Tsunami Warning Centres: Summary Overview on SOPs - Daily Operations, Flow Charts, Timelines

Stuart Weinstein
PTWC

Laura Kong
Masahiro Yamamoto
UNESCO IOC
Tsunami Warning Systems as an end-to-end system

- **upstream**
  detection, verification, tsunami forecast, warning dissemination

- **downstream**
  delivery of warnings, initiate national counter-measures, prepare and implement standardized reaction

--- Goal: same quality at every time ---
A description and procedure on agreed steps by TWC used in coordinating Who, What, When, Where, How for tsunami early warning"
What are SOPs?

Based on US Env Prot Agency Manual

1) Set of **written instructions** for routine / repetitive organization activities. Procedure followed in an emergency.

2) Detail **work processes** conducted / followed within organization.

3) Document way activities performed for **consistent conformance** to system requirements and organization’s mission.
Different Types of SOP Documents

1. Official SOP documents for **management** purposes

2. Comprehensive **TW operations** SOP documents with many **details** for study and reference during **non-crisis**

3. **Quick-Reference** SOP documents for reference **during crisis**

4. **Systems** SOP documents so **recipients understand** TWC SOP and what to expect (Users Guide)
Official SOPs for Management

- **Directives**
  - TWC Performance Expectations
  - *Roles & Responsibilities / Concept of Operations*
  - Maintained by Parent Organization
  - Formal Review / Change Process with Organizational Stakeholders

- **Station Duty Manual**
  - Duty Staff Performance Expectations
  - Maintained by TWC Management
  - Includes *Tasks outside Crisis Operations*
  - Formal Review / Change Process with Staff
JMA...
- Issues tsunami warning
- Takes measures for warning dissemination
- Makes efforts to disseminate warning to public, asking for media cooperation

Local governments...
- Disseminate warning to residents
- Warn residents and relevant organizations to take actions against expected disasters
Concept of Operations -
Operation 24 hrs/day, 7 days/week ...

Succession of Operation

✓ Morning/Evening Briefings -
  overlap in shifts to brief next shift

✓ Daily Report -
  issued EQ info, seismic activity,
  system status during shift

✓ Daily Schedule Sheet -
  checklist of daily tasks
  logged as completed
SOPs are Living Documents

Main TWC Characteristics
- Fast
- Accurate
- Reliable
- Effective

Main TWC Activities
- Seismic Data Collection and Analysis
- Sea Level Data Collection and Analysis
- Decision-Making Tools and Procedures
- Message Creation and Dissemination
TWC Operations
What should SOPs cover:

- TWC Capabilities
  - Observational Networks
  - Analysis and Decision Tools
  - Communication Methods
  - Personnel

- Maintain Readiness
  - Regular Checks of Critical Systems
  - Routine Communication Testing
  - Continuity of Operations - Backup Systems
  - Repair of Non-functioning Components

- Reporting Requirements
Tsunami Warning - REQUIREMENTS

Earthquake Components - Tsunami warning system

- Network of seismographs
- Real time data transmission
- Real time data processing
- Criteria for Tsunami grade
- Communication facility to Disseminate Tsunami Warning
- Sea Level Network to monitor tsunami

Tsunami

Detection Tsunami

Evaluate Tsunami

Issue Tsunami Warning

Issue Tsunami Information

Re-evaluate Tsunami

Detect Seismic Wave

Determine Magnitude, Hypocenter

Tsunami Warning
They should also be geared to maintaining:

100% Operational Reliability
1. Data availability monitoring
2. Data quality monitoring
3. Maintenance and repair priorities
4. System Alteration Procedures
5. System Failure Procedures

Long Term Readiness:
1. Communication Tests
2. Table-top Exercises

e.g., For Warning Centers, SOPs are not just on what to do in an Earthquake.
TWC Operations Manual: (Refer to during non-crisis)

- Most Detailed
- Steps to Carry Out
  - How? Why?
- Logical Flow
  - Flow Charts, Timelines
- Background Information
  - Scientific Basis
  - Organizational Basis
  - Definitions
- Format
  - Paper, Electronic (Web Based)
General TWC SOP during an Event

0. **EQ!!! - Digital Alarm - Duty Staff paged**
1. Detect and Analyze Large Earthquake
2. Determine Tsunami Hazard based on Pre-Determined Criteria
3. Issue Initial Message
4. Further Seismic Analyses
5. Detect and Analyze Tsunami Signals
6. Re-evaluate Tsunami Hazard
7. Issue Additional Message
8. Repeat Steps **4-7** until Threat Passed
9. Cancellation or Final Message
Quick Reference SOPs (Crisis mode)

- **Timeline-driven activities**
  - Need to act rapidly (minutes)
    >> there is no time to read detailed manual!
  - E.g., How much time do you have?
    - What information is wanted?
  - Flow Charts describe overall flow, but Checklists allow faster response

- **Criteria Tables & Checklists**
  - What to use / What to look at
  - What is the action required
  - When is the action needed by
  - What are the steps/procedures **not** to forget
  - Who to notify (with ph nbrs, etc)
## Event Operations - TIMELINE-DRIVEN

### CASE 2: Center with Real Time Seismic Processing, Distant Earthquake/Tsunami

<table>
<thead>
<tr>
<th>STEP</th>
<th>TIME since EQ*</th>
<th>ACTIVITY</th>
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<tbody>
<tr>
<td>1</td>
<td>3 min</td>
<td>Seismic Alarm Trigger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Alarm sounds from an automatic seismic processing system</td>
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<tr>
<td></td>
<td></td>
<td>• Information provided by international centers; PTWC, WC/ATWC, JMA, WDC-Seismology-NEIC, GFZ??</td>
</tr>
<tr>
<td>2</td>
<td>10 min</td>
<td>Earthquake Review and Sea Level monitoring for tsunami generation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Review/update automatic phase picks and solution, including addition of other international seismic stations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Calculation to tsunami travel times to nearest international sea level stations and national territory</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If tsunami travel time to the national territory is within the predefined time, GO to STEP 3.</td>
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<tr>
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<td></td>
<td>• Continue to monitor sea level data located at near epicenter.</td>
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<tr>
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<td></td>
<td>• If there is enough time, NTWC shall issue Information that event is under evaluation for the tsunami threat to the national territory.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• (If no tsunami is observed in the near source region, Information is issued that there is no tsunami threat.)</td>
</tr>
<tr>
<td>3</td>
<td>13 min</td>
<td>Tsunami Threat Decision Making</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Decide on tsunami threat (height and area) based on pre-decided criteria, depending on whether tsunami simulation database exists or not; estimated tsunami</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If tsunami is observed at nearby sea level stations, evaluate a tsunami magnitude based on distance and observed tsunami height.</td>
</tr>
<tr>
<td>4</td>
<td>15 min to hours</td>
<td>Issue warning and related information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If warning thresholds (for earthquake magnitude or expected tsunami height) are exceeded, issue warning to tsunami-threatened areas immediately.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If very distant, advise and wait until threat closer for warning.</td>
</tr>
<tr>
<td>5</td>
<td>30 min to hours</td>
<td>Re-analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Monitor sea level data (coastal run-up, coastal sea-level, deep-ocean gauges)</td>
</tr>
<tr>
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<td>• Re-evaluation of focal parameter (Step 2) using additional data</td>
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<td></td>
<td>• Comparison to focal parameters and tsunami forecasts provided by international/regional centers (PTWC, JMA, NEIC)</td>
</tr>
<tr>
<td>6</td>
<td>30 min to hours</td>
<td>Re-evaluation and issuance of new information</td>
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<td>• Upgrading of warning if observed tsunami are higher than the expected at Step 3</td>
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<td>• Issuance of tsunami arrival and height observations</td>
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<td>• (Downgrade or Cancel if tsunami is smaller or no tsunami observed.)</td>
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</tbody>
</table>
PTWC CHECKLISTS - REMINDERS

PTWC Checklist (mod)- Pacific Events - Initial Bulletin (10-20 min)

Locate Epicenter (Tele-EQ, Pick, nquake) .............................................. O
Make/Examine Location Map (nquake) .................................................... O
Determine Depth (nquake) ....................................................................... O
Determine Magnitude (Mwp) .................................................................... O
Issue Observatory Message ..................................................................... O
Start Mm (with email to Papeete if Mw>7), SMAG, Theta ..................... O
Coordinate with WC/ATWC or their parameters if EQ in their AOR ...... O
Select Message Type based on Criteria ................................................ O
Call in Other Watchstanders to Help (Warnings) .................................... O
Compute/Print/[Map] ETAs if a Warning or Tsunami TIB ..................... O
Run Message Software (for Pacific and Hawaii) ..................................... O
For Both Pacific / Hawaii Messages, Check before Sending: Pacific Hawaii
  Bulletin Number (should be 1) ............................................................ O
  Message Type .................................................................................... O
  Which Places in Warning/Watch and Hawaii Status ........................... O
  Add Statement for Anything Unusual ................................................ O
  Earthquake Parameters ...................................................................... O
  Estimated Arrival Times .................................................................... O
Read HAWAS message (hawmsg) ........................................................ O
Check that all Messages Went Out and Resend if Necessary
  DCS, AFTN, NMC, Fax/Telex, NWW .................................................... O
  Web, Email, IDN, EMWIN, HFO Fax ................................................... O
Call Down List ....................................................................................... O
PTWC Checklist (mod)- Pacific Events - Initial Bulletin (10-20 min)

**Locate** Epicenter (Tele-EQ, Pick, nquake) ..............................................O
**Make/Examine Location Map** (nquake) ...................................................O
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**Determine** Magnitude (Mwp) .....................................................................O
**Issue Observatory Message** ......................................................................O
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**Select** Message Type based on Criteria ..................................................O
**Call in** Other Watchstanders to Help (Warnings) ......................................O
**Compute/Print/[Map] ETAs** if a Warning or Tsunami TIB ..........................O
**Run** Message Software (for Pacific and Hawaii) ......................................O

For Both Pacific / Hawaii Messages, **Check** before Sending: Pacific Hawaii

**Bulletin Number** (should be 1) ................................................................. O 0
**Message Type** ......................................................................................... O 0
**Which Places in Warning/Watch and Hawaii Status** ............................. O 0
**Add Statement for Anything Unusual** .................................................... O 0
**Earthquake Parameters** .......................................................................... O 0
**Estimated Arrival Times** .......................................................................... O 0

**Read** HAWAS message (hawmsg) ............................................................ O

**Check** that all Messages Went Out and Resend if Necessary

  DCS, AFTN, NMC, Fax/Telex, NWW ..........................................................O
  Web, Email, IDN, EMWIN, HFO Fax ..........................................................O

**Call Down** List ............................................................................................ O
## CRITERIA TABLES – ACTIONS

### PTWS MESSAGE ISSUANCE GENERAL SUMMARY

PTWC, NWPTAC for the issuance of bulletins.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>PTWC, NWPTAC ACTIONS</th>
</tr>
</thead>
</table>
| Mw greater than Alarm threshold. | **PTWC:** Issue Observatory Message - preliminary earthquake parameters  
**NWPTAC:** No bulletins issued. |
| Pacific region, Mw > 6.5 < Mw <=7.5  
Or EQ > 7.5 but deep inside earth, clearly inland, or outside Pacific Basin.  
* Thresholds lower for some earthquake source regions. | **PTWC:** Issue Tsunami Information Bulletin, with evaluation - widespread destructive tsunami not generated.  
**NWPTAC:**  
a. Shallow undersea Northwest Pacific event with 6.5 < Mw <= 7.0: Very small possibility of destructive local tsunami  
b. Shallow undersea Northwest Pacific with 7.0 < Mw <= 7.5: Possibility of destructive local tsunami w/i 100 km of epicenter |
| Shallow undersea Pacific Basin, 7.5 < Mw <= 7.8  
* Thresholds lower for some EQ source regions. | **PTWC:** Issue Regional Fixed Tsunami Warning Bulletin for coastal areas w/i 1000 km of epicenter.  
Update hourly until sea level gauge readings confirm no further threat exists.  
**NWPTAC:** Issue Advisory stating possibility of destructive regional tsunami w/i 1000 km of epicenter |
| Shallow undersea Pacific Basin, Mw > 7.8 | **PTWC:** Issue Regional Expanding Tsunami Warning and Watch Bulletin putting coastal areas w/i 3 hours tsunami estimated time of arrival (ETA) into warning and areas w/i 3-6 hours tsunami ETA into Watch.  
**NWPTAC:** Issue Advisory stating possibility of ocean-wide destructive tsunami. |
| Confirmed tsunami with destructive potential far from source | **PTWC:** Issue Pacific-wide Tsunami Warning Bulletin putting all coastal areas in Warning |
Flow Charts

Effective Way of Presenting SOPs

Flow Charts Indicate:

- Steps to be followed
- Decision Tree
- Systems or subsystems involved

- Flow Charts can be nested!
- BUT, often not useful in real event (cannot give answer when there is uncertainty or data lacking)
  (experience is most important)
PTWC SOP - Pacific Basin EQ

Initial Bull. Only!

- Pacific Region
  - Is Mw ≥ 6.5? NO → No Further Action
  - YES →
    - Is EQ clearly on land? YES → Issue Pacific TIB (land)
    - NO →
      - Is EQ depth clearly >100km? YES → Issue Pacific TIB (deep)
      - NO →
        - Is EQ in WC/ATWC AOR? YES → Issue Hawaii TIB (land)
        - NO →
          - Pacific Marginal Seas

- Is Mw > 7.5? NO → Issue Hawaii TIB
  - YES →
    - Is Mw > 7.8? NO →
      - Issue a Pacific Fixed Regional Warning Bulletin
      - YES → Issue a Pacific Expanding Tsunami Warning
        - Is Hawaii ETA < 3 hrs YES → Issue Hawaii Warning
          - NO →
            - Is Hawaii ETA < 6 hrs YES → Issue Hawaii Watch
              - NO → Issue Hawaii Advisory
            - NO → Issue Hawaii Advisory
        - NO →
          - Is EQ north of 35°N? YES → Issue Hawaii Watch
            - NO → Issue Hawaii Advisory
          - NO → Issue Hawaii Advisory

Back to Main Page
Timeline to Issue Initial Warning Bulletin

- First Location
- Watchstanders Paged
- Refining Location, Magnitude
- Heads Up Voice Message
- Voice Warning Issued
- Text Bulletin Issued

Time in Seconds

0 30 120 180 240
Earthquake Outside Hawaii Region

Timeline to Issue Initial Bulletin

Watchstanders Paged

First Location

Refining Location, Magnitude

Earthquake Msg. Issued (CISN)

Text Bulletin Issued

Time in Minutes

0 2 5 6 7 10

ITP Training Course, Honolulu HI, Aug. 20-31, 2012
For TWC Customers – Users Guide

- System overview / history
- Arrangements / Organizations
- TWC Procedures / Criteria (SOPs)
- Products and their Meaning, includes Example Products
- Technical Background and Interpretation Guidance
  - Tsunami science and hazard
  - EQ source characterization
  - Message interpretation for emergency response
  - Sea level measurement
  - Travel time calculation
  - Wave forecasting
  - Glossary
SUMMARY - MOVING FORWARD

- Develop SOPs
- Use SOPs (Real Event or Exercise)
- Did they work?
  - If not, revise them IMMEDIATELY
- KEEP IT CLEAR, CONCISE, SIMPLE
- FOLLOW YOUR PROCEDURES
- It becomes your basis for action, and is defendable post-event
Thank You

Stuart Weinstein
PTWC

Laura Kong
Masahiro Yamamoto
UNESCO IOC
# Event Operations - TIMELINE-DRIVEN

## CASE 1. Center with Real Time Seismic Processing, Local Earthquake/Tsunami

<table>
<thead>
<tr>
<th>STEP</th>
<th>TIME since EQ*</th>
<th>ACTIVITY</th>
<th>ACTION AND PROCEDURES</th>
</tr>
</thead>
</table>
| 1    | 1 min          | Seismic Alarm Trigger | • Feel earthquake / respond, receive phone call  
• Alarm sounds from automated seismic processing system  
• For a strongly felt earthquake (greater than Modified Mercalli Intensity Scale VI), alert should be **issued immediately** to the public and national disaster management or emergency operations centers advising to clear the beach. |
| 2    | 2 min          | Earthquake Review | • **Review/update automatic** phase picks and solution  
• Perform interactive analysis if required  
• **Highest priority** for review is earthquake magnitude & focal depth |
| 3    | 3 min          | Tsunami Threat Decision Making | • If tsunami simulation database is operational, expected tsunami threat area and heights are determined.  
• If no tsunami simulation database, earthquake magnitude and depth criteria are used as proxy for tsunami threat height and area.  
• **Tsunami Threat threshold criteria should be pre-decided using historical and other science data.** |
| 4    | 5 min          | Issuance of warning and related tsunami information | • If warning thresholds (for earthquake magnitude or expected tsunami height) are exceeded, **issue warning** to tsunami-threatened areas immediately  
• **Calculate tsunami travel times and issue expected tsunami arrival time at forecast points** |
| 5    | 7 min          | Re-analysis | • **Monitor sea level data** (coastal run-up, coastal sea-level, deep-ocean gauges)  
• **Re-evaluation** of focal parameter from Step 2 with additional data.  
• Comparison to focal parameters and tsunami forecasts provided by international/regional centers |
| 6    | 10 min         | Re-evaluation and issuance of new information | • **Upgrading** of warning if observed tsunami are higher than the expected at Step 3  
• **Issuance of tsunami arrival and height observations**  
• (Downgrade or Cancel if tsunami is smaller or no tsunami is observed.) |
| 7    | 10 min to hours | Information | • If tsunami is generated, **tsunami information is regularly issued** until no tsunami threat exists. Neighboring and international tsunami center information should be considered in evaluation. |