SEAW Reconnaissance
Great Northeast (Tohoku) Japan Earthquake

Jon Siu, PE, SE

Principal Engineer/Building Official

City of Seattle, DPD

Participant Organizations

- City of Seattle
- DCI Engineers, Inc.
- GeoEngineers, Inc.
- Hart Crowser, Inc.
- HNTB Corporation, Inc.
- KPFF Consulting Engineers, Inc.
- MRP Engineering, LLC
- Reid Middleton, Inc.
- Tokyo Institute of Technology


Sendai
Tokyo
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Data © 2011 MIRC/JHA
© 2011 Cnes/Spot Image
Image © 2011 TerraMetrics
©2010 Google
38°41'27.14" N 140°08'20.72" E elev 794 ft
Eye alt 1611.18 mi

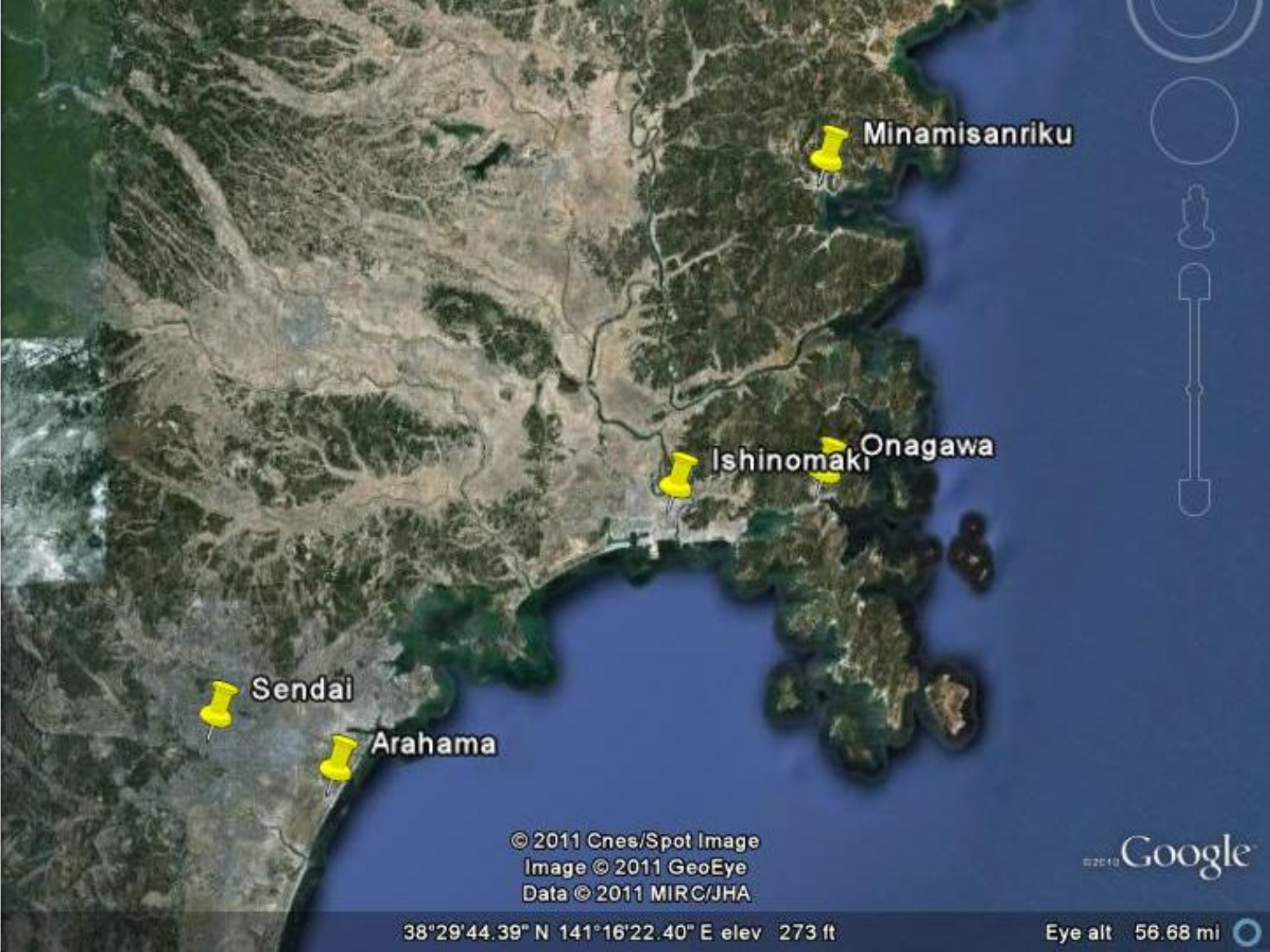
Minamisanriku
Onagawa
Ishinomaki
Sendai
Arahama
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Image © 2011 GeoEye
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Google
38°29'44.39" N 141°16'22.40" E elev 273 ft
Eye alt 56.68 mi

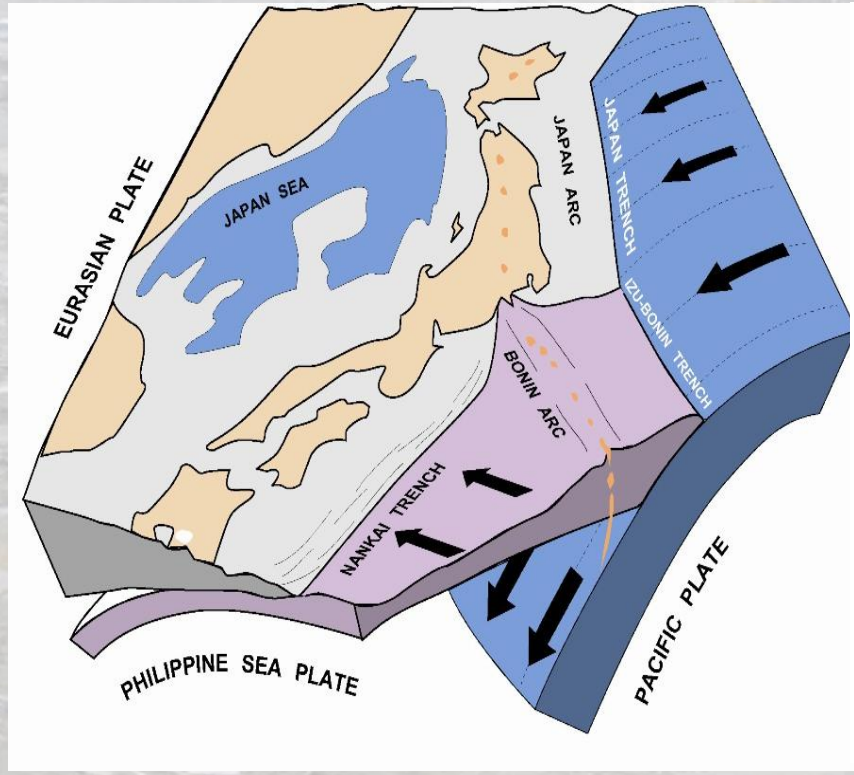
EQ Specifics/Impacts (5/25/2011)

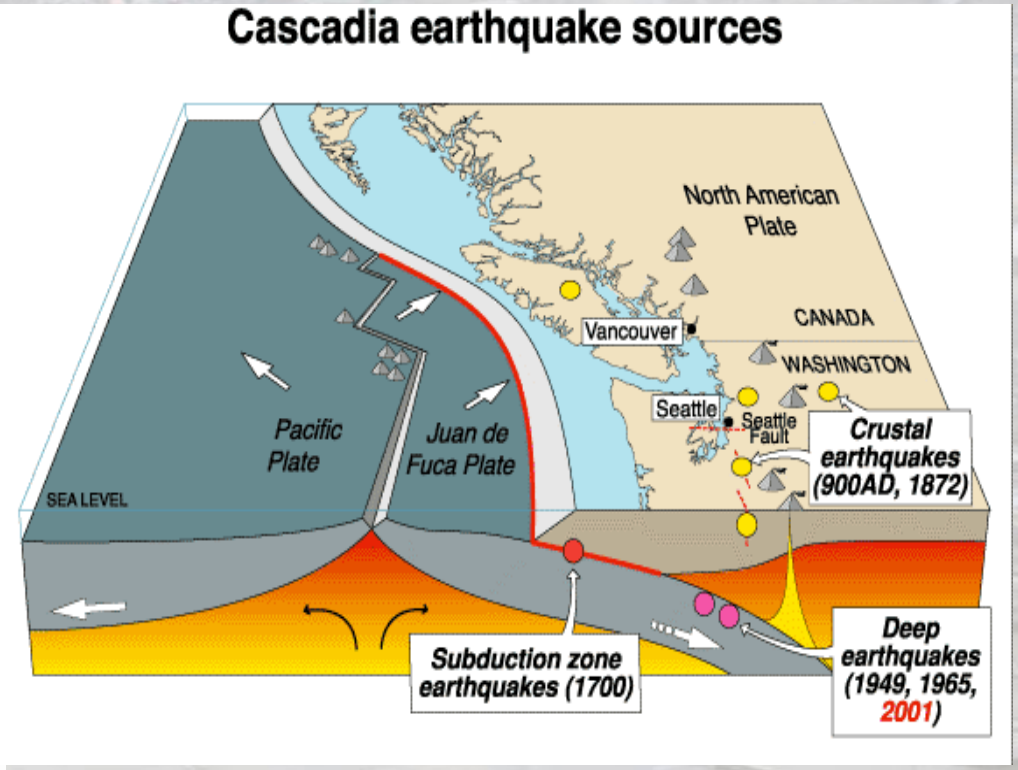
- Friday, March 11, 2011 2:46 pm local time
- Subduction EQ, M9.0
- Up to 5 minutes duration
- Tsunami heights (est.):
  - Port of Sendai – 7.2 m
  - Ishinomaki City – 7.7 m
  - Onagawa City – 14.8 m
  - Minamisanriku Town – 15.9 m
- Largest ever in Japan, 4th largest in world

- Miyagi Prefecture
  - 8,986 deaths
  - 5,243 missing
  - 338 seriously injured
  - 3,056 slightly injured
  - 392 evacuation shelters
  - 27,753 Evacuees
- Total for All of Japan
  - 15,217 deaths
  - 8,666 missing

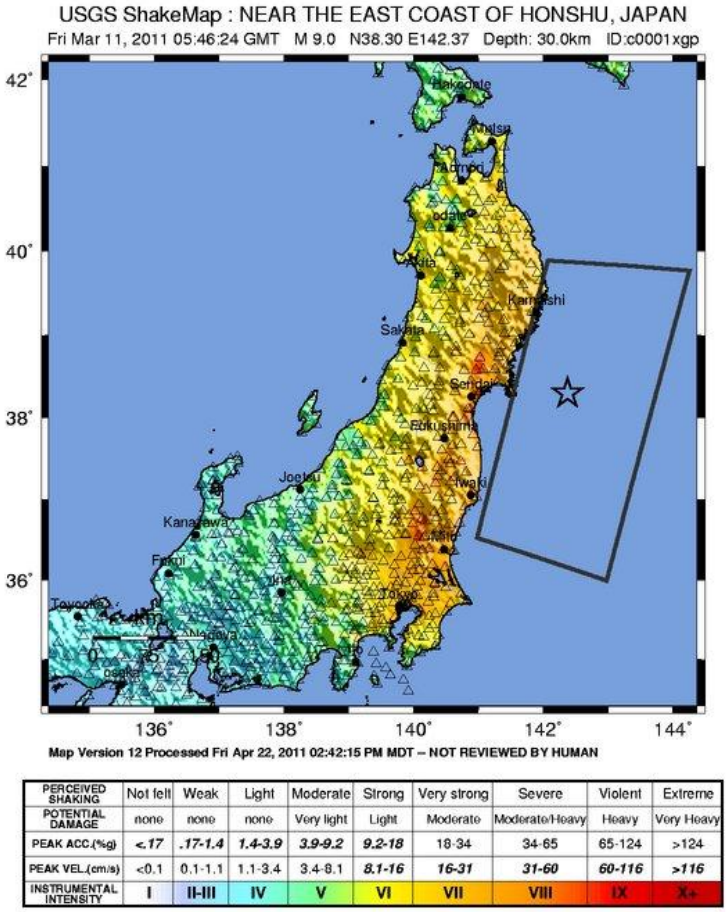
Swanson

Tectonic Setting – Japan vs PNW





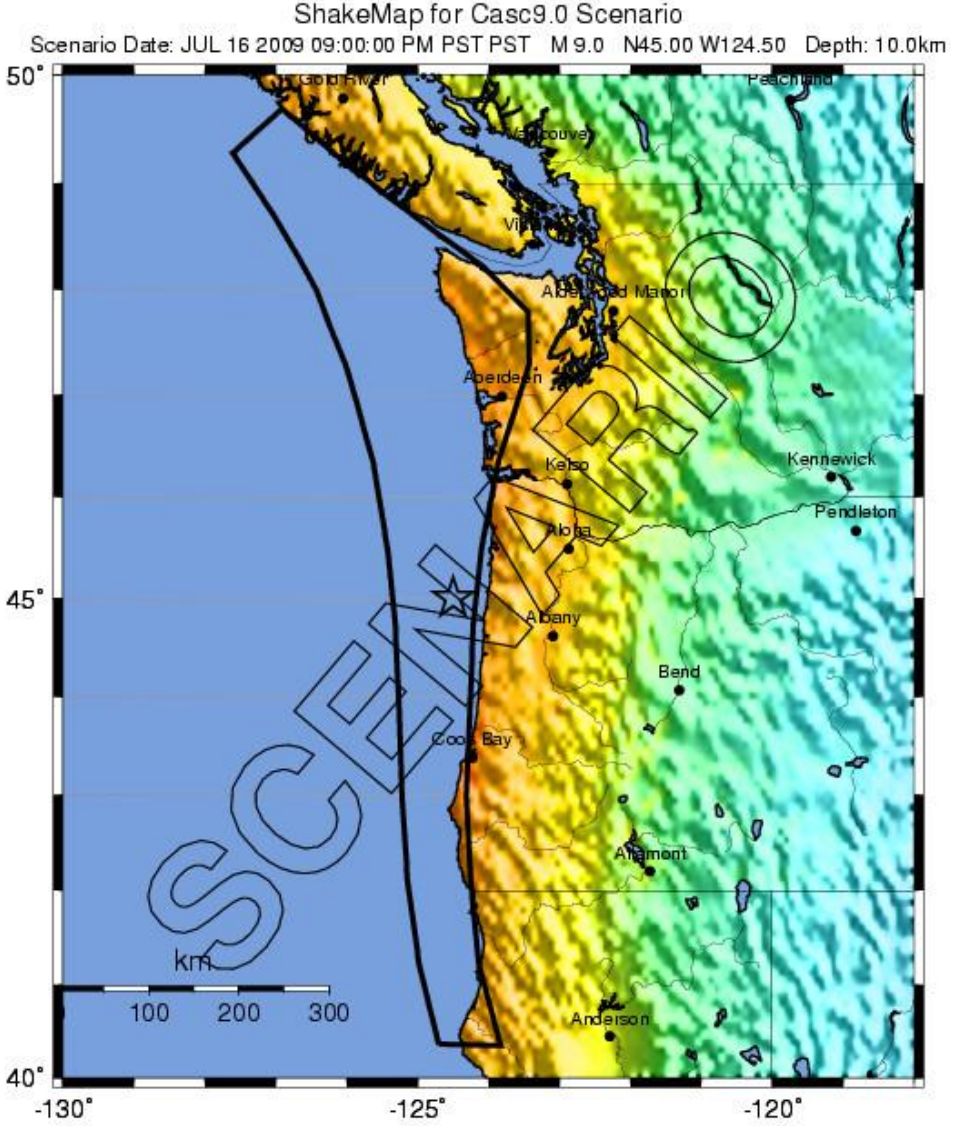
Chin



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+

Table 1. Closest Distance (in km) for Various Cities to Fault Rupture

Japan City	Distance to Fault Rupture (km)	Washington City	Distance to Expected CSZ Fault Rupture (km)
Tokyo	150	Bellingham	153
Chiba	138	Seattle	112
Utsunomiya	111	Tacoma	104
Fukushima	90	Vancouver	91
Morioka	87	Olympia	71
Sendai	75	Port Angeles	56
Iwaki	50	Aberdeen	20



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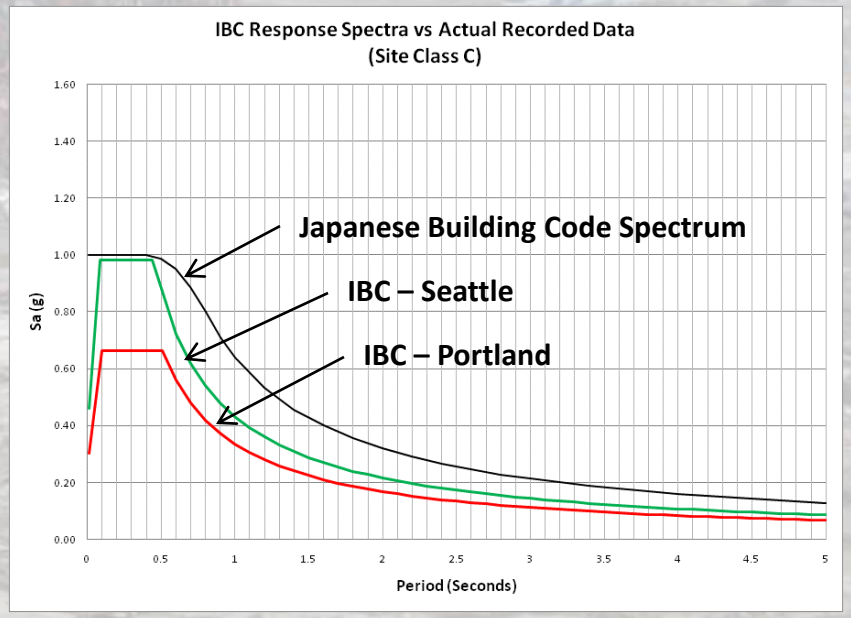
Chin

Code Comparison

- Building codes in Japan and the US consider similar seismic hazard levels and have similar design philosophies for life-safety
- Japan requires "serviceability" check for moderate EQ = increased resilience



Taylor/Chin

Building Performance – Tohoku EQ

- Not a lot of EQ-related structural damage
- Performance of post-1980s buildings was good
  - Unless other issues (e.g., soils)
- Damage to pre-1980's buildings resulted from already-known problems
  - Possible other contributing factors

Protection Technology

- High-tech solutions widely used for new and existing buildings
  - ~3600 commercial bldgs
  - > 3800 single family homes
- Top 5(?) construction companies required to invest % of profits in research/development
  - Kajima: 300 people, $150M/year ($16-18B construction/year)

Retrofitted Buildings

- More common in Japan than US
  - Less concern with architectural impacts
- Retrofitted buildings in Sendai appeared to perform well
  - Example: Sendai City Hall
- Public/owners demand seismic performance

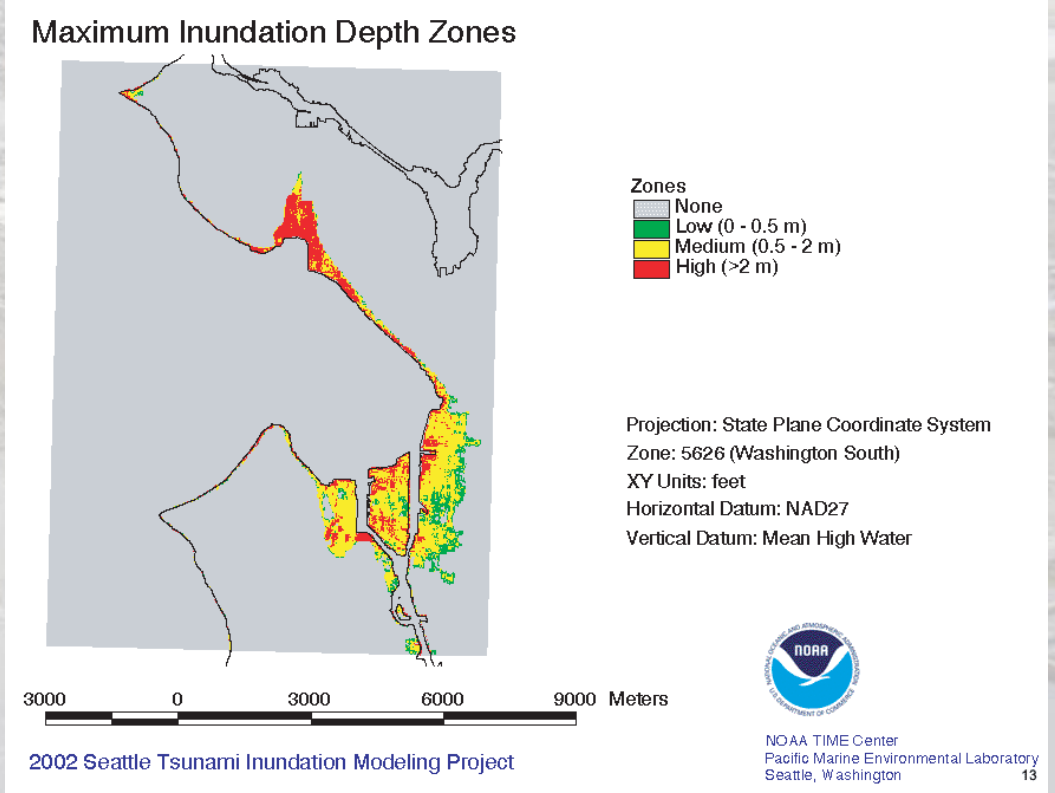
Tsunamis

Minamisanriku Before

Minamisanriku After

Tsunamis in Seattle

- Cascadia Subduction EQ Scenario
  - Not much of an issue
  - 1-2(?) m
- Seattle Fault model
  - Up to 5 m
  - Model based on 7+ m displacement of fault
  - Actual height will depend on amount of displacement



Summary of Observations

- Japan is the most prepared country in the world for both earthquakes and tsunamis
- Seismic retrofit and protection technology works
- Current U.S. building codes and standards for earthquake design are very good for life safety
- Life Safety performance is not enough for earthquake-resilient communities
- An earthquake very much like the Tohoku Earthquake will happen in the Pacific Northwest

What Next for Seattle?

- Mitigation
  - Encourage retrofit of older buildings
  - Decide acceptable level of resilience
    - Life safety or more?
    - Will determine changes to codes
  - Impacts to utilities
    - “High rise refugees”