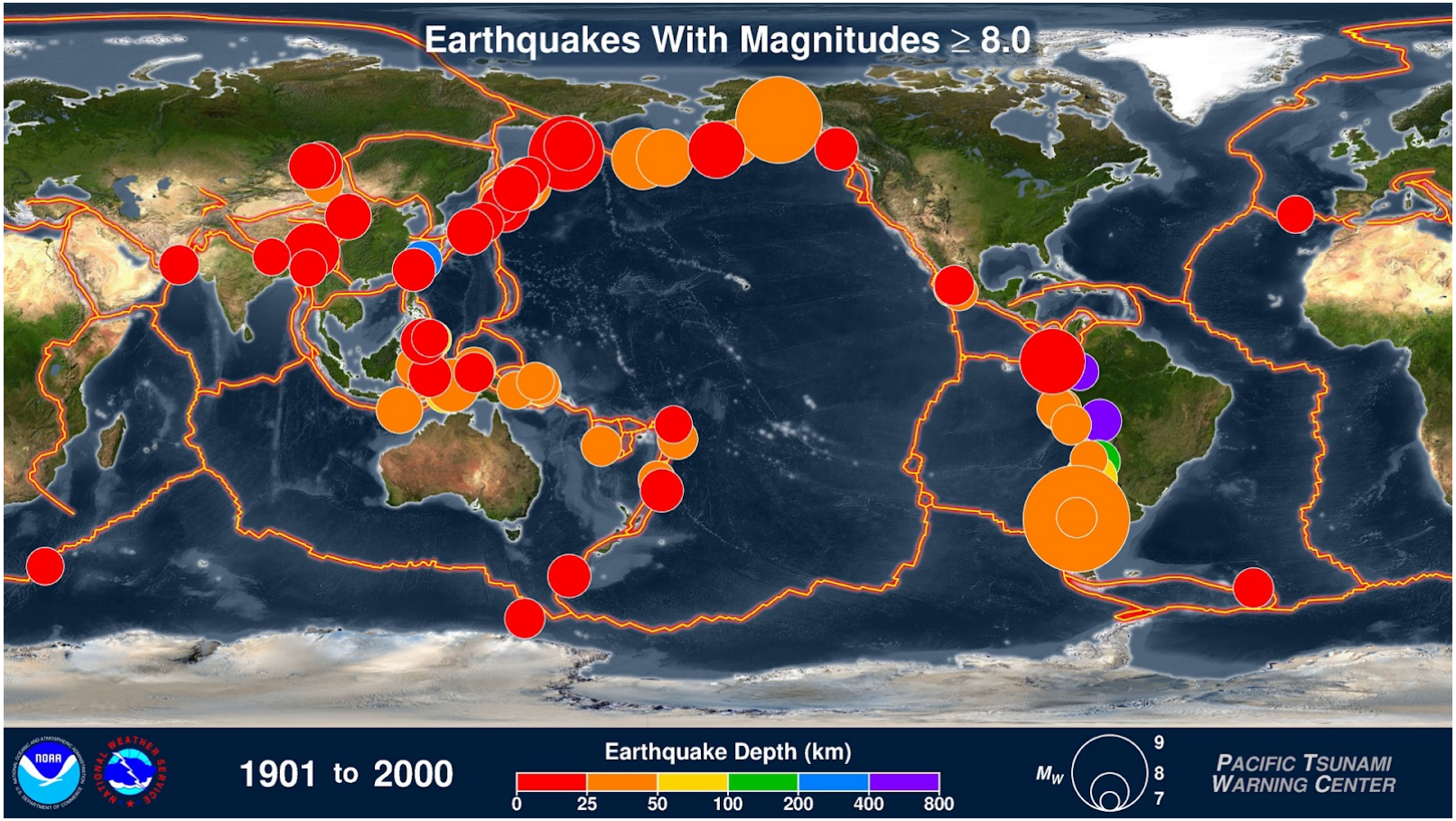
UNESCO/IOC – NOAA ITIC Training Program in Hawaii (ITP-TEWS Hawaii)
TSUNAMI EARLY WARNING SYSTEMS
AND THE PACIFIC TSUNAMI WARNING CENTER (PTWC) ENHANCED PRODUCTS
TSUNAMI EVACUATION PLANNING AND UNESCO IOC TSUNAMI READY PROGRAMME
15-26 September 2025, Honolulu, Hawaii

Responding Rapidly and Effectively: Tsunami Warning and Emergency Response Requirements and Timeline-driven SOPs

Dr. Laura Kong
Director, ITIC, USA NOAA

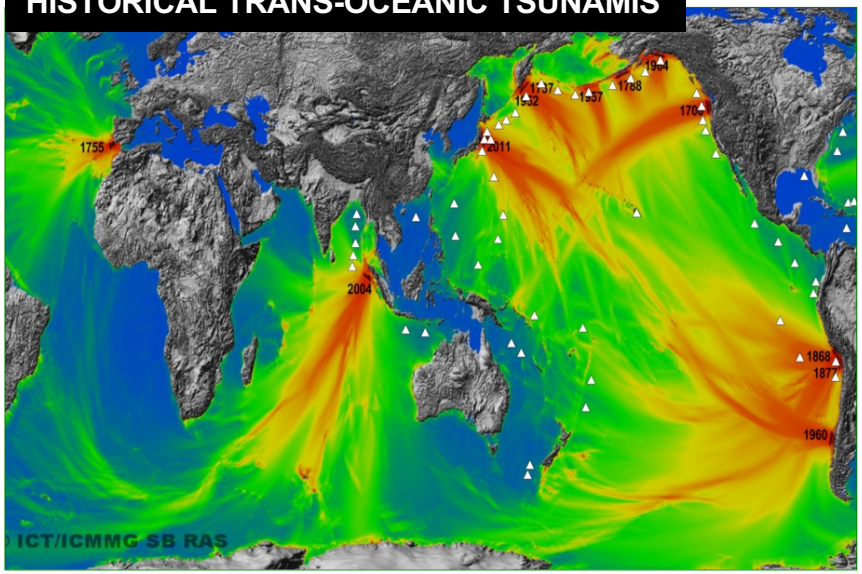
FACT 1: Dangerous Earthquakes & Tsunamis



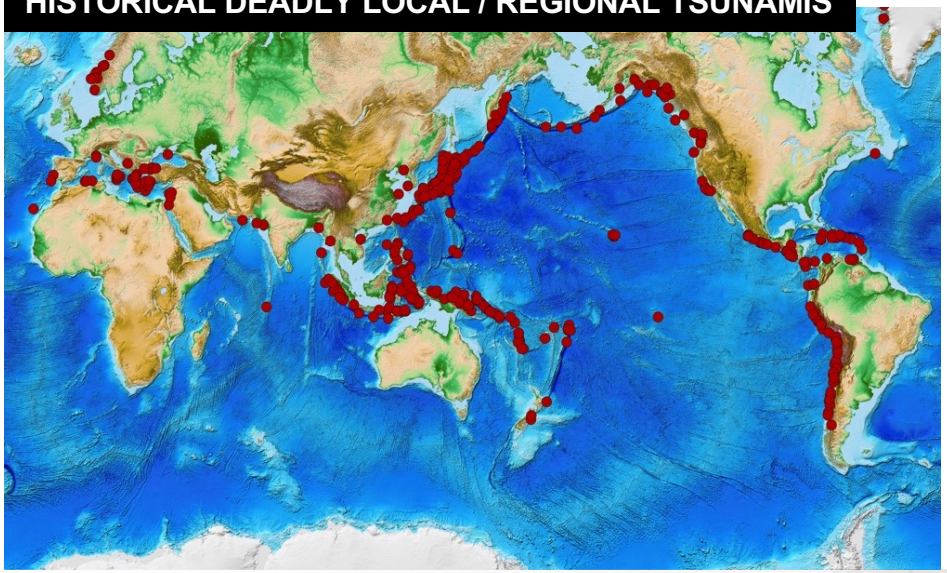
Click below for video EQ-Tsunami 1901-2021

FACT 2: Deadly Tsunamis – Distant to Local

HISTORICAL TRANS-OCEANIC TSUNAMIS



HISTORICAL DEADLY LOCAL / REGIONAL TSUNAMIS

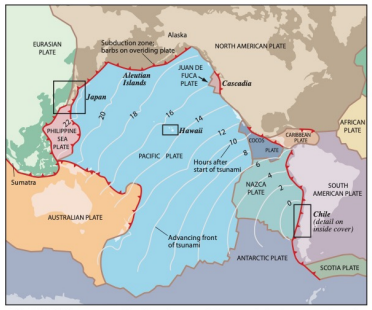


- ~70% in Pacific Ocean and Marginal Seas, 80% caused by earthquakes
- Most tsunami are local (< 1 hr) or regional (1-3 hrs). Cause 90% of deaths)
- Communities: Prepare beforehand. Self-evacuate on natural warnings

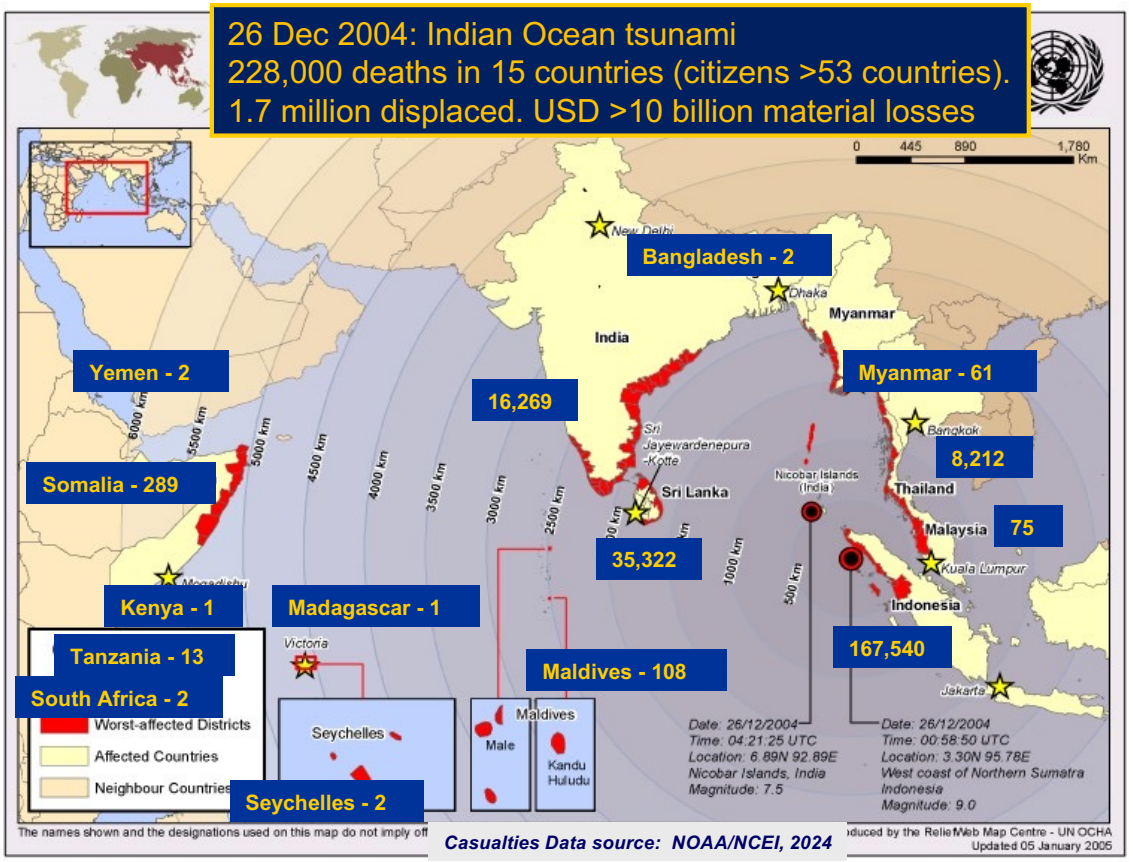
FACT 3: Tsunamis do not discriminate

- Danger continues for many hours
- High fatality hazard
- Global Impact – blind to country boundaries

- ***Locally, arrives in minutes***
- ***Distant, travels hours across ocean basin***



The 1960 Chilean tsunami radiated outward from a subduction zone along the coast of Chile. Its waves reached Hawaii in 15 hours and Japan in 22 hours.

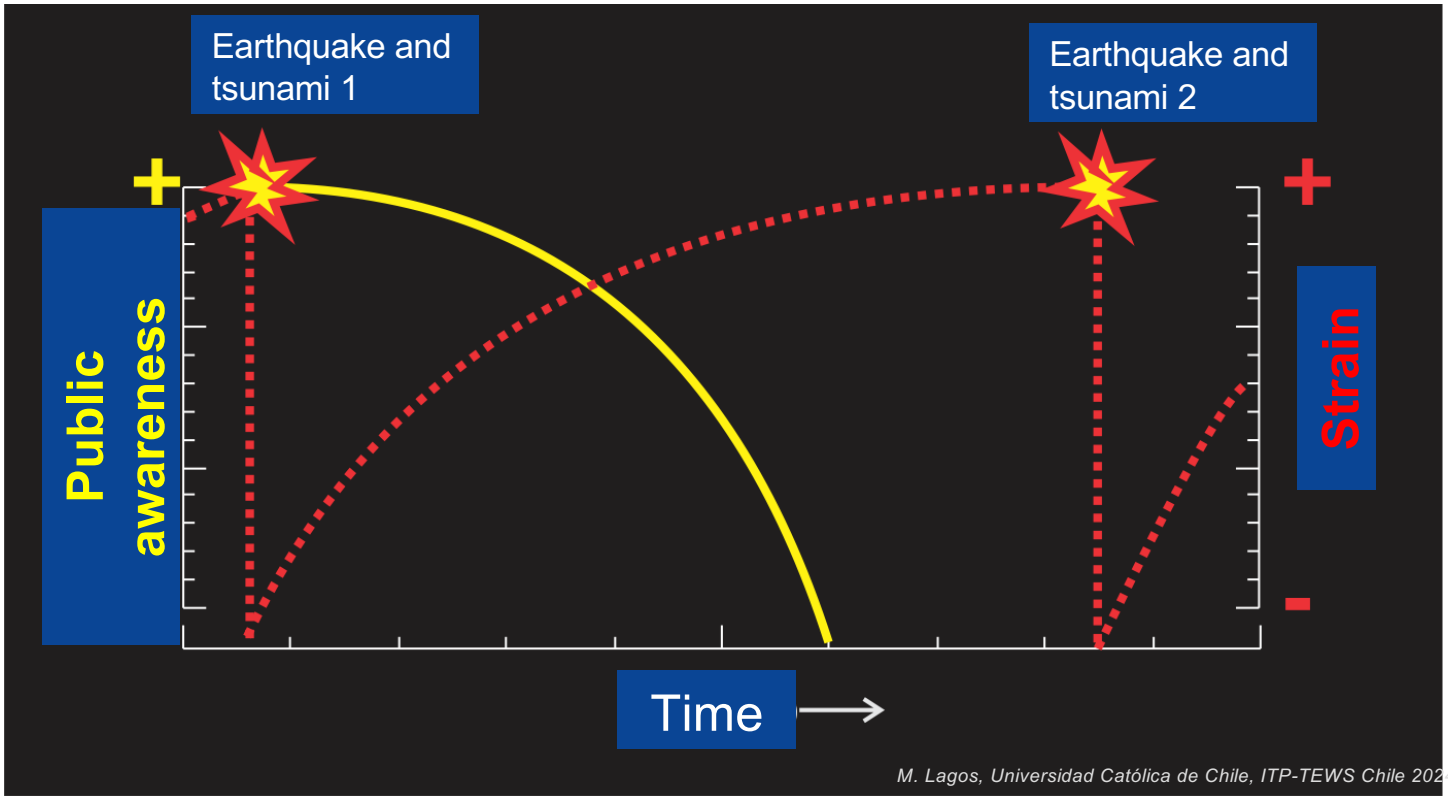


Casualties Data source: NOAA/NCEI, 2024

FACT 4: Tsunamis infrequent – people forget

Inverse relationship between awareness and strain accumulation (causing earthquake)

2004 IO (500-800 yrs); 2011 Japan (1100 yrs); Chile (300-500 yrs), Cascadia (300 yrs)



TSUNAMI WARNING – 2 THREATS

LOCAL / REGIONAL:

- Generated nearby
- Strikes shore quickly (in minutes)
  => NO TIME for official evacuation

➢ Education, Awareness, Preparedness

➢ Every person recognizes / acts immediately

February 27,2010, Chile

DISTANT / OCEAN-WIDE:

- Generated far away, instr detection
- Strikes shore later (2+ hours)
  => TIME for official evacuation
- Widespread Damage

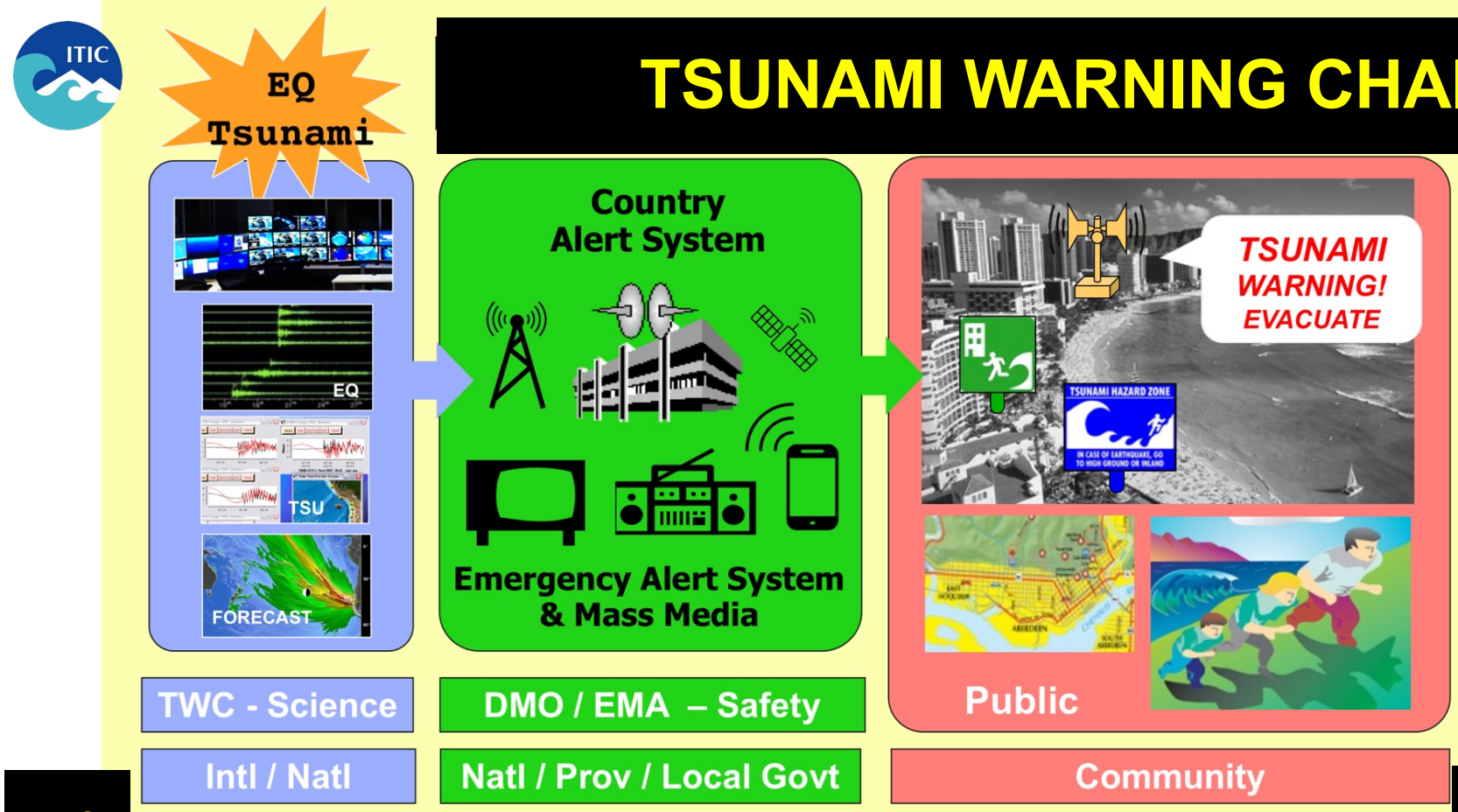
➢ Tsunami Warning Centre, then

➢ People know what to do and where to go - evacuate

May 22, 1960, Chile tsunami in Hilo

ITIC

TSUNAMI WARNING CHAIN



Effective Tsunami Warning - Stakeholders

- **3 Key Stakeholders – work closely together**
  Warning, Response, Awareness, Preparedness
- **NATIONAL TSUNAMI WARNING CENTER**
  - Assess and confirm dangerous tsunami
- **NATIONAL / LOCAL DISASTER MANAGEMENT**
  - Assess threat to coastal community
  - Inform community/public what to do (Evacuate, All-Clear safe-to-return)
- **LOCAL COMMUNITIES - ACT**
  - Aware and prepared
  - How to receive warning, what to do, where to go

Taking Action – Timely Warnings

- **Goal**:
  Act fast
  w/o confusion

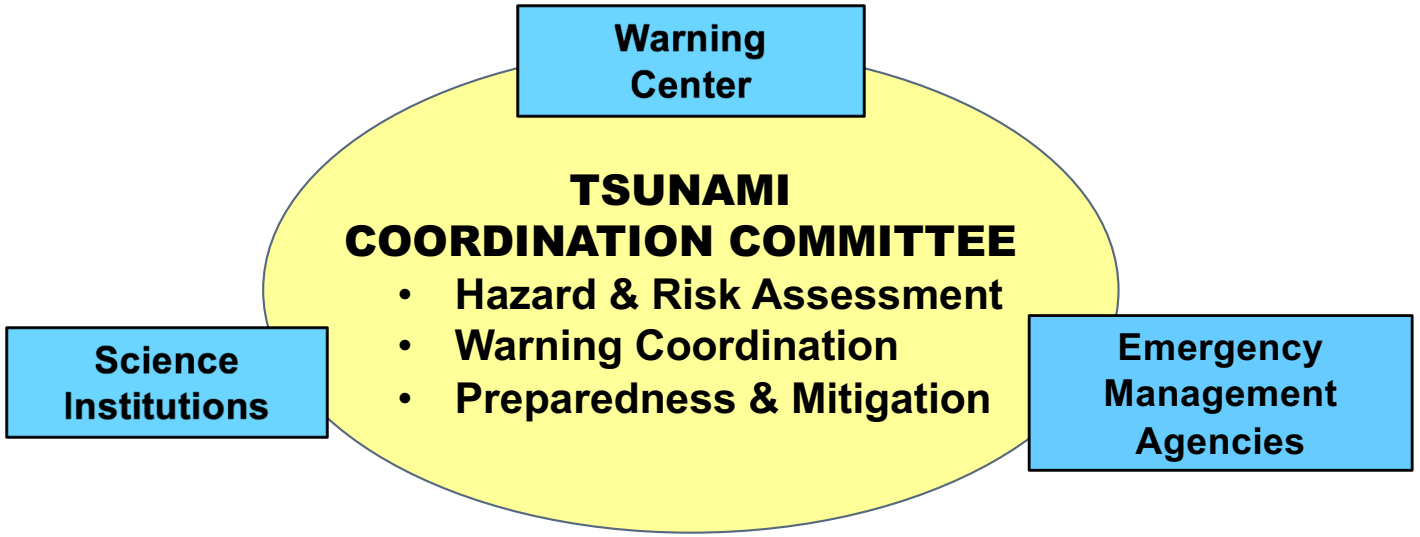
- **Requirements**:
  - **Know what to do**
    - Develop TWC and TER / DMO SOPs
  - **Practice**
    - Test Communications end-to-end
    - Conduct Drills since tsunamis are infrequent

SOP Definition

"A description and procedure on agreed steps by institutions used in coordinating who, what, when, where and how for tsunami early warning and response"

From Indonesia Local SOP Workshops: Capacity Building for Development of Local SOPs for Tsunami Early Warning and Response. 2006-2007

Stakeholder Coordination is Essential



Civil Society & NGOs

- **Community organizations** (social, gender, cultural, age, language, religious …)
- Trade, business organizations
- Disaster response & relief

Government Agencies:

- Planning & Development
- Transportation
- Health & Education
- Coastal Management
- Social Services

Other:

- Media
- Utilities
- Tourism
- International Agencies

ITIC, NZ, IOC, SeismicReady Consulting, 2009-2015

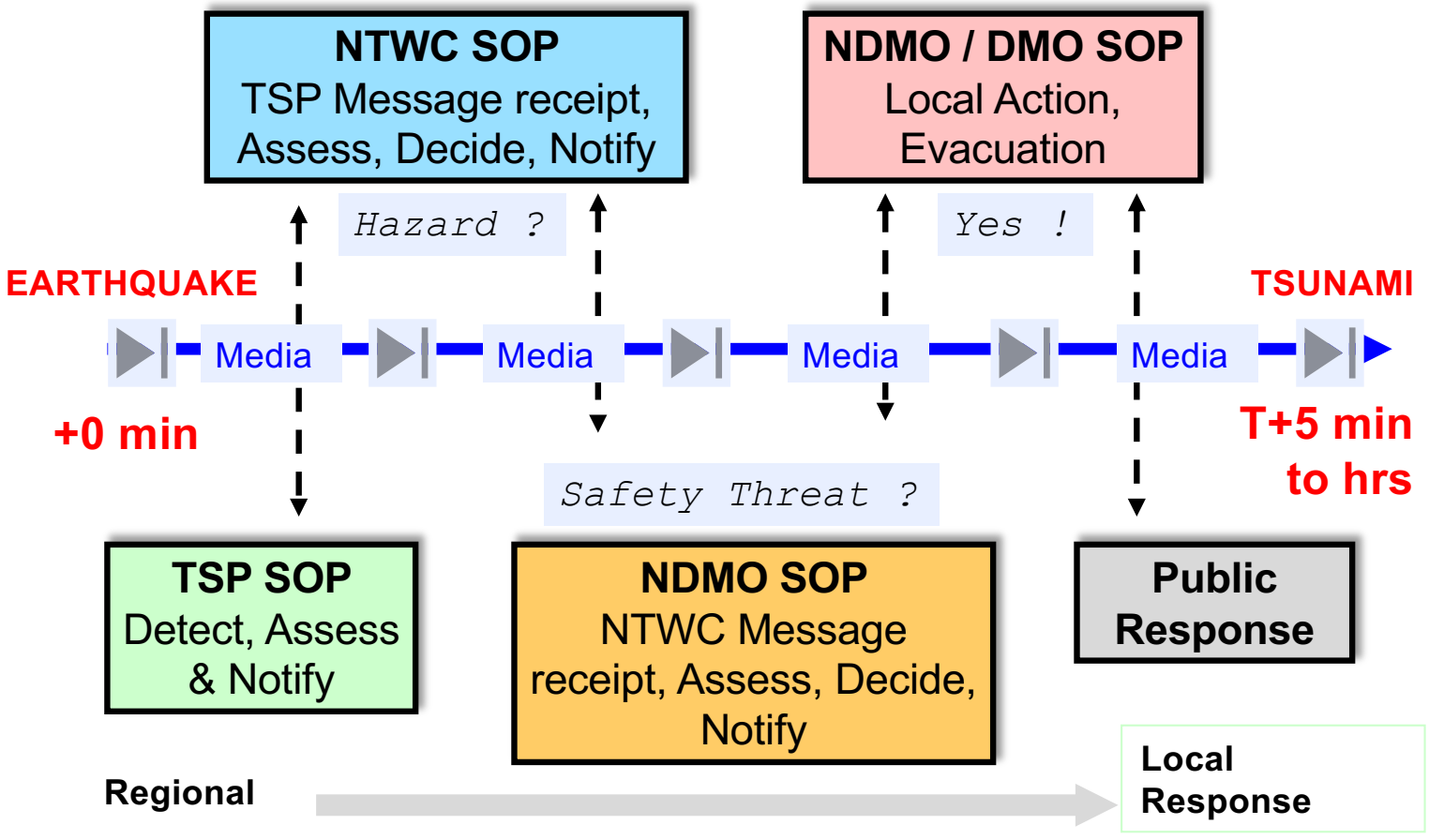
Tsunami Warning: What needs to be in place to save lives - warn, respond

- **Warn.** Early Detection, Threat Assessment, Rapid Alerting
  SOP: Earthquake triggers. Forecast gives threat.
  Sea Level Monitoring confirms tsunami
- **Respond.** Community at risk, Evacuation, Safe Return
  SOP: Pre-event preparedness – get Tsunami Ready
  Hazard risk maps, awareness, evacuation plan, practice exercises

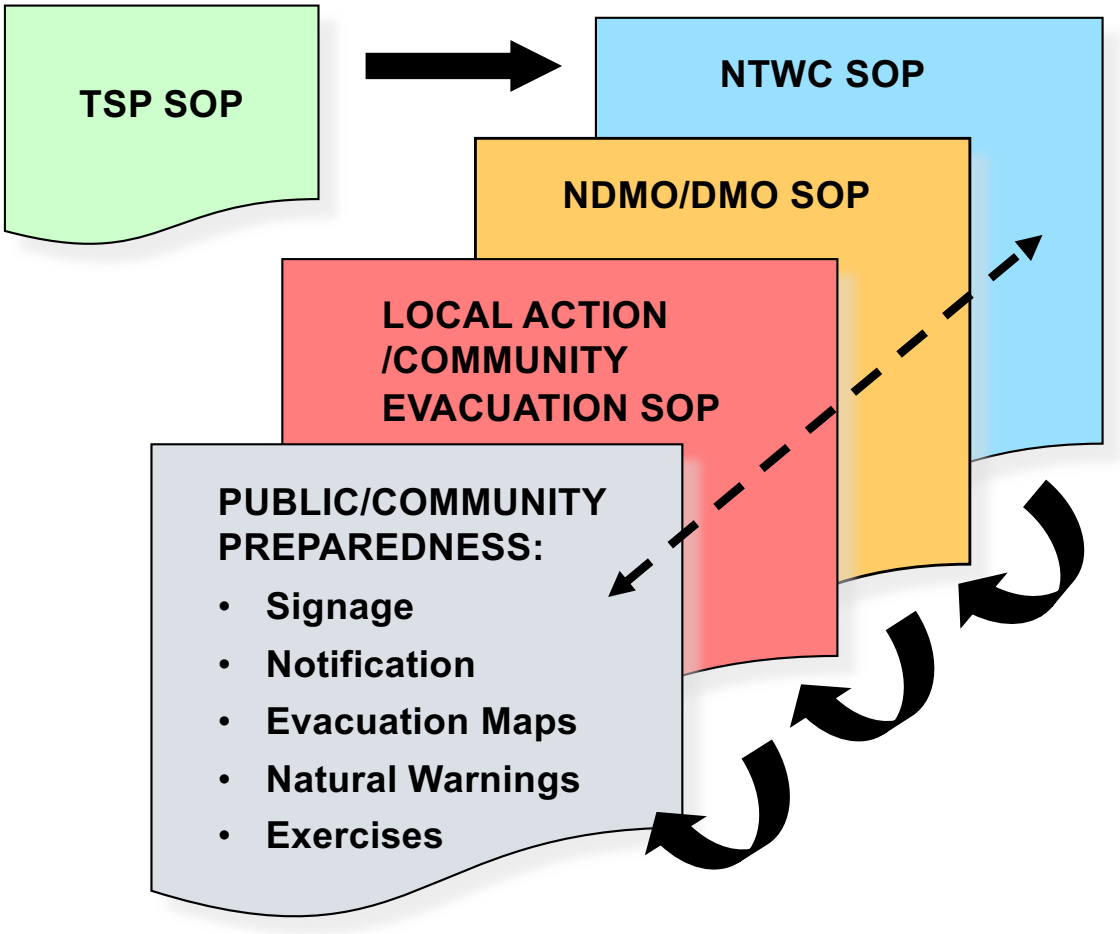
➢ ***Ready, Rapid, Reliable***

Credibility requires same-quality response (SOPs)

End-to-End Warning and Response



Warning Chain – set of linked SOPs



Plans & Procedures (SOPs): Practice

A perfect warning will be useless if people do not know what to do in case of an emergency

Build Strong, Reliable Systems
Science and Technology

- Earthquake Monitoring and Analysis
- Tsunami Monitoring and Detection
- Forecast Modeling (timely)
- Warning Communications (broadcast)
- Hazard Risk Assess – Paleotsunami history
- Hazard Risk Assess – Engineer Strong Structures
- Hazard Risk Assess – Ports and Harbors Policy

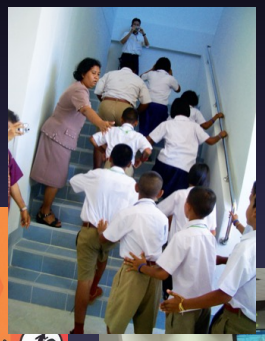


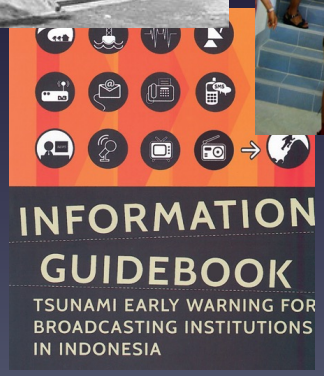





Build Strong & Reliable Systems
Preparedness and Readiness

- Evacuation (who, where, when, vertical)
- Education and Awareness (early, sustained)
- Indigenous Knowledge (sharing)
- Exercises (all levels)
- Training (ops, public)





ITIC

Tsunami Evacuation Maps, Plans, and Procedures (TEMPP)

… communities knowing what to do and where to go

ITIC Essential Community Preparedness
Capacity Building, Honduras, Central America, 2015-16

Community Preparedness is Collaborative

GOAL: Disaster-resilient community "TSUNAMI READY"

Indonesia, I. Rafliana, 2008
ITIC, L. Kong 2013

Great East Japan Tsunami
Warning decision point, Evacuation, and Human Response

Simple lessons

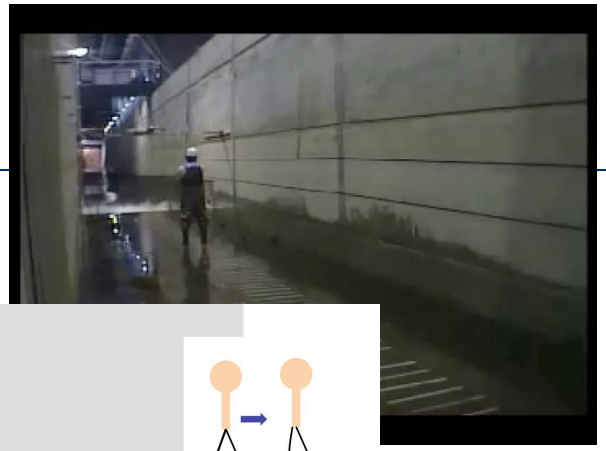
Deciding to issue warnings – Facts

- **JMA Warning timely,** incl wave forecast 3+ m
  (but was underestimate)
- **Small waves can be dangerous**
  Laboratory expts show waves 30 cm flow depth cause people to lose balance / cars to float
- **Swift-moving waves are dangerous**
  especially later waves as debris-laden rivers and/or walls of water.
- **Most people evacuated. Some did not.**
  Only 5% died, nonetheless, it was ~18,000

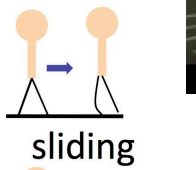
⇒ **NTWC must be CONSERVATIVE (ENSURE SAFETY)**

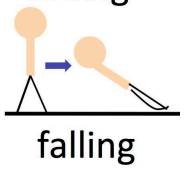
⇒ **For LOCAL tsunami, PUBLIC must SELF-EVACUATE. Do NOT wait for NTWC**

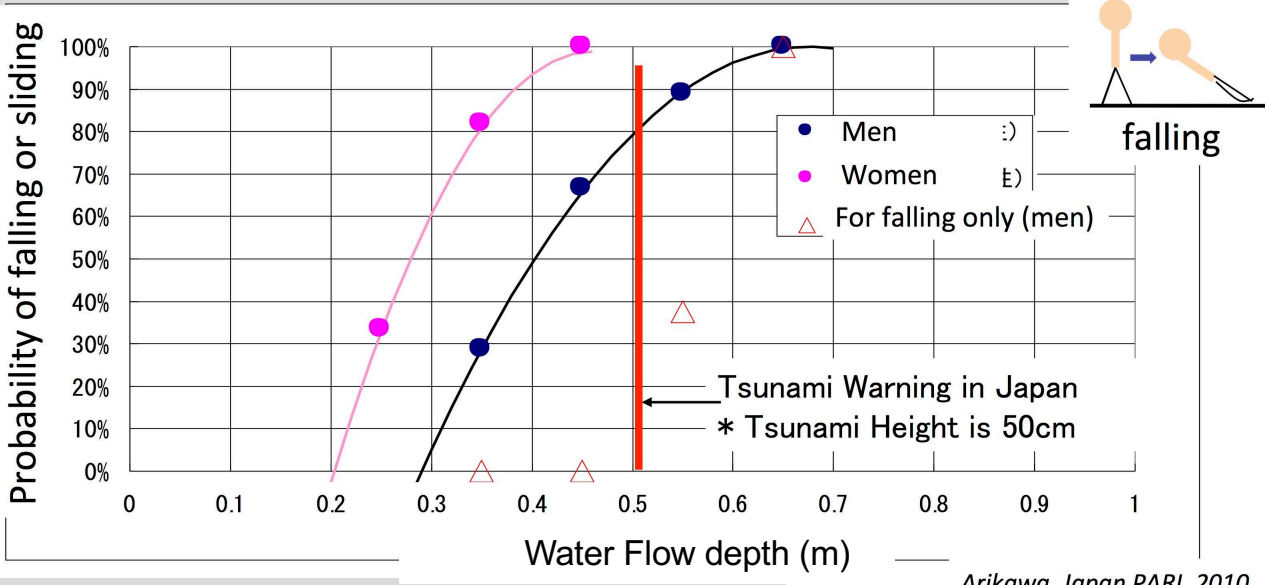
Flow Depth – Humans



Preliminary Results:
Probability of falling or sliding
=> lose balance at 0.3 m (1 ft) depth







Arikawa, Japan PARI, 2010

Velocity > 2-3 m/s (7-11 km/hr, 4-7 mph, 4-6 kts)

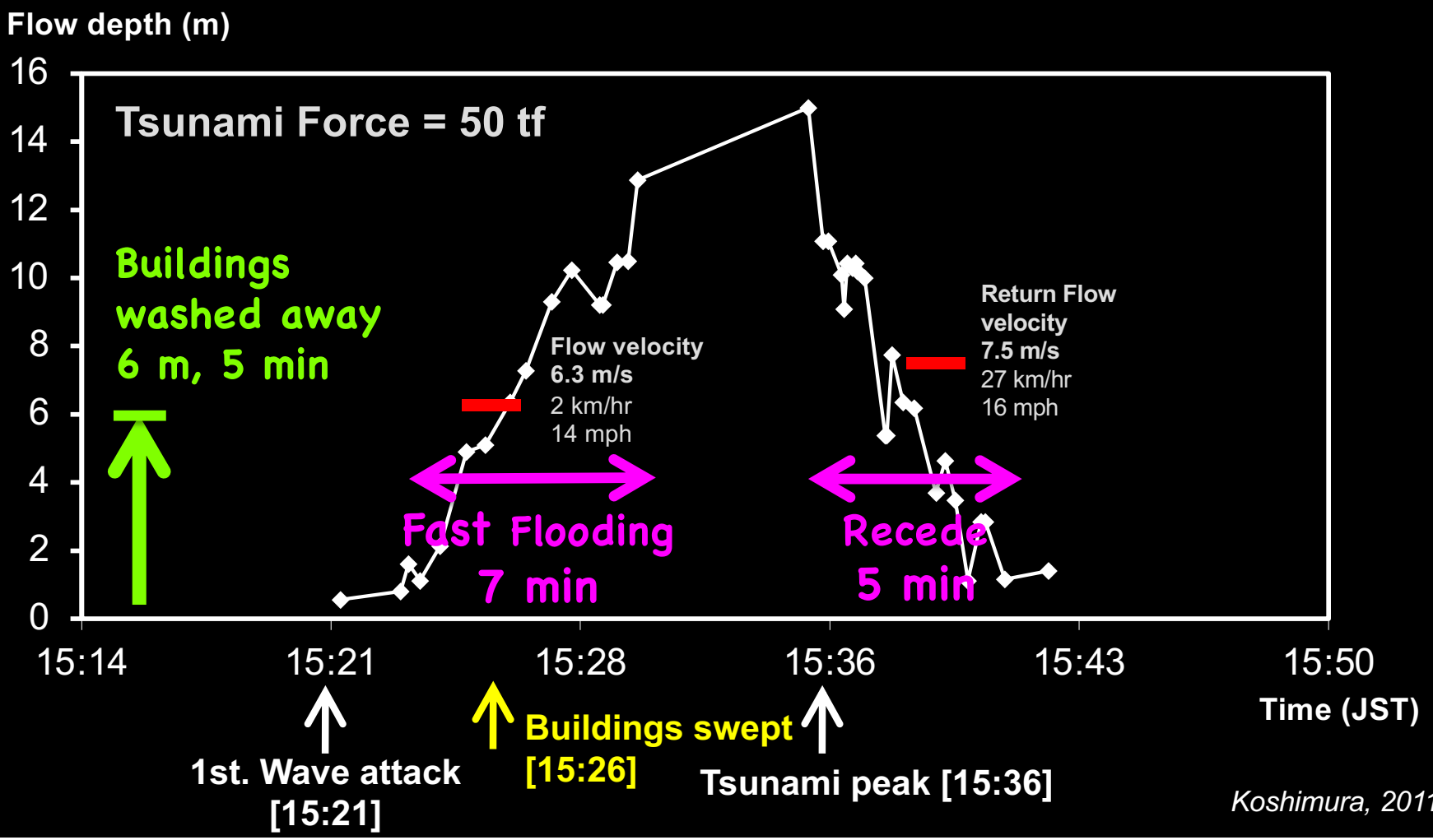
Onagawa, Miyagi Pref.

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.

Koshimura, 2011

Koshimura, 2011

Time series of tsunami inundation interpreted from video

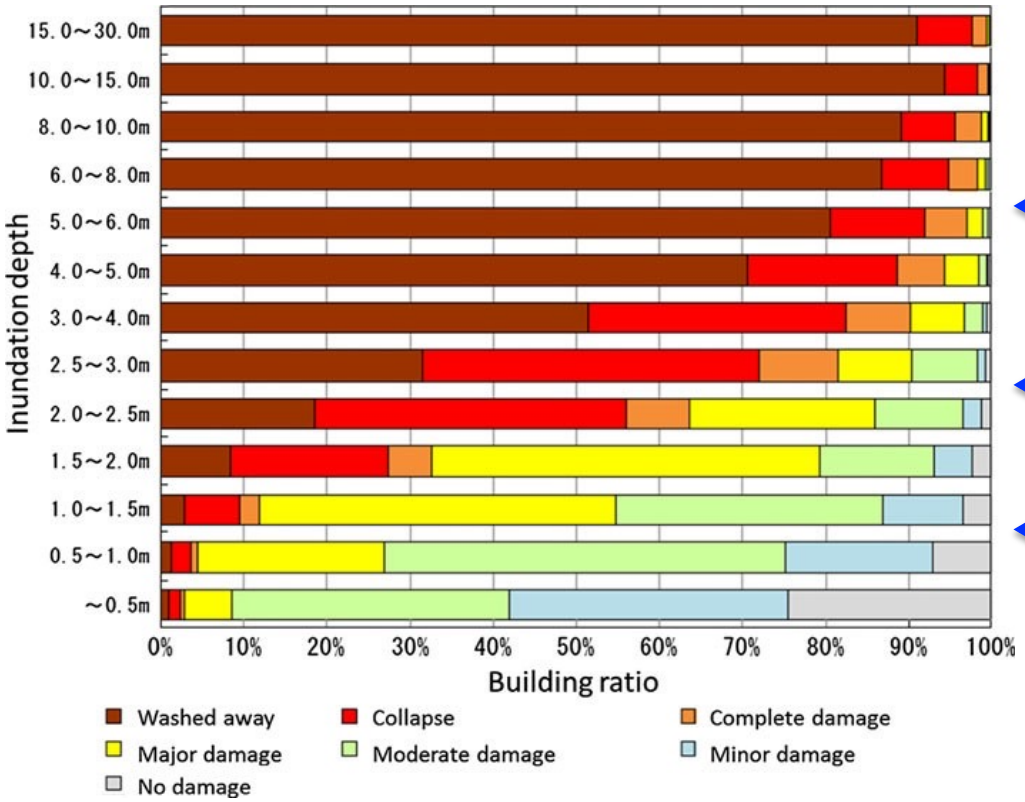


Koshimura, 2011

Onagawa, Japan

Koshimura, 2011

Flow Depth - Building Damage



← 6 m: 80% washed away
Onagawa

← 2 m: 20% washed away
55% collapsed

← 1 m: 5% collapse
40% moderate damage
PTWC Threat (Warning, Evacuate)

0.4-7m: People lose balance (drown)
Lab Expt

11 March 2011 Data: Fig. 2 Distribution of the total 251,301 building data surveyed by MLIT (2012) Ministry of Land, Infrastructure and transportation (MLIT): Survey of tsunami damage condition: http://www.mlit.go.jp/toshi/toshi-hukkou-arkaibu.html. Accessed 4 July 2012

Suppasri et al., 2013

Expect Fast Flooding - Have a Personal Plan

Thank You
Muchas Gracias

Dr. Laura Kong
Director, ITIC, USA NOAA