and landslides are an addition.

Introduction
Recent research about the existence of great earthquakes of the Washington, Oregon, and northern California coastline and resulting tsunami waves and effects. 1997 has led to the issue of tsunami hazard from the potential of great earthquakes. Since then, several studies have been conducted to estimate tsunami hazard in the Pacific Northwest. The most recent study was done by the Washington Department of Geology and Earth Resources (DGER) in 2002. This study was part of the Washington Department of Geology and Earth Resources (DGER) Open File Report 2002-2.

Map Edge
The tsunami hazard map of tsunami inundation is based on a computer model of wave generation and propagation. The model uses a computer model of wave generation and propagation. The model uses a computer model of wave generation and propagation. The model uses a computer model of wave generation and propagation.

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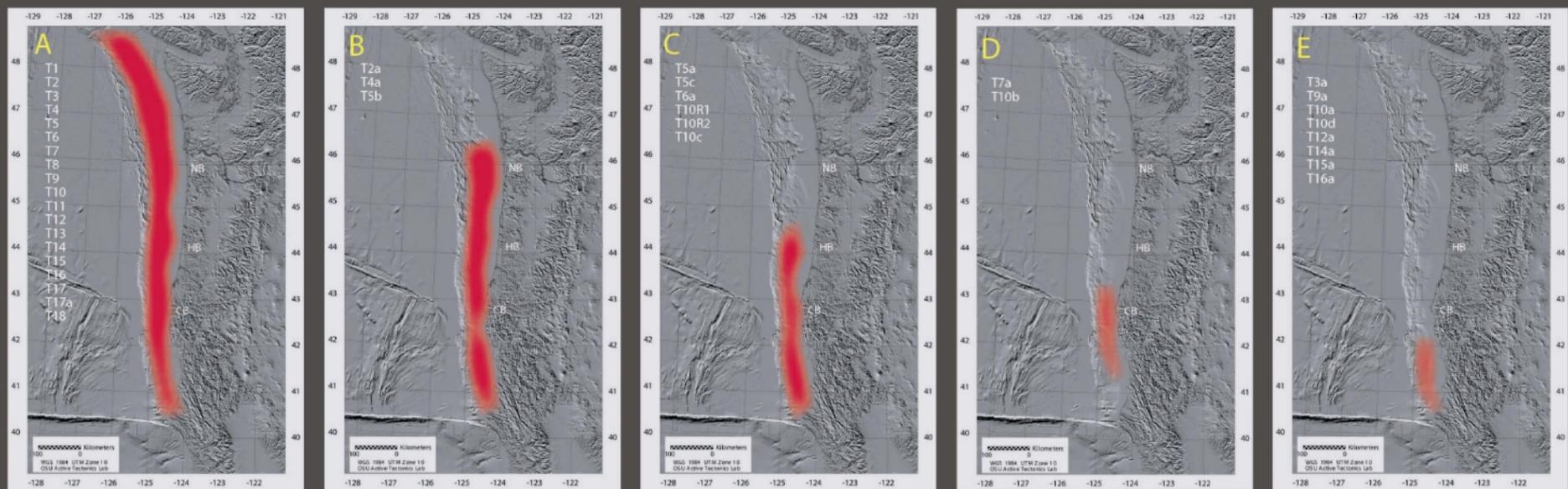
Tsunami Hazard Zone

IN CASE OF EARTHQUAKE, GO TO HIGH GROUND OR INLAND



Timothy J. Walsh
Edward P. Myers III
Antonio M. Baptista

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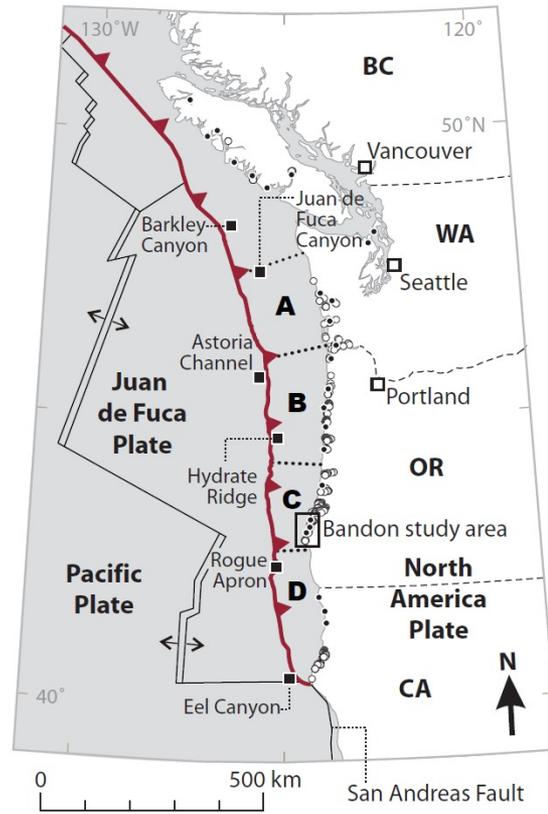


This led them to conclude that 21 turbidites were simultaneously triggered along the entire Cascadia margin, while another 20 or so had shorter spans. This, Adams earlier work, and Atwater's work all led to the conclusion that the full length of Cascadia ruptured, on average, with a 550 yr recurrence interval. Goldfinger et al. further proposed that smaller ruptures occurred between the larger ones and were confined to the south.

From Chris Goldfinger
and others



Witter and others combined data from Goldfinger, from Bandon, and Bradley Lake to infer that some tsunamis over the last 10,000 years had been larger than the one in AD 1700. They constructed hypothetical earthquake scenarios simulated tsunamis, then compared them to these data.



- EXPLANATION
- Seaward edge of subduction zone
 - Seafloor spreading ridge
 - Vertical strike-slip fault
 - Turbidite cores
 - Sand sheets
 - Coastal subsidence

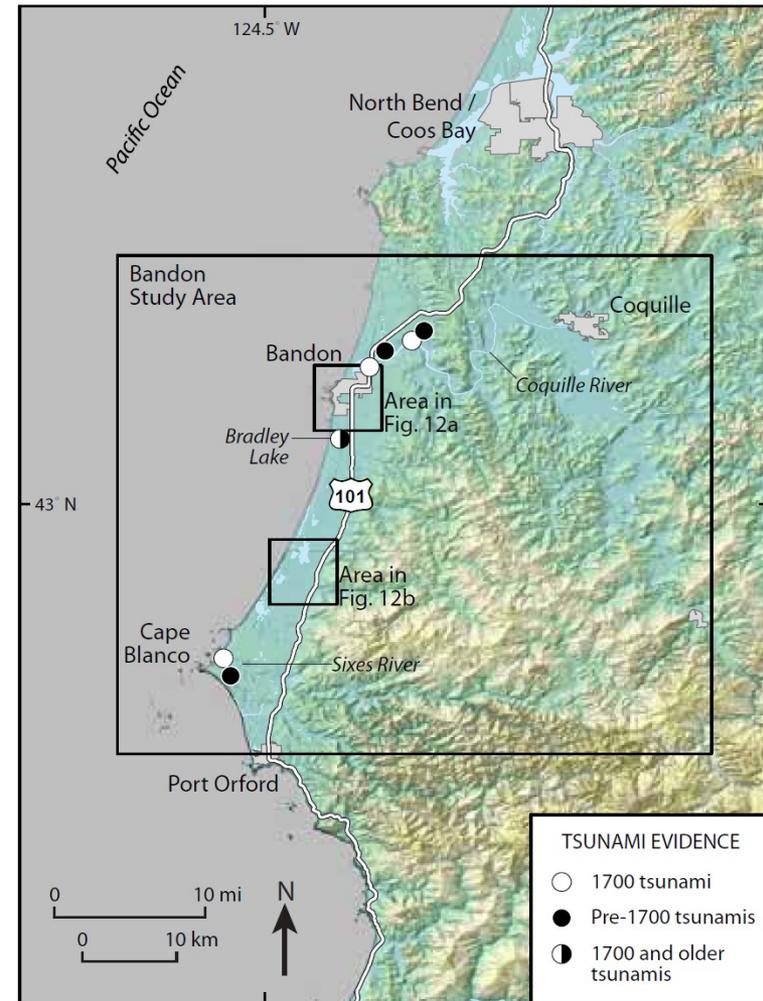


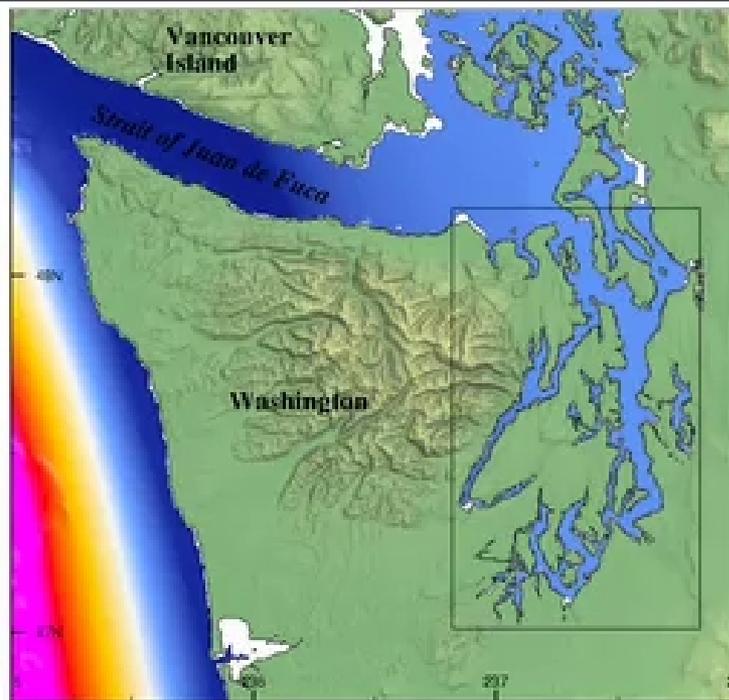
Figure 2. Relief map of the Bandon, Oregon, project area showing locations of human population centers and major coastal rivers. Sites of deposits left by the AD 1700 tsunami are shown by white circles; sites of older Cascadia tsunami deposits are shown as black circles; sites preserving both types of evidence are shown by circles half white and half black.

Table 3. Cascadia earthquake source parameters used to define 15 rupture scenarios. Logic tree branch weights shown in parentheses. Total scenario weight listed in right column.

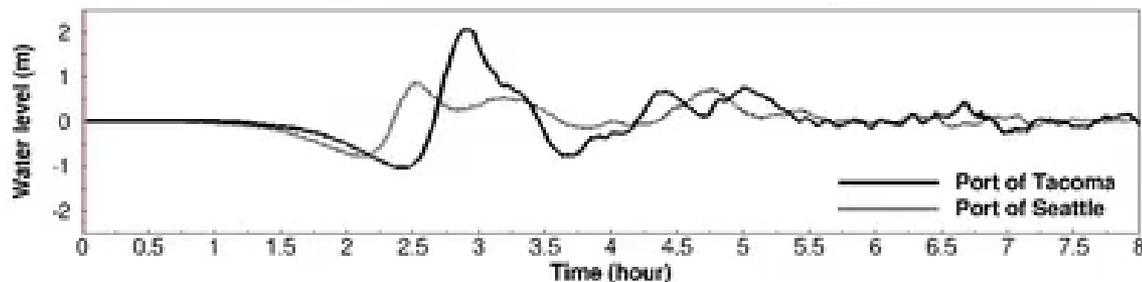
| Earthquake Size | Interevent Time (yrs) | Fault Geometry | Slip Range (m) | | M_w | Scenario Name | Total Weight |
|-------------------------------------|-----------------------|------------------------------|----------------|---------|-------|---------------|--------------|
| | | | Maximum | Average | | | |
| Extra Extra Large (0.025) | 1,200 | Splay fault (0.8) | 36–44 | 18–22 | ~9.1 | XXL 1 | 0.02 |
| | | Shallow buried rupture (0.1) | 36–44 | 18–22 | ~9.2 | XXL 2 | 0.0025 |
| | | Deep buried rupture (0.1) | 36–44 | 18–22 | ~9.1 | XXL 3 | 0.0025 |
| Extra Large (0.025) | 1,050–1,200 | Splay fault (0.8) | 35–44 | 17–22 | ~9.1 | XL 1 | 0.02 |
| | | Shallow buried rupture (0.1) | 35–44 | 17–22 | ~9.2 | XL 2 | 0.0025 |
| | | Deep buried rupture (0.1) | 35–44 | 17–22 | ~9.1 | XL 3 | 0.0025 |
| Large (0.16) | 650–800 | Splay fault (0.8) | 22–30 | 11–15 | ~9.0 | L 1 | 0.128 |
| | | Shallow buried rupture (0.1) | 22–30 | 11–15 | ~9.1 | L 2 | 0.016 |
| | | Deep buried rupture (0.1) | 22–30 | 11–15 | ~9.0 | L 3 | 0.016 |
| Medium (0.53) | 425–525 | Splay fault (0.6) | 14–19 | 7–9 | ~8.9 | M 1 | 0.318* |
| | | Shallow buried rupture (0.2) | 14–19 | 7–9 | ~9.0 | M 2 | 0.106 |
| | | Deep buried rupture (0.2) | 14–19 | 7–9 | ~8.9 | M 3 | 0.106 |
| Small (0.26) | 275–300 | Splay fault (0.4) | 9–11 | 4–5 | ~8.7 | SM 1 | 0.104 |
| | | Shallow buried rupture (0.3) | 9–11 | 4–5 | ~8.8 | SM 2 | 0.078 |
| | | Deep buried rupture (0.3) | 9–11 | 4–5 | ~8.7 | SM 3 | 0.078 |

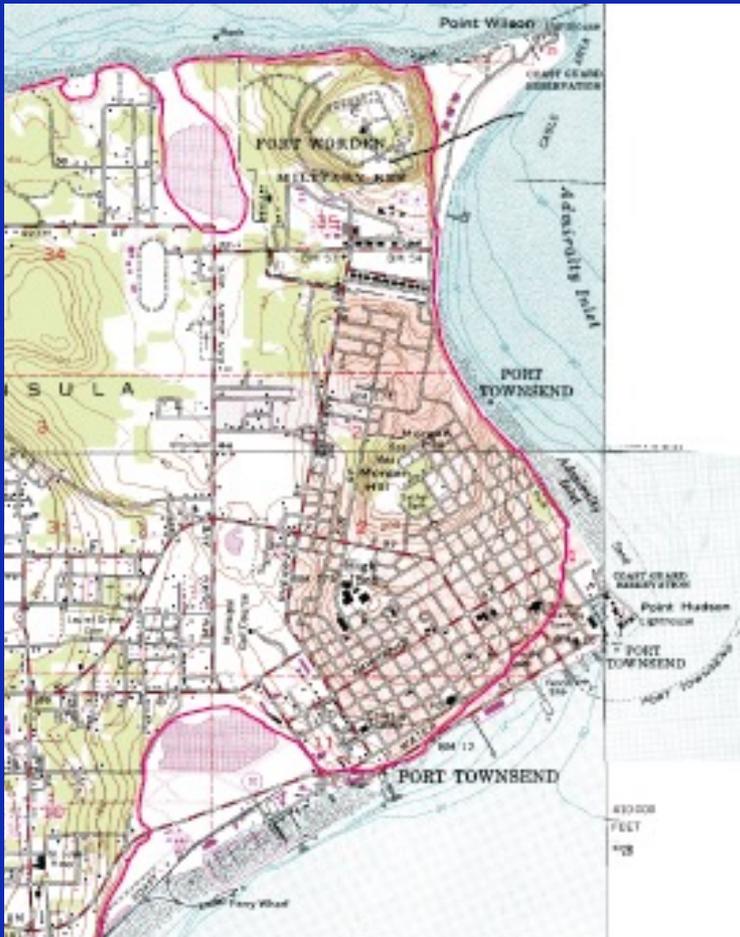
*Scenario M1 carries the highest weight and represents the “most likely” event in our analysis.

The initial condition in the model is the L1 Scenario (Fig. 2) (Witter and others, 2011) which is a splay fault model in which some slip is partitioned into a thrust fault in the accretionary wedge that is subparallel to and with the same sense of movement as the plate interface, resulting in a broader uplift than a simple fault rupture. The land surface at Port Townsend is modeled to subside during ground shaking only minimally or not at all

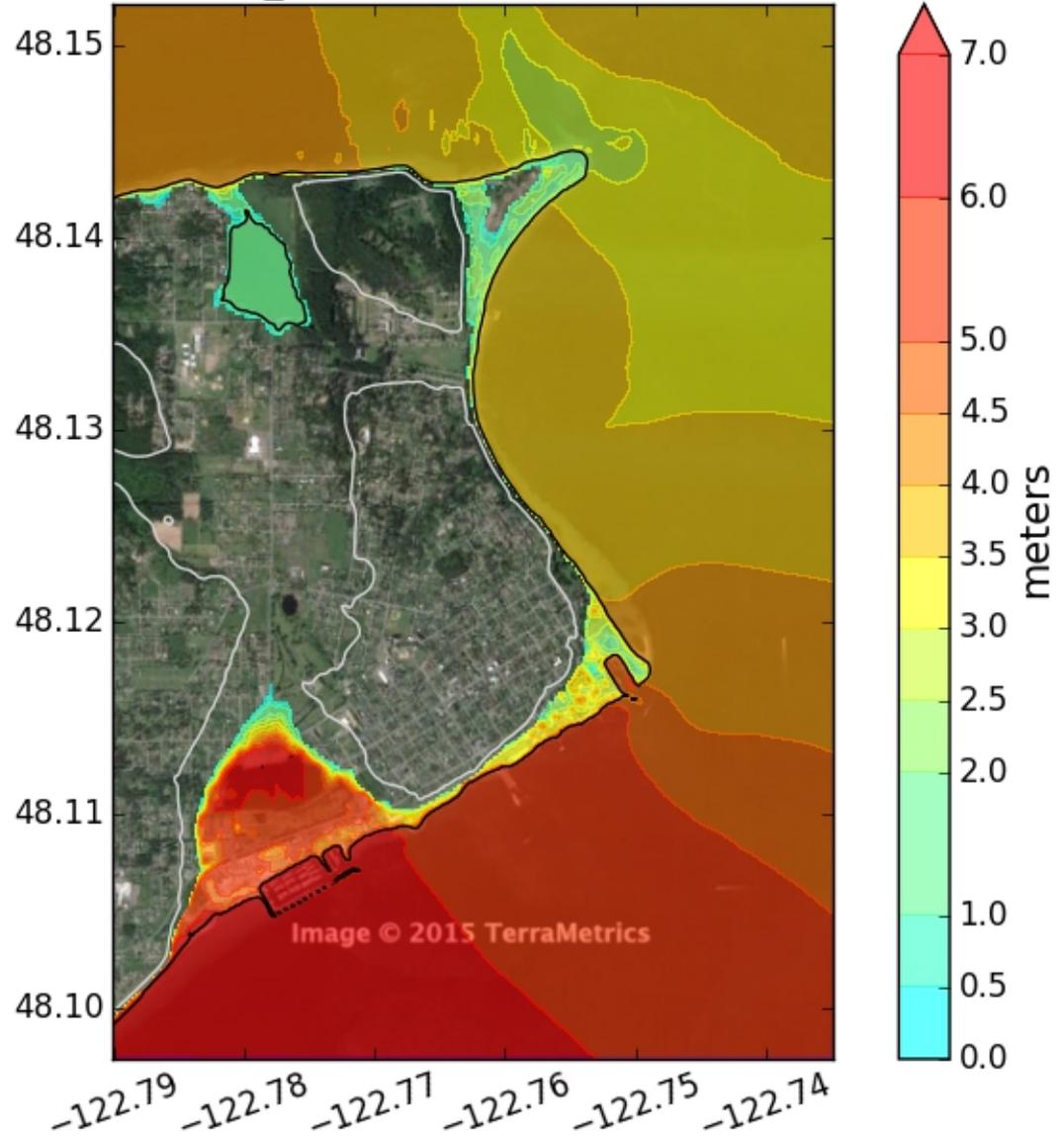


Tsunami impact along the Puget Sound Caused by the M_w 9.0 L1 EQ scenario





Port_Townsend Zeta Maximum

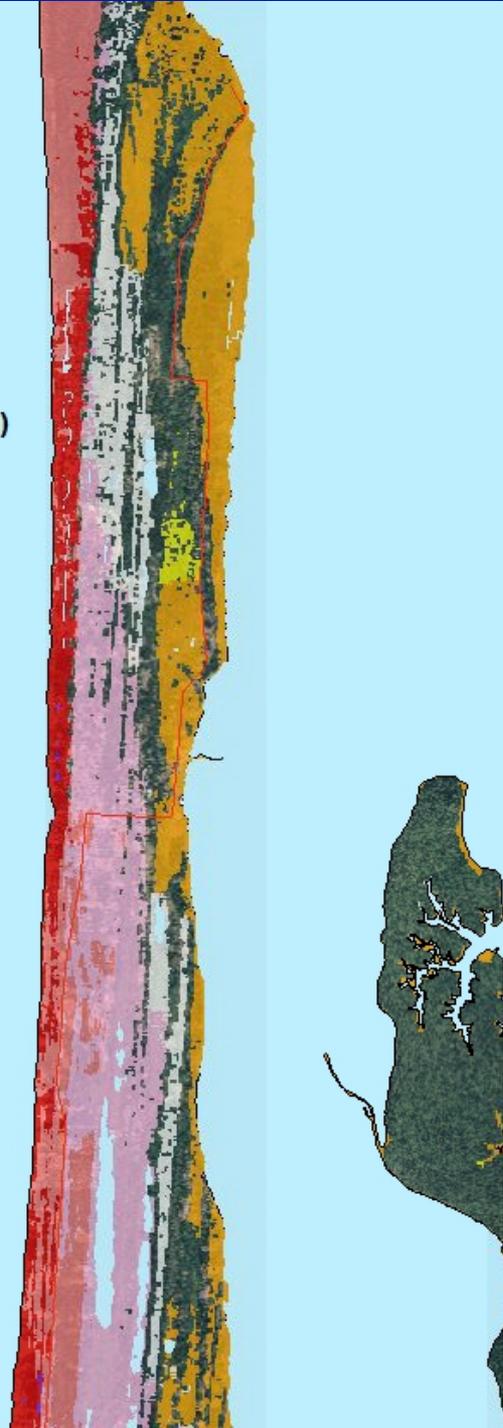
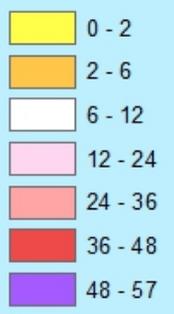


Inundation Depth (ft)

- 0 - 2
- 2 - 6
- 6 - 12
- 12 - 24
- 24 - 36
- 36 - 48
- 48 - 57



Inundation Depth (ft)



Inundation Depth (ft)

