Overview of Risk Analysis Methods

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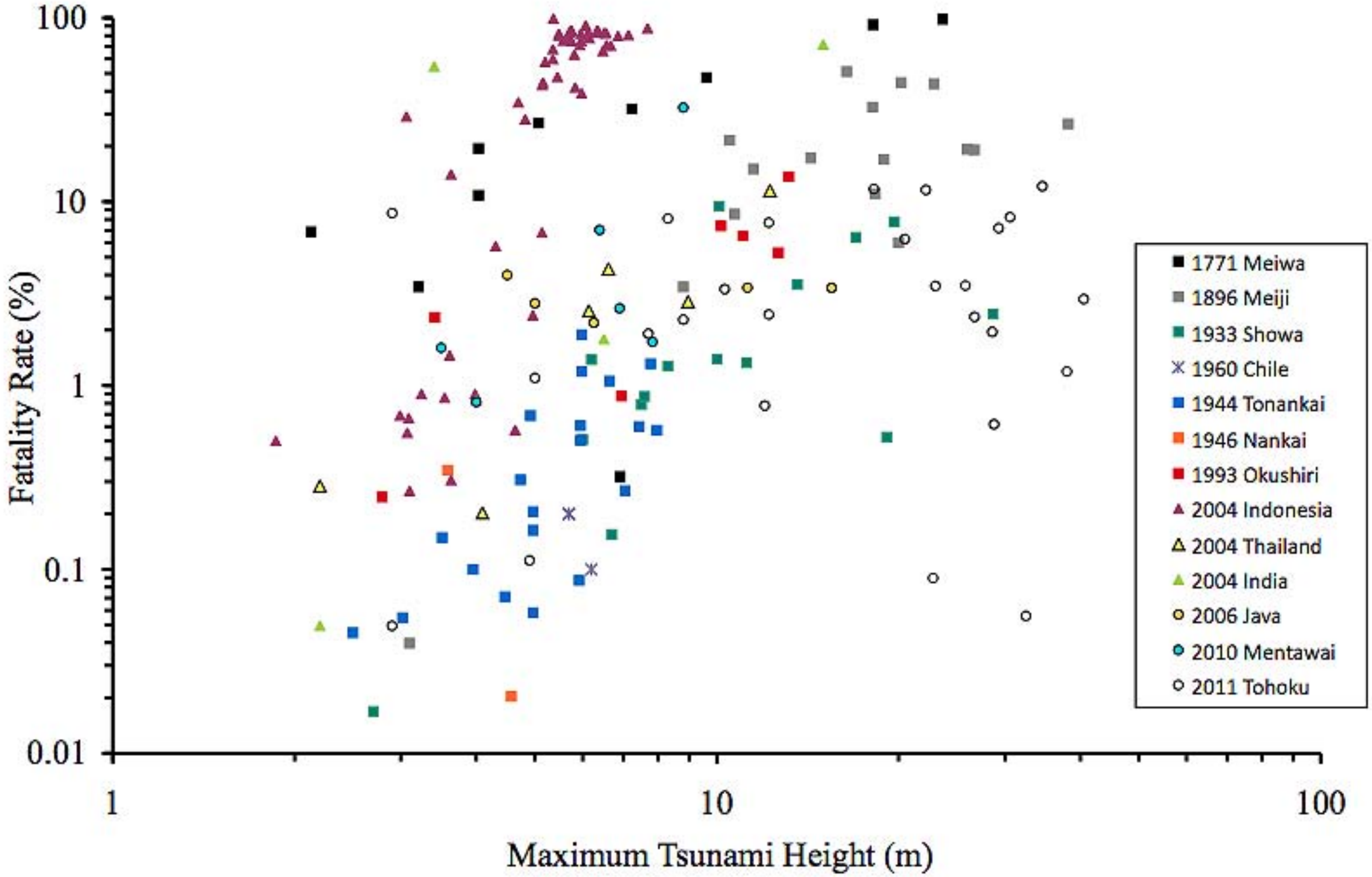
Risk Analysis

- Casualty
  - Effective warning system and predictions.
  - Inundation and evacuation maps: routes and signs.
  - Education for tsunami awareness.
- Structure Damage
  - Seawalls; breakwaters; watergates.
  - Tsunami evacuation buildings.
  - Critical coastal facilities.
- Lifelines and Debris

Estimation of Tsunami Casualty

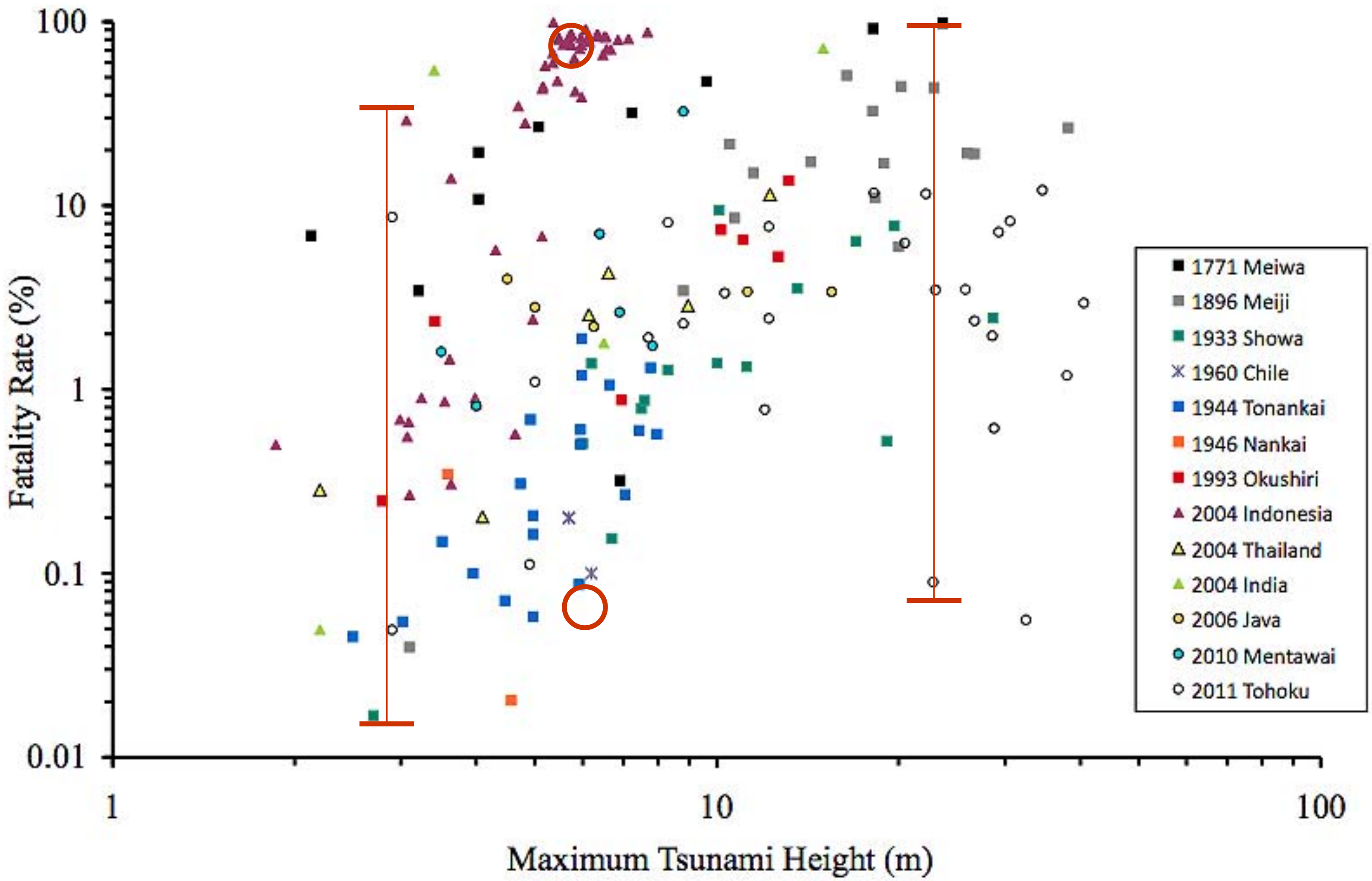
Indication from the Statistics

The comprehensive data compiled by Suppasri et al. (2011).



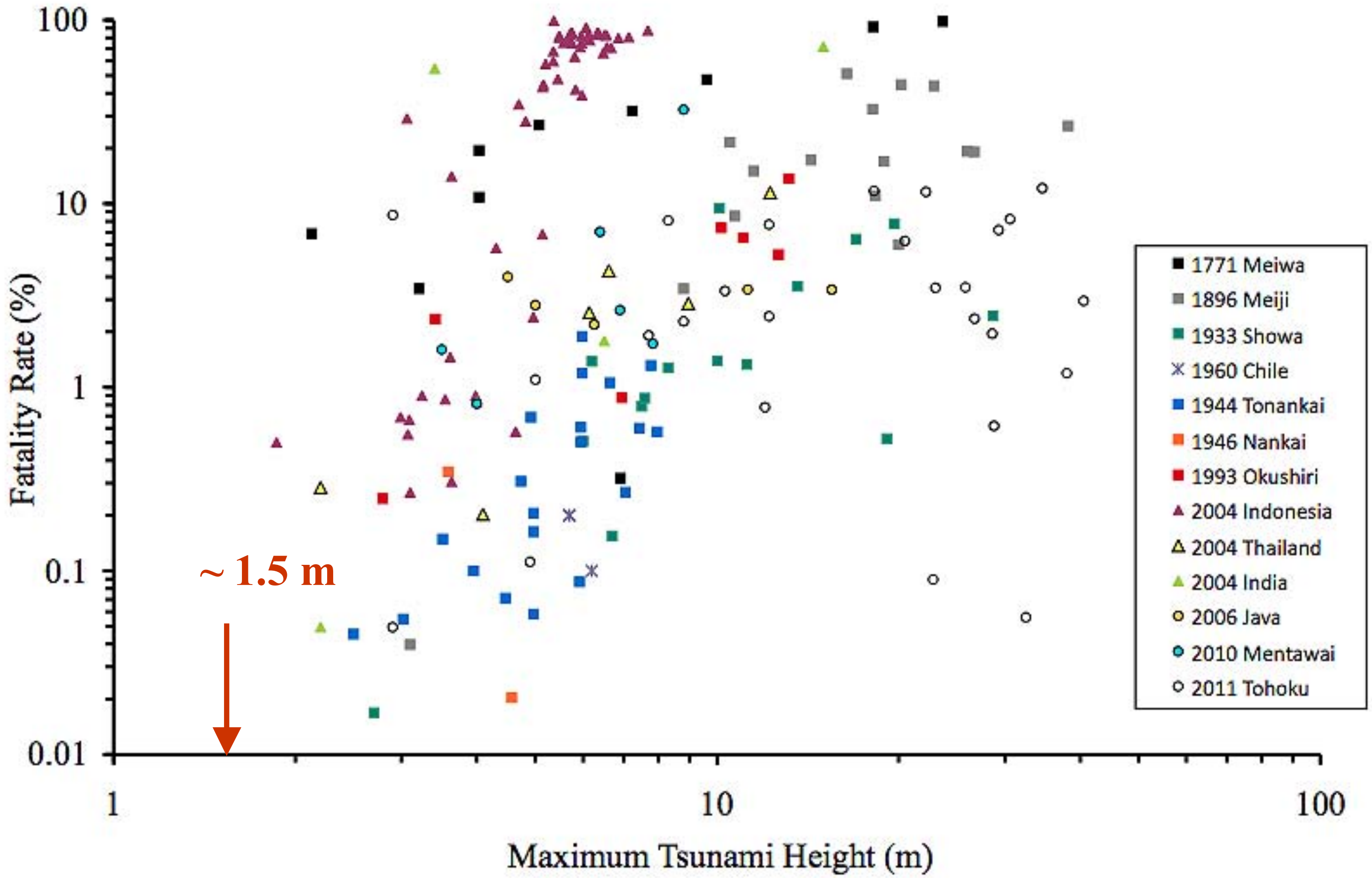
Indication from the Statistics

It is evident that tsunami's flow condition is not the controlling factor for fatality **rate**.



Indication from the Statistics

Only trend that we can detect from the figure is that tsunami fatality rate diminishes when maximum tsunami “**height**” is less than, say 1.5 m. No other correlation can be found.



What Determines Tsunami Casualty Rate?

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Pacific County, WA: after Wood and Schmidtlein (2011)

HAZUS-MH/Tsunami

The following temporal and spatial information are crucial:

a) Warning time including the natural cue.
b) Tsunami arrival time.
c) Time to the maximum runup.
d) Evacuee travel times depending on age, gender, and other human factors

People in a given block spreads depending on individuals’ decision to commence evacuation: how individuals react to the warning.

During evacuation, the evacuees further spreads depending on individuals’ walking speeds (the effect of evacuee travel time).

Casualty (Fatality and injury) rates are determined by what portion of the initial population remains in the inundation: the maximum and the water-depth contours (x-m) at the maximum penetration.

The number of casualty is computed by the rate times the population.

Analysis for Structural Damage

Analysis for Structural Damage

- It may be unrealistic in the US to construct large tsunami seawalls or breakwaters to protect every coastal community.
- Yet, we still need to consider tsunami resistant design and construction for **critical coastal structures**.
    - Hospitals,
    - Major ports and facilities,
    - Critical coastal bridges,
    - Oil and natural gas storage facilities,
    - Emergency tsunami evacuation buildings,
    - Coastal power plants.
    - **Essential military facilities**
    - **Nuclear power plants**

Critical Coastal Infrastructures and Facilities

Coastal Nuclear Power Plants are Critical Facilities

Diablo Canyon

San Onofre

Critical Coastal Infrastructures and Facilities

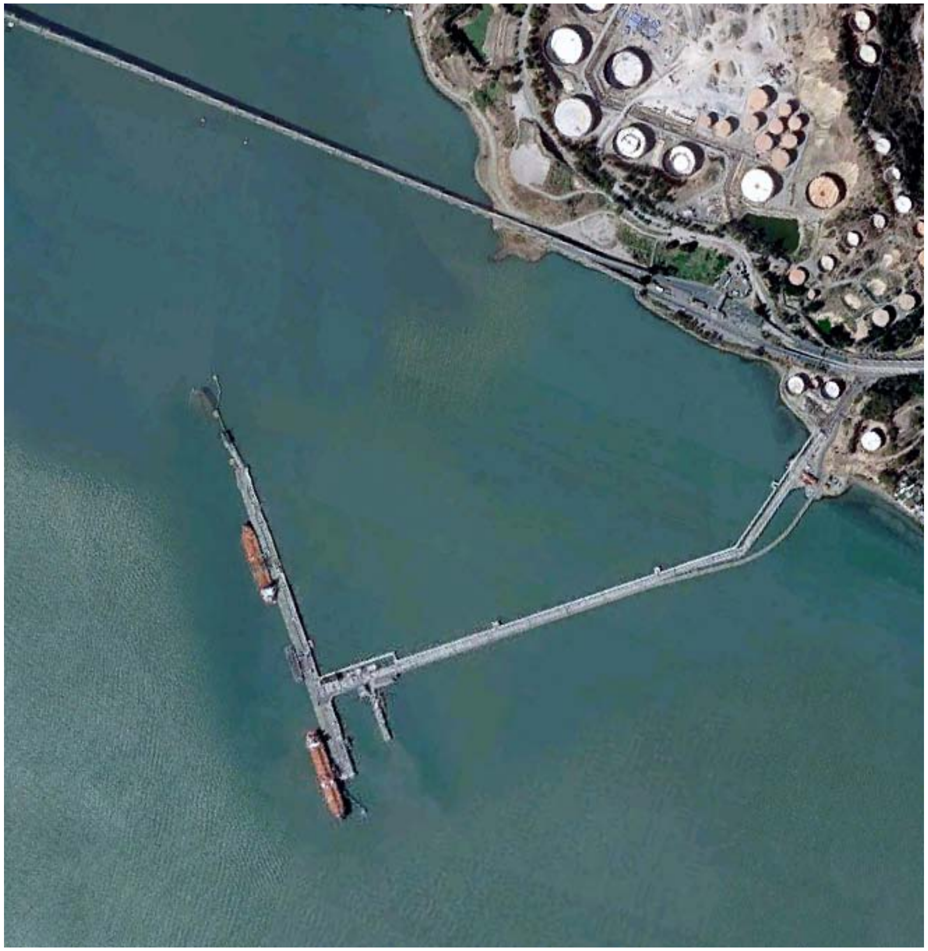
US Navy Bases are Critical Facilities

San Diego

Bangor

Critical Coastal Infrastructures and Facilities

Oil and LNG Berth and Storage are Critical Facilities



Point Richmond

Anacortes

Critical Coastal Infrastructures and Facilities

Kesen-numa

Scenes of the Japan Tsunami one day after

Ishinomaki

Photos by Satake: March 12, 2011

Some Extra Considerations for Estimation of Structural Damage

The March 2011 East Japan Tsunami: Onagawa

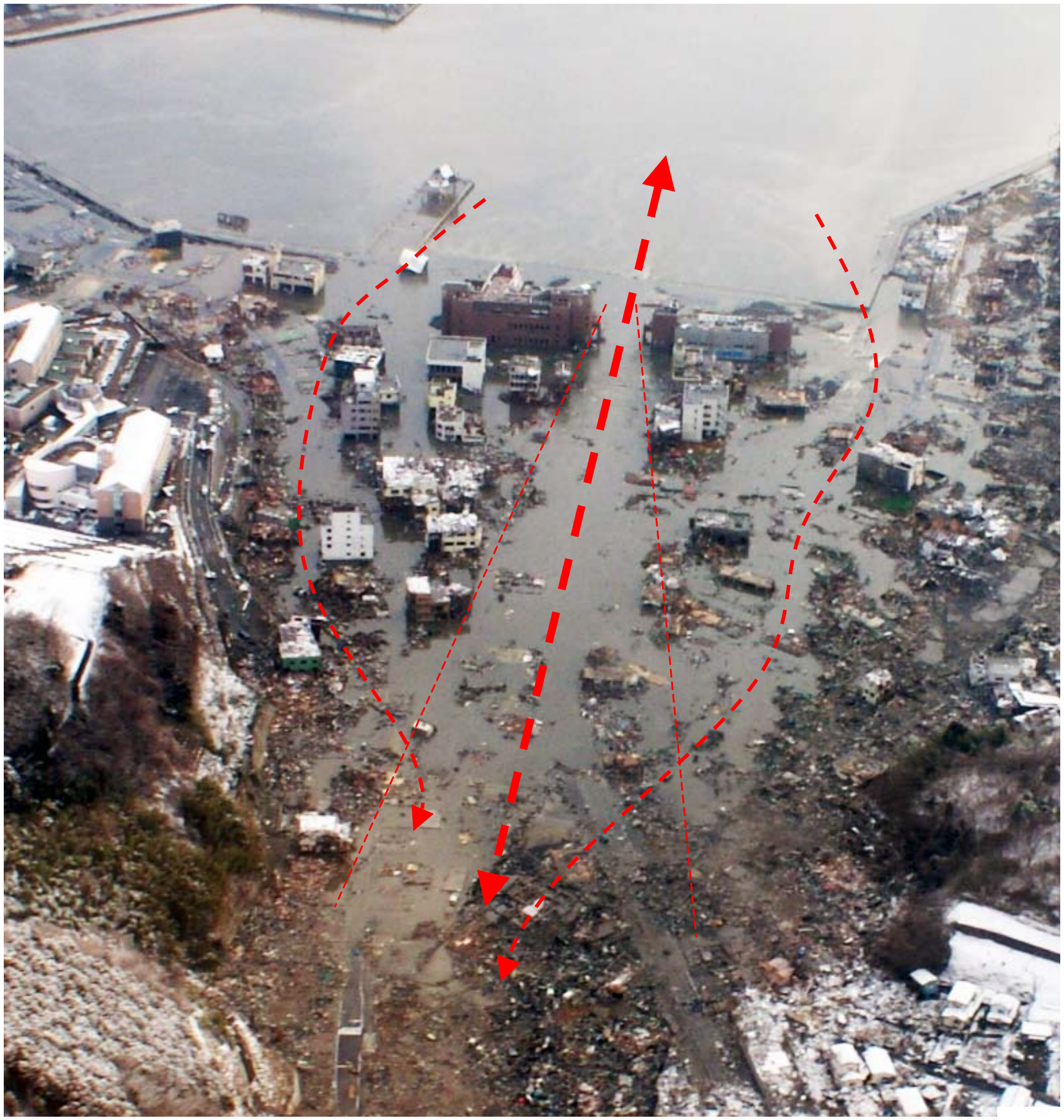


Photo by Satake: March 12, 2011

Tsunami impacts are significantly affected by the surroundings.

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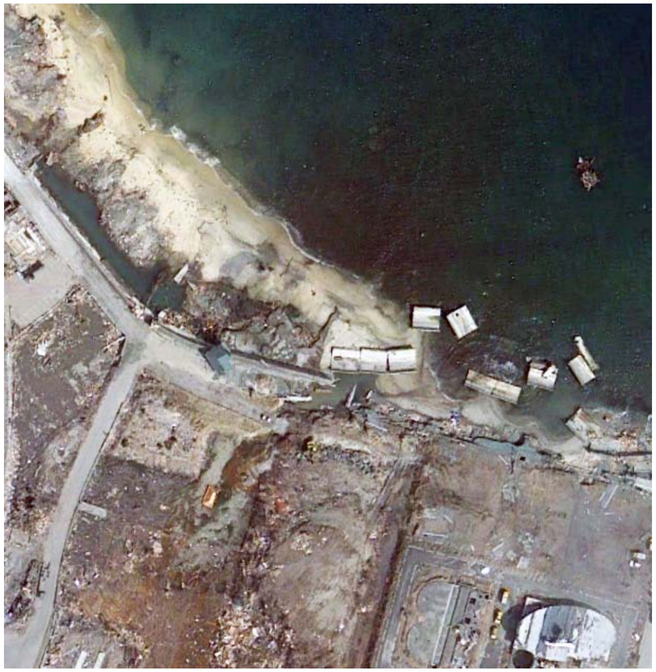
This resembles engineering considerations for wind loadings on high-rise buildings.

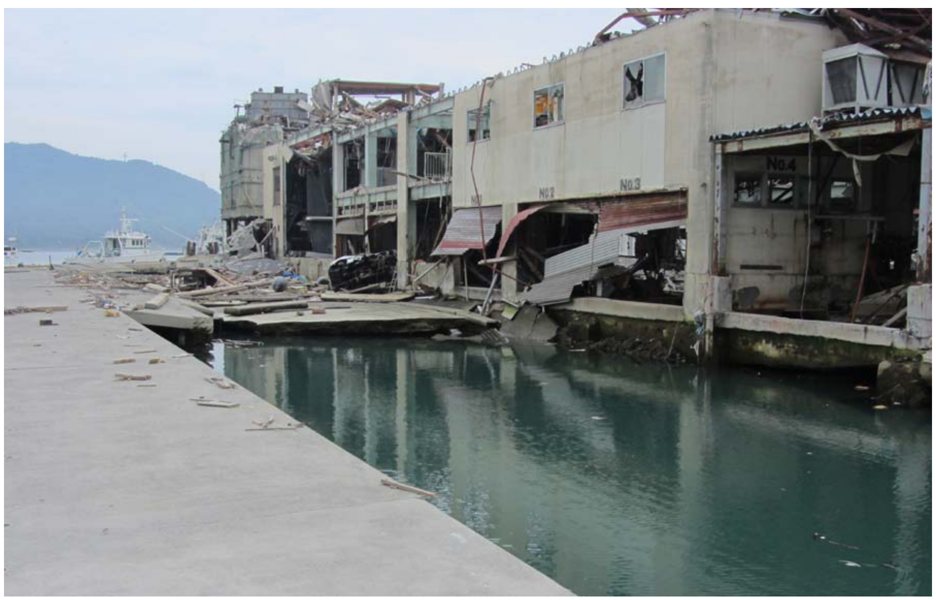
The 2011 Tohoku Tsunami



39°22’15.4”N 141°56’45.0”E

Kirikiri: R_{max} = 16.2 m

The 2011 Tohoku Tsunami



38°26’28.5”N 141°26’53.5”E

Onagawa

Soil instability is an important factor to evaluation structural damage.

Rapid Rescue Response and Recovery

Rapid Response and Relief Mission are Critical

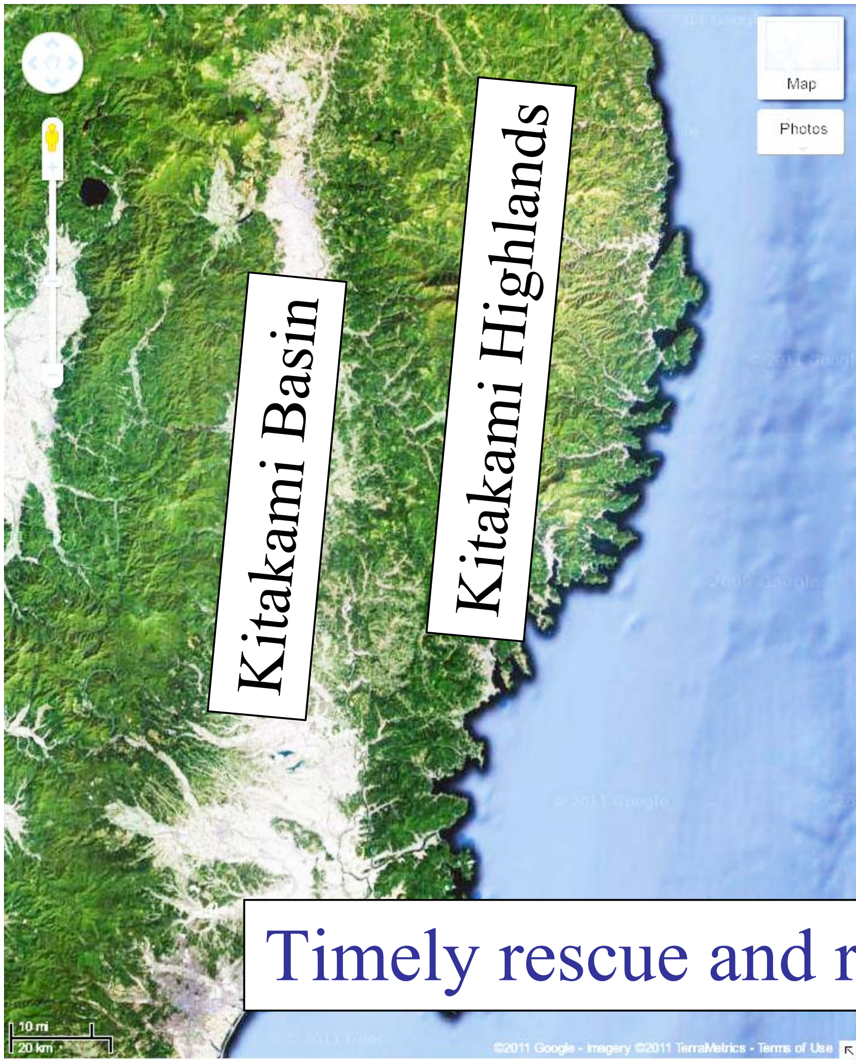
The 2011 Tohoku Tsunami

No water, no food, and no heat and blankets for more than one week!

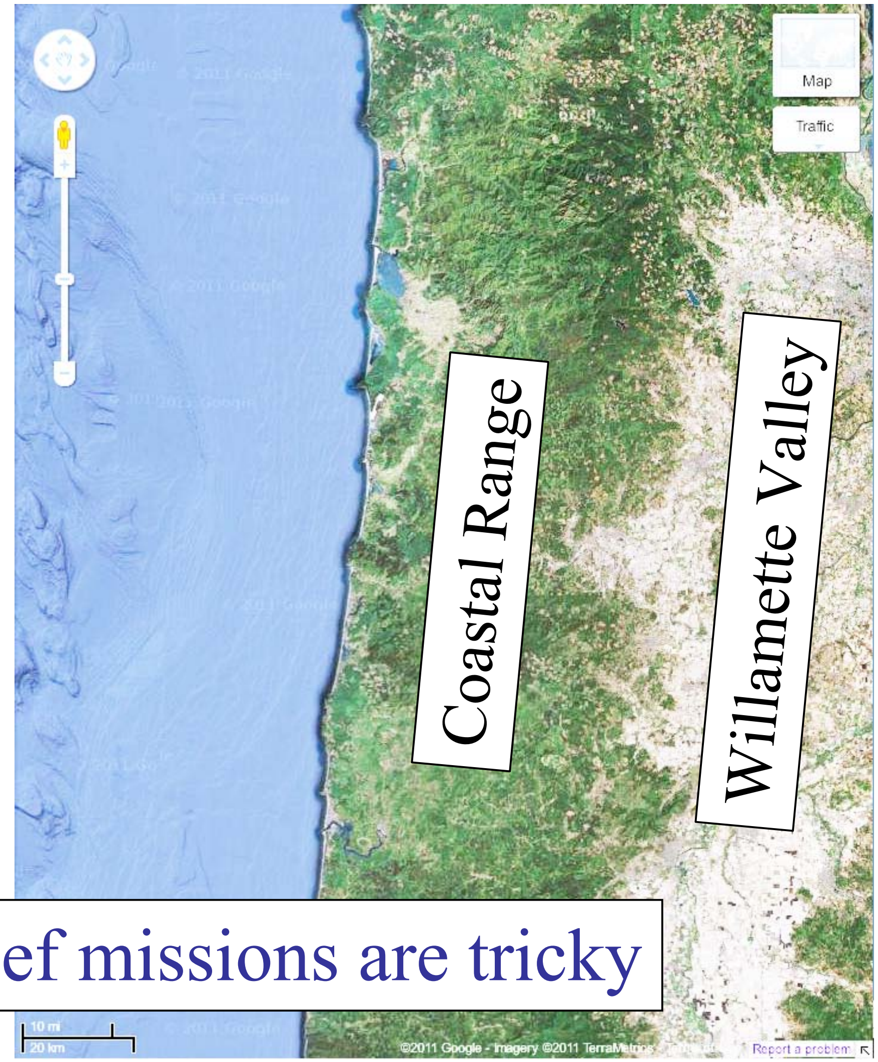
- Rugged mountain geography and the affected areas spread along the coasts.
- Lack of gasoline for automobiles.
- Lack of communication means.
- and more.

Similarity between Sanriku and Oregon Coasts

Sanryiku Coast, Japan



Oregon Coast



Timely rescue and relief missions are tricky

Debris Deposits Affect Rapid Response and Relief

Debris accumulation near the maximum penetration that can block roads, causing the delay of rapid rescue and relief missions.

Washed-away debris offshore blocking the rapid relief mission from the sea.

Scenes in the morning of March 12, 2011: Photo by Satake

Comments on Tsunami Risk Analysis Methods

- Strategic plans for rapid rescue response and recovery mission. Ground subsidence/uplift; debris/sediments accumulations; identification of the critical facilities: what are the critical?
- Tsunami actions affected by the local features (both man-made and natural).
- Soil instability caused by a combination of strong ground shaking and subsequent tsunamis → development of tsunami geo-hazard map.
- Consider multiple tier risk analysi methods
  a) General coastal community
  b) Important facilities: e.g. hospital, bridges, water-supply systems, communication stations.
  c) Critical facilities and structures: e.g. class-1 structures in nuclear power plants, essential military facilities → probable maximum analysis based on the physics.

Tsunami Risk Analysis Methods

- Close Link to Other Tsunami Mitigation Activities
  - o ASCE 7: Minimum Design Loads for Buildings and Other Structures – Tsunami Loads and Effects. In progress (Gary Chock)
  - o FEMA P646 (2008): Guidelines for Design of Structures for Vertical Evacuation from Tsunamis. Currently being revised (Ian Robertson)
  - o HAZUS-MH Tsunami Methodology. Currently in the development stage.
  - o Direct collaboration with Japanese counterpart (JMA, PARI, MILM): important to obtain lessons learned from the 2011 event.
- Promote Scenario Simulation Exercises: a series or workshops in early 2000's.
- Develop the methods designed for Community Based Risk Management.