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

Laura Kong
UNESCO/IOC – NOAA International Tsunami Information Center
Early Warning is part of Preparedness

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

Preparedness
- Awareness & education
- Contingency Plans

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

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

Focus on SOP Strengthening
End-to-End Tsunami Warning

EQ Tsunami

Country Alert System

Emergency Alert System & Mass Media

DMO – Public Safety Evacuate / All-Clear

Natl / Local Govt

Public

ITIC, SeismicReady Consulting 2009 after Japan Cabinet Office 2005

UNESCO/IOC-NOAA
International Tsunami Information Center
Earthquake and generation of Tsunami

Early Warning Based on Natural Signs
Ground shaking by earthquake

Early Warning Based on seismic data and modeling

Confirmation or Cancellation Based on ocean observation, forecast

Early Warning Based on Natural Signs
Seawater withdraws
Loud roar

“All Clear”
No more Tsunami wave expected

Process: Dissemination of Warning

Process: Reaction to Warning

Process: SAR & Response

Early Warning is part of Preparedness

3 Processes!
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:**
  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

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

**Science Institutions**

**Emergency Management Agencies**

**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
End-to-End Warning and Response

NTWC SOP
TSP Message receipt, Assess, Decide, Notify

NDMO / DMO SOP
Local Action, Evacuation

EARTHQUAKE
+0 min
TSP SOP
Detect, Assess & Notify

Safety Threat ?

Media

Yes !

Public Response

NDMO SOP
NTWC Message receipt, Assess, Decide, Notify

Regional

Local

Hazard ?

T+15

TSUNAMI
PUBLIC PREPAREDNESS:

- Signage
- Notification
- Evacuation Maps
- Natural Warnings
- Exercises
# Timeline-driven SOP

<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>Alarm triggers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-15</td>
<td>Tsunami might come</td>
<td>Msg 1</td>
<td>Alarm CISN triggers</td>
<td></td>
</tr>
<tr>
<td>15-30</td>
<td>Tsunami confirmed</td>
<td>Msg 2 Forecast</td>
<td>WARNING</td>
<td>EVACUATION</td>
</tr>
<tr>
<td>30-60</td>
<td></td>
<td>Msg 3 SL obs</td>
<td>Confirm Dangerous Tsunami</td>
<td></td>
</tr>
<tr>
<td>1-2+ hrs</td>
<td></td>
<td>Msg 4+ SL obs</td>
<td>Monitor and report SL obs</td>
<td></td>
</tr>
<tr>
<td>2-8+ 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>3+ hrs</td>
<td>Safe to Return</td>
<td></td>
<td></td>
<td>ALL-CLEAR</td>
</tr>
</tbody>
</table>
Tsunami Timeline

Earthquake

5
- Local Tsunami Warning from TWC
- Tsunami information based on forecast

7
- Siren from EOC - local government;

15
- Evacuation

30
- Tsunami information based on observation
- Evacuation status

60
- Tsunami information based on observation
- Evacuation status

120
- Cancellation - Local Tsunami Warning from TWC

180
- All Clear
- Return to evacuation zone

SOP in TWC, issue warning
SOP in DMO EOC, sound siren, evacuate
Sign, route, shelter
SOP, issue All-Clear
SOPs: Practice

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

Earthquake

Tsunami or not

Evacuation or not

No casualties

Monitoring
Processing

Dissemination
Preparedness

Decision Point

Response

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

- **Timely NTWC Warning**, incl wave forecast 3+ m
- **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

![Graph showing Probability of falling or sliding vs Inundation depth with data points for men and women.]

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

Arikawa, Japan PARI, 2010
Onagawa, Miyagi Pref.

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
Flow depth
Velocity
6.3 (m/s)
7.5 (m/s)

1st. Wave attack [15:21]

Tsunami peak [15:36]

Buildings swept [15:26]

Time series of tsunami inundation interpreted from the video

Tsunami Force = 50 tf

Flow velocity
6.3 m/s
22 km/hr
14 mph

Return Flow velocity
7.5 m/s
27 km/hr
16 mph

Time (JST)

Koshimura, 2011
Onagawa, Japan
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Koshimura, 2011

Suppasri et al., 2013
Criteria to estimate damage by tsunamis

Inundation depth

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

Sendai, Japan, March 11, 2011
Thank You

Laura Kong
UNESCO/IOC – NOAA International Tsunami Information Center