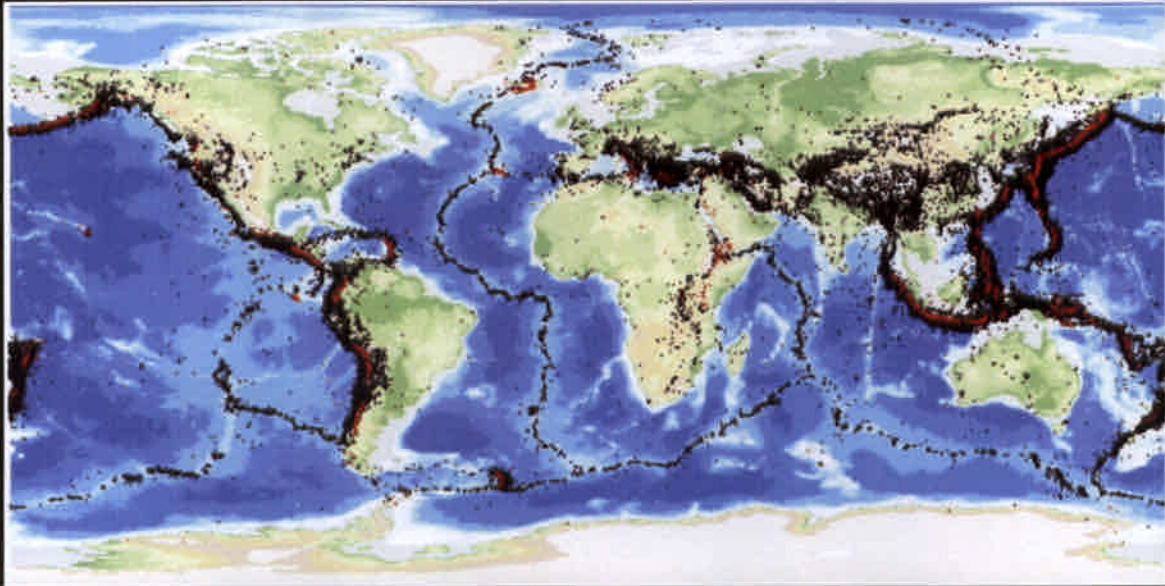


Question

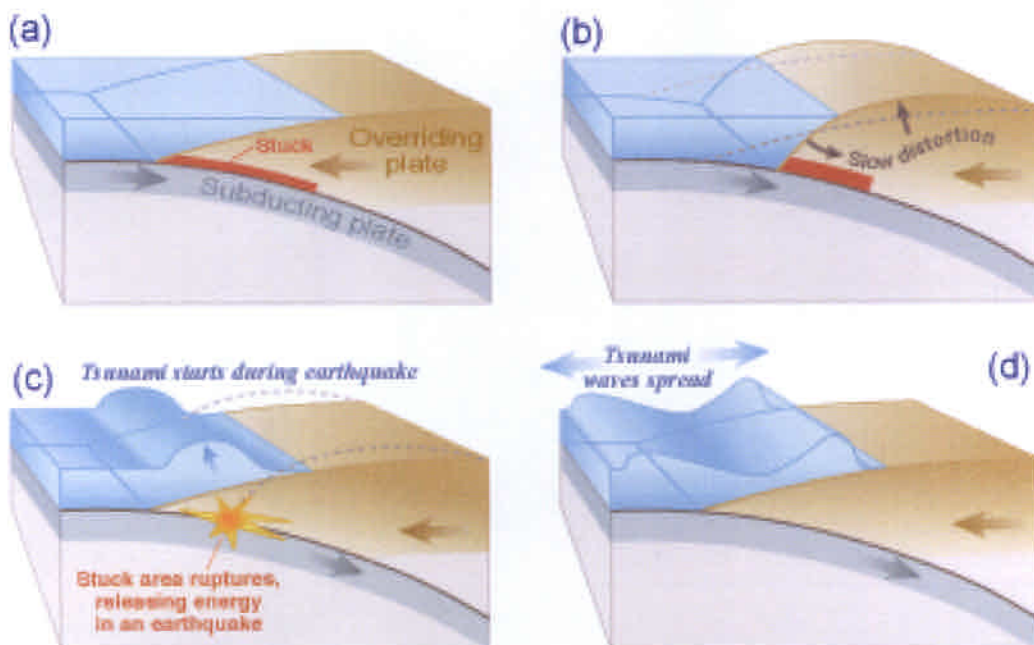
Is it possible to survive
from tsunami ?

Earthquakes in the world



Source : British Geological Survey

Tsunami generation



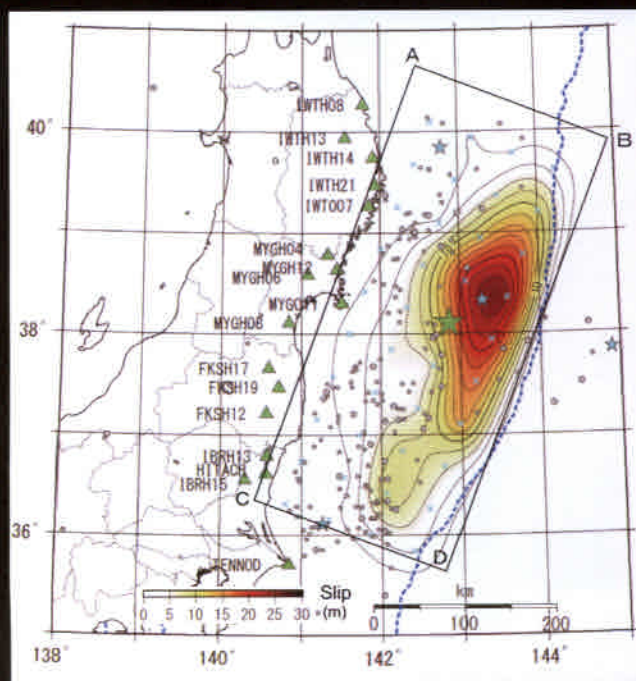
Atwater et al., 1999

Tsunami generation



2:46 PM, 11 March 2011 (JST)

The 2011 off the Pacific Coast of Tohoku Earthquake (M9.0)



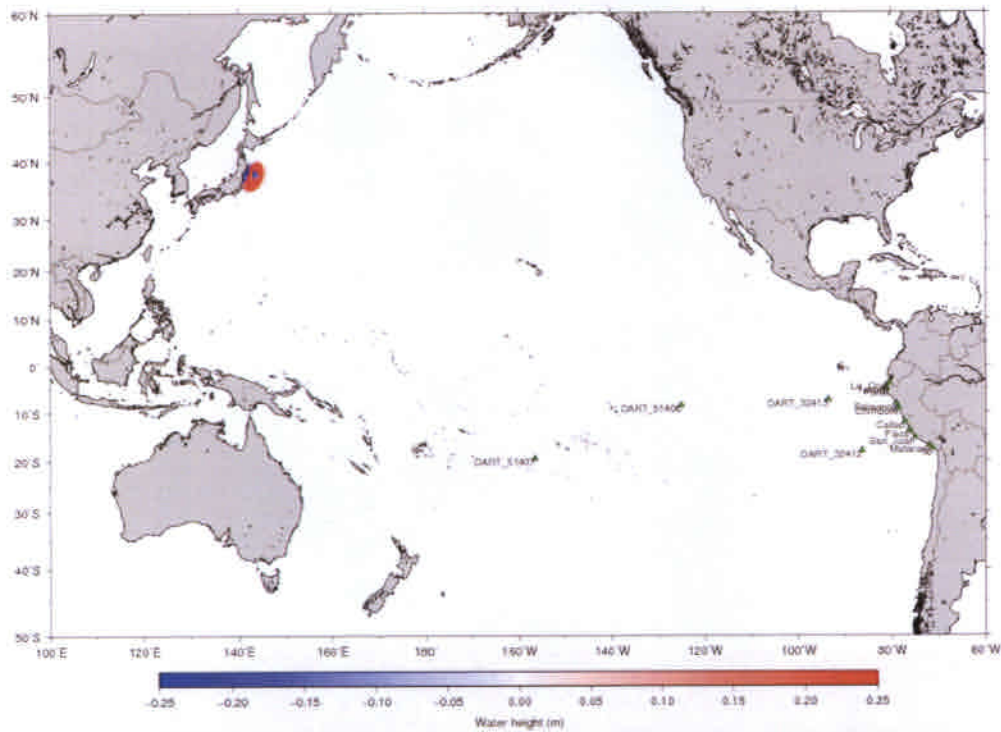
Source :JMA



Source : Headquarters of Earthquake Research Promotion

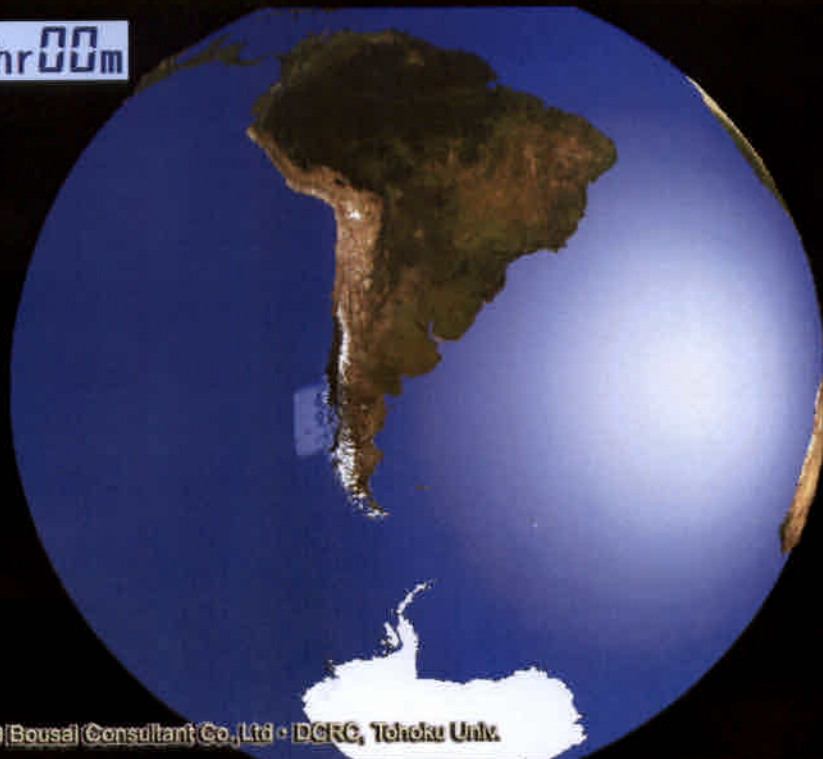
Tsunami has no borders

2011 Japan Earthquake 0010 min



Tsunami has no borders

0hr00m



©2009 Bousai Consultant Co., Ltd. • DCRE, Tohoku Univ.

Tsunami has no borders



The 2011 Tohoku Tsunami



The 2011 Tohoku Tsunami



12 March 2011



Damage Summary

❖ **Fatality**

- 15,781 people were killed, and 4,086 people are still missing (nation wide).

❖ **Structural damage**

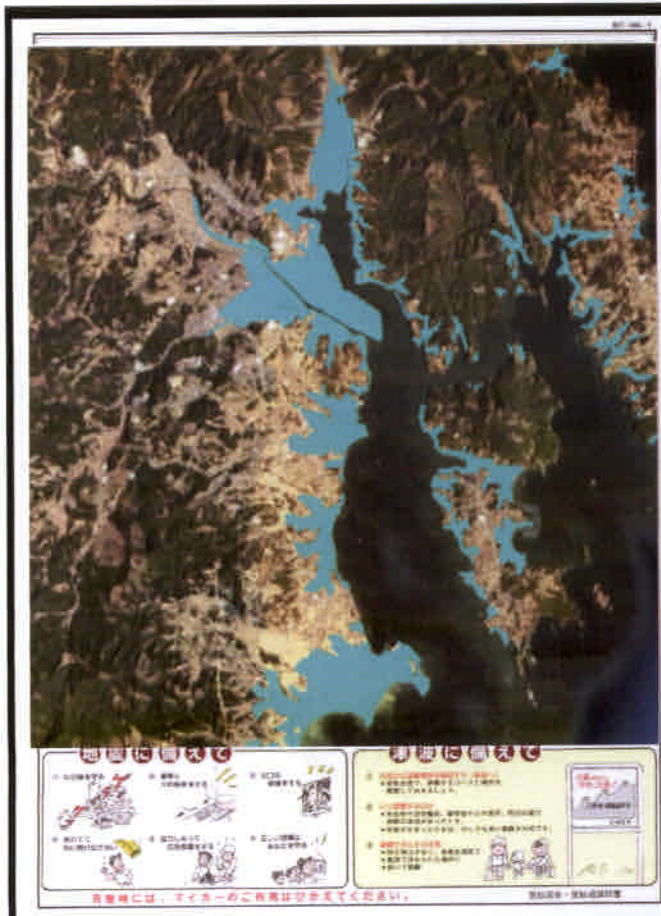
- Washed-away/Collapsed buildings were up to 115,151.

❖ **Tsunami debris**

- 23 mil. ton, 80% removed.

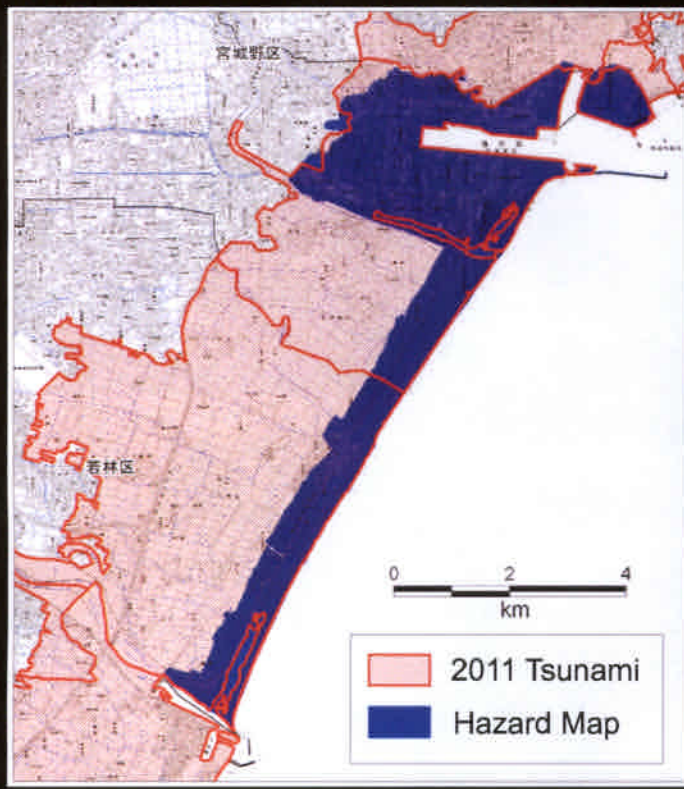
❖ **Economic losses**

- 16 to 25 trillion JPY, ¼ of annual budget of Japan.



***Kesen-numa
Fatality : 1467***

The tsunami was far more extensive than expected



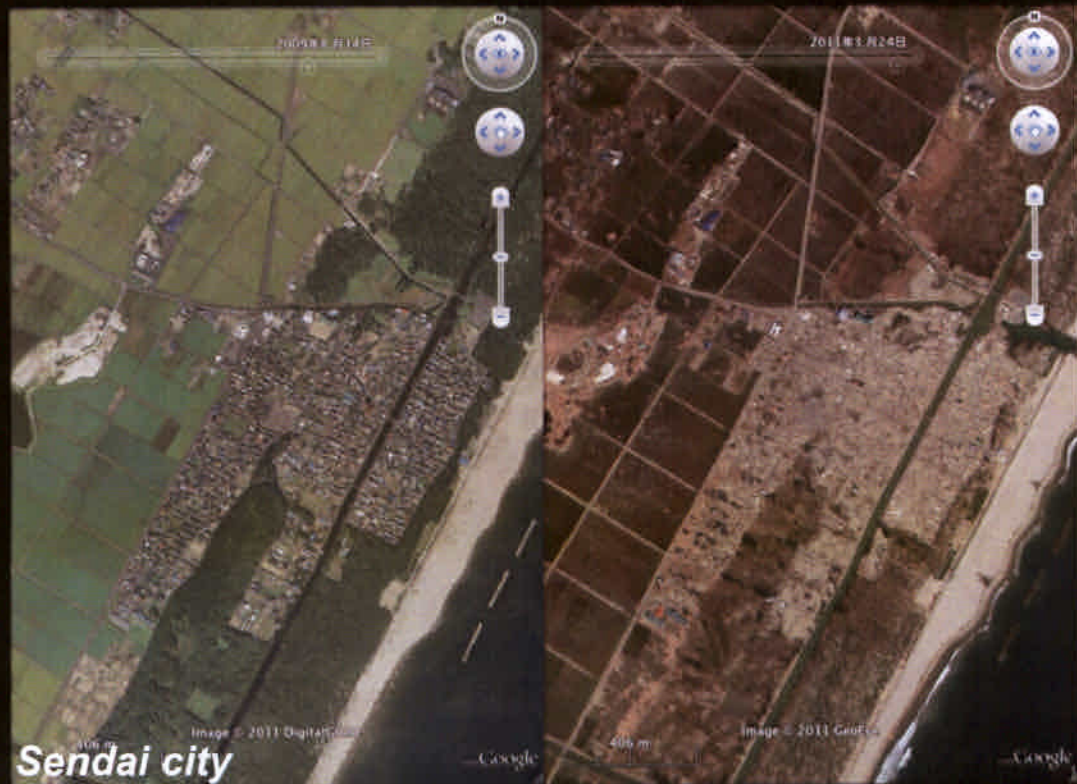
Sendai
Fatality : 755



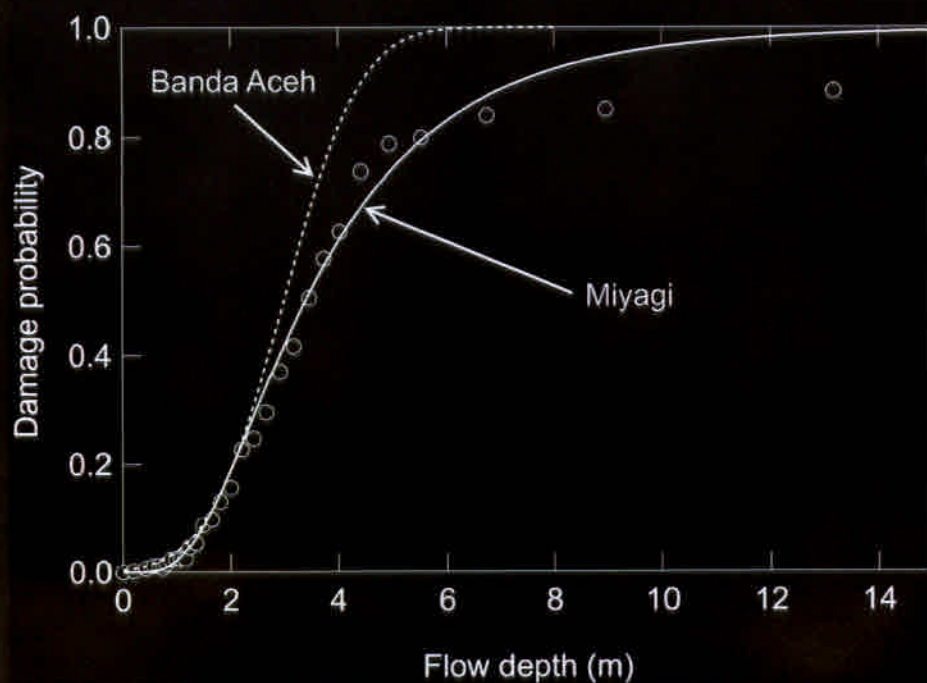
Lesson

There are two aspects of meaning in hazard maps...

Devastated coastal communities



Tsunami fragility curve



Lesson

Over 2 m tsunami flow depth potentially causes severe damage on houses or may devastate.

High-rise/robust reinforced concrete buildings can withstand and be used for vertical evacuation. But the regulation should be revised.

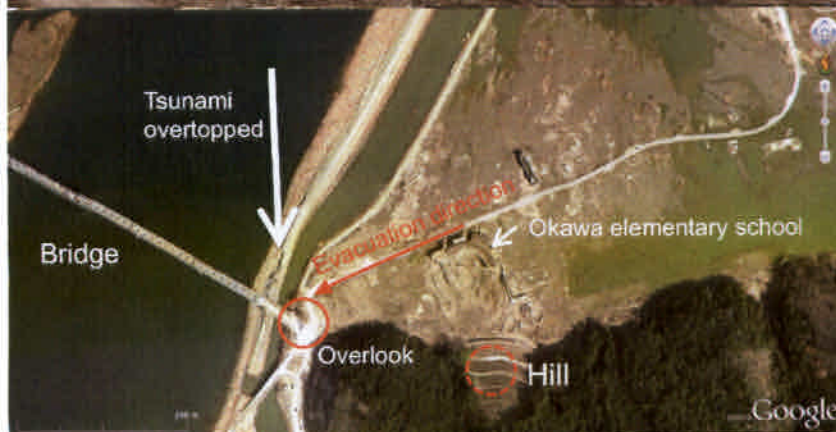
School buildings should also have similar requirement to ensure children's safety.



Okawa elementary school

If only the school building were 3-story.

Lost 74 pupils out of 108



Onagawa, Miyagi Pref.

宮城県大川町 (2011年3月29日撮影)



www.town.onagawa.miyagi.jp:

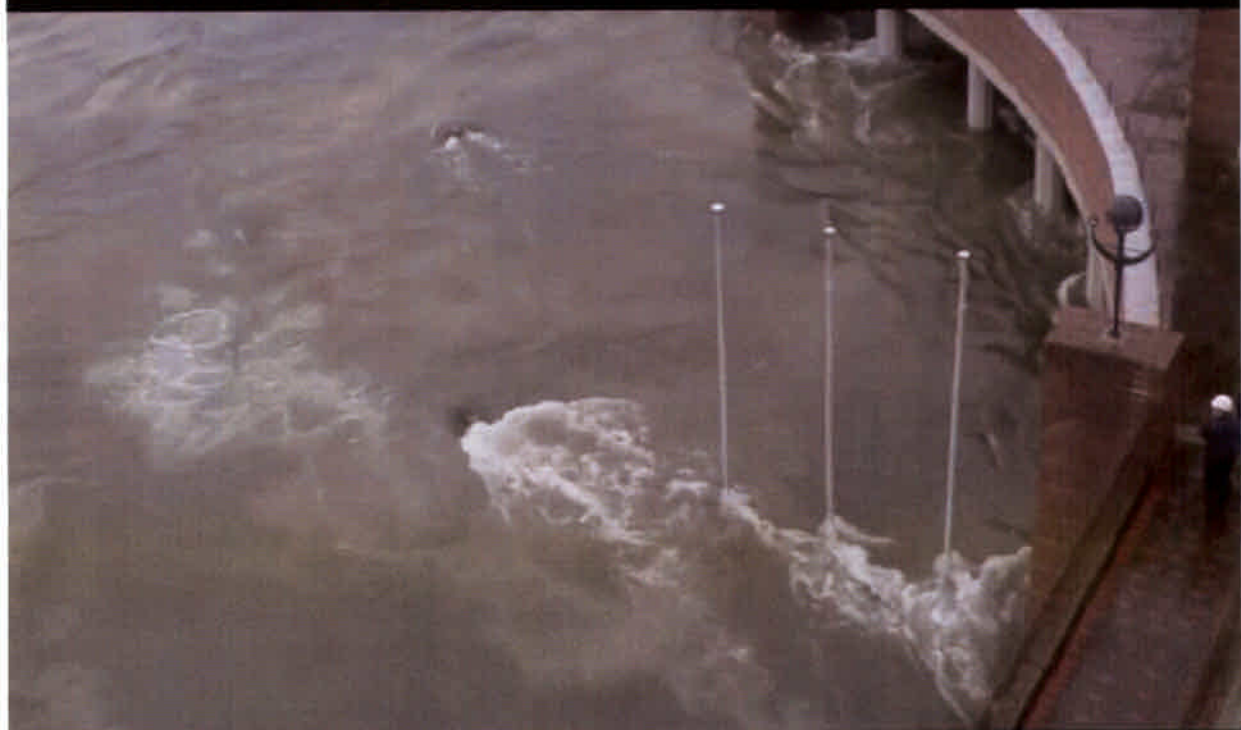
Fatality: 455, Missing: 739 (Pop. 10,010). 12% of population were killed or missing.

Destroyed houses/buildings: 4432. 70% of houses in town was severely damaged.

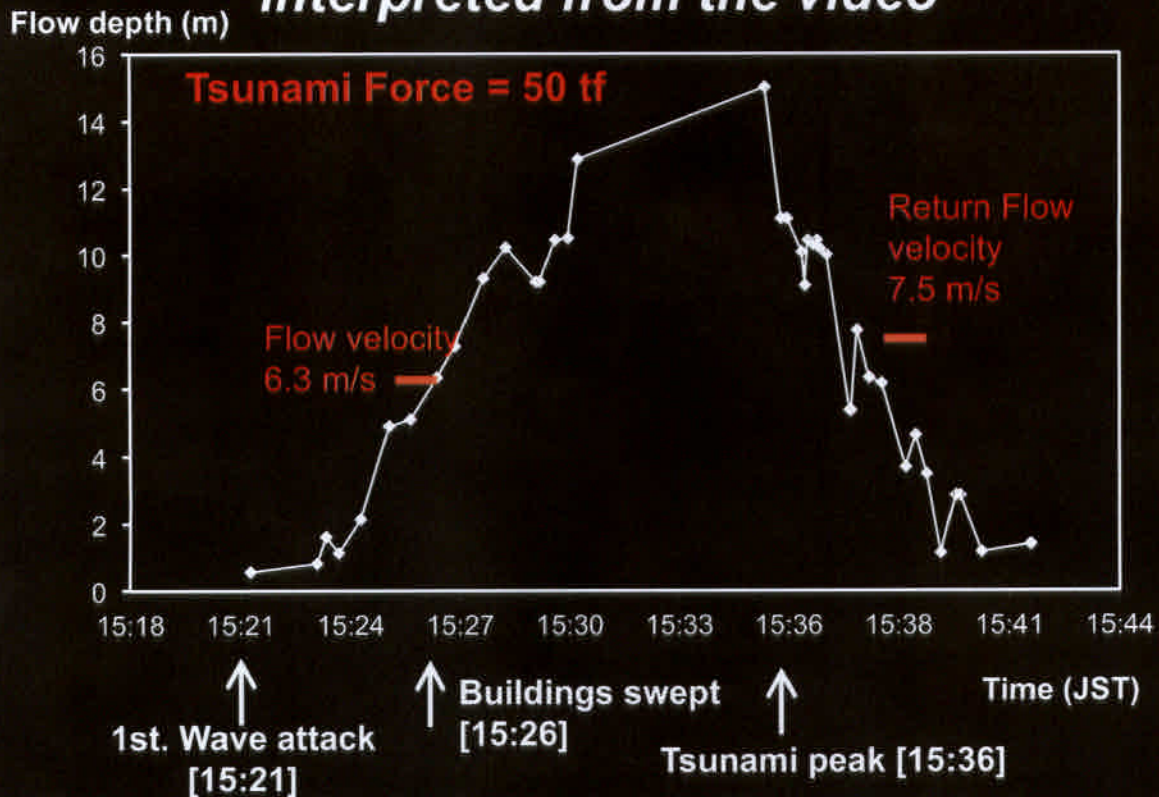




***Survivor videos
Onagawa, Miyagi Pref.***



Time series of tsunami inundation interpreted from the video



Lesson

*The sea does NOT always recede
when tsunami comes.*

Lesson

NEVER go to the coast to watch a tsunami.

Speed of tsunami propagation (m/s)

$$\sqrt{gh}$$

g : Gravitational acceleration (=9.8 m/s²)

h : Water depth (m)

Tsunami disaster countermeasures in Japan

1. Coastal protection

Building seawalls and break waters to protect life and property

2. Building tsunami-resilient community

Urban planning, land use, relocation.

3. Emergency response and preparedness

Tsunami warning, evacuation (horizontal and vertical), public education.

Tsunami breakwater in Kamaishi

Length : 2km, Surface height above sea level : 8m, Width : 20m



Seawalls down



Lesson

**Breakwaters and seawalls can
NOT always protect our lives
and properties.**

***Relocation
Kamaishi
[Iwate Pref.]***

The 1933 Showa tsunami
(50 days after the event occurred)



Source : B.E.R.I



1934



2009



2011

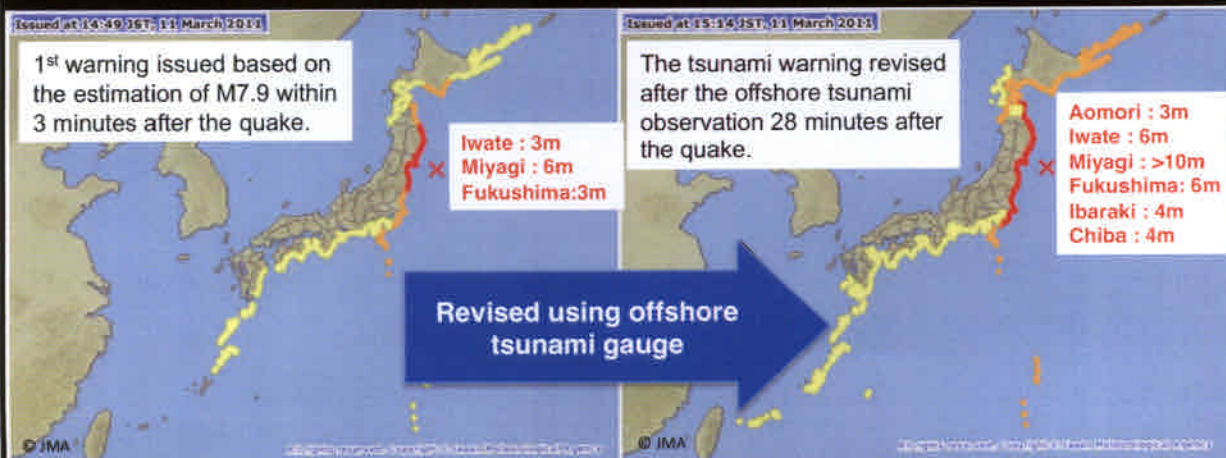
2009



Lesson

To build tsunami-resilient communities, **NEVER** forget the memories of disasters and keep it around us.

JMA Tsunami warning issued based on 100,000 cases of pre-computed database of tsunami forecasting



Lesson

Still limitations exist on reliability of science and technology used in the limited amount of time.

Tsunami warning information is to know we are in danger, but it does NOT guarantee our safety.

Do NOT wait for official information.

If you can walk or run, driving is not a good idea



Lessons

- **Knowing risks**
 - Very important to know risks but sometimes the nature is beyond our science and technology.
 - Remember negative aspects of hazard maps.
 - Computer simulation can NOT predict whole picture of disaster.
- **Structural vulnerability**
 - Breakwaters and seawalls can NOT always protect our lives.
 - Do NOT rely on coastal protection.
 - Over 2 m tsunami flow depth potentially causes destruction on houses.
 - Multi-story (high-rise) reinforced and robust concrete buildings can withstand and be used for vertical evacuation. But the regulation should be reconsidered.
 - School buildings should have the similar requirement to ensure children's safety.

Lessons

- **To survive**
 - Go to higher place as soon as possible.
 - Strong ground shaking is the 1st. alert to take action.
 - NEVER go to the coast to watch a tsunami. *Otherwise, you must run faster than motorcycles.*
 - *The sea does NOT always recede when tsunami comes.*
 - Where to go ? (Higher ground, Designated RC buildings for vertical evacuation)
 - Reduce difficulties of the access to shelter to reach within several minutes.
 - How to go ? If you can walk or run, do not use a car.
- **Tsunami warning and information**
 - Increase the reliability.
 - Quick, accurate and robust disseminations system.
 - Attitude NOT to rely on official information.

Muchas Gracias!
