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

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NOAA-NWS Caribbean Tsunami Warning Program
Early Warning is part of Preparedness

Disaster Risk Reduction
- Mitigation
- Planning & regulations
- Technical Measures (walls, bldgs)

Preparedness
- Awareness & education
- Contingency Plans

Early Warning
- Actions in response to the warnings: Evacuation...

Response
- Response to the disaster
- Intervention: Search & Rescue
- Humanitarian Affairs
- Reconstruction & Rehabilitation

Focus on SOP Strengthening
End-to-End Tsunami Warning

- **Country Alert System**
- **Emergency Alert System & Mass Media**
- **DMO – Public Safety Evacuate / All-Clear**
- **Natl / Local Govt**
- **Public**

**EQ Tsunami**

**Tsunami Awareness**

UNESCO/IOC - NOAA

International Tsunami Information Center

ITIC, SeismicReady Consulting 2009 after Japan Cabinet Office 2005
Effective Tsunami Warning

• 2 Essential Stakeholders
  • Both must work closely together.

• NATIONAL TSUNAMI WARNING CENTER
  • ISSUES WARNING
  • Assess and confirm dangerous tsunami

• NATIONAL / LOCAL DISASTER MANAGEMENT
  • RECEIVES WARNING
  • Assess threat to coastal community
  • Inform community/public what to do
    (Evacuate, All-Clear safe-to-return)
Taking Action – Timely Warnings

- Goal: 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

**TSUNAMI COORDINATION COMMITTEE**
- Hazard & Risk Assessment
- Warning Coordination
- Preparedness & Mitigation

- Media
- Utilities
- Tourism
- International Agencies

**Emergency Management Agencies**

**Science Institutions**

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

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

ITIC, NZ, IOC, SeismicReady Consulting, 2009-2015
End-to-End Warning and Response

NTWC SOP
TSP Message receipt, Assess, Decide, Notify

NDMO / DMO SOP
Local Action, Evacuation

TSP SOP
Detect, Assess & Notify

NDMO SOP
NTWC Message receipt, Assess, Decide, Notify

Public Response

Regional

Local

Media

EARTHQUAKE

+0 min

Hazard ?

Safety Threat ?

Yes !

T+15

TSUNAMI

Media

Media

Media

Media
Tsunami Warning SOPs are coherent

PUBLIC PREPAREDNESS:
- Signage
- Notification
- Evacuation Maps
- Natural Warnings
- Exercises
## Tsunami Warning SOPs are timeline-driven

<table>
<thead>
<tr>
<th>TIME min after EQ</th>
<th>OBSERVATION</th>
<th>ACTION PTWC</th>
<th>ACTION NTWC</th>
<th>ACTION NDMO / Local Auth</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Strong ground shaking locally</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5</td>
<td>TSUNAMI MIGHT COME</td>
<td>Alarm triggers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-15</td>
<td>TSWAMI confirmed</td>
<td>Msg 2 Forecast</td>
<td>WARNING</td>
<td>EVACUATION</td>
</tr>
<tr>
<td>15-30</td>
<td>TSUNAMI confirmed</td>
<td>Msg 3 SL obs</td>
<td>Confirm Dangerous Tsunami</td>
<td></td>
</tr>
<tr>
<td>30-60</td>
<td>TSUNAMI confirmed</td>
<td>Msg 4+ SL obs</td>
<td>Monitor and report SL obs</td>
<td></td>
</tr>
<tr>
<td>1-2+ hrs</td>
<td>Dangerous waves stop</td>
<td>Msg 5+ Last Msg</td>
<td>CANCEL WARNING</td>
<td>Search and Rescue</td>
</tr>
<tr>
<td>2-8+ hrs</td>
<td>Safe to Return</td>
<td></td>
<td></td>
<td>ALL-CLEAR</td>
</tr>
<tr>
<td>3+ hrs</td>
<td>Safe to Return</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Effective Warnings: Practice SOPs

A perfect warning will be useless if people do not know what to do in case of an emergency.
Tsunami Early Warning: Science and Public Safety

SCIENCE

PUBLIC SAFETY

Earthquake

Tsunami or not

Evacuation or not

No casualties

Monitoring
Processing

Dissemination
Preparedness

Decision Point

Assess

Response

ITIC, BMKG, 2009
2011 Great East Japan Tsunami Warning and Human Response
Facts

• **Timely NTWC Warning**, incl wave forecast 3+ m but was underestimate => 1\textsuperscript{st} message most critical

• **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
Flow Depth – Human

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

Velocity > 2-3 m/s (7-11 km/hr, 4-7 mph)
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
Time series of tsunami inundation interpreted from the video

Tsunami Force = 50 tf

Flow depth (m)

- Buildings ashed away 6 m, 5 min
- Max Flooding 12 min
- Recede 8 min
- Time series of tsunami inundation interpreted from the video
- Tsunami peak [15:36]
- Return Flow velocity 7.5 m/s 27 km/hr 16 mph
- Flow velocity 6.3 m/s 22 km/hr 14 mph
- 1st. Wave attack [15:21]
- Buildings swept [15:26]

Koshimura, 2011
Flow Depth - Building Damage


Suppasri et al., 2013
Tsunami Impact - summary

Criteria to estimate damage by tsunamis

- Inundation depth
  - Human: killed $>> 50$cm
  - House: partially damaged $>> 1.0$m
  - Totally damaged $>> 2-3.0$m
  - Building: damaged $>> 5.0$m
Expect Fast Flooding - Have a Plan

Sendai, Japan, March 11, 2011
Thank You

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