UNESCO/IOC – NOAA ITIC Training Program in Hawaii (ITP-TEWS Chile)
TSUNAMI EARLY WARNING SYSTEMS
AND THE PACIFIC TSUNAMI WARNING CENTER (PTWC) ENHANCED PRODUCTS
TSUNAMI EVACUATION PLANNING AND UNESCO IOC TSUNAMI READY PROGRAMME
19-30 August 2024, Valparaiso, Chile

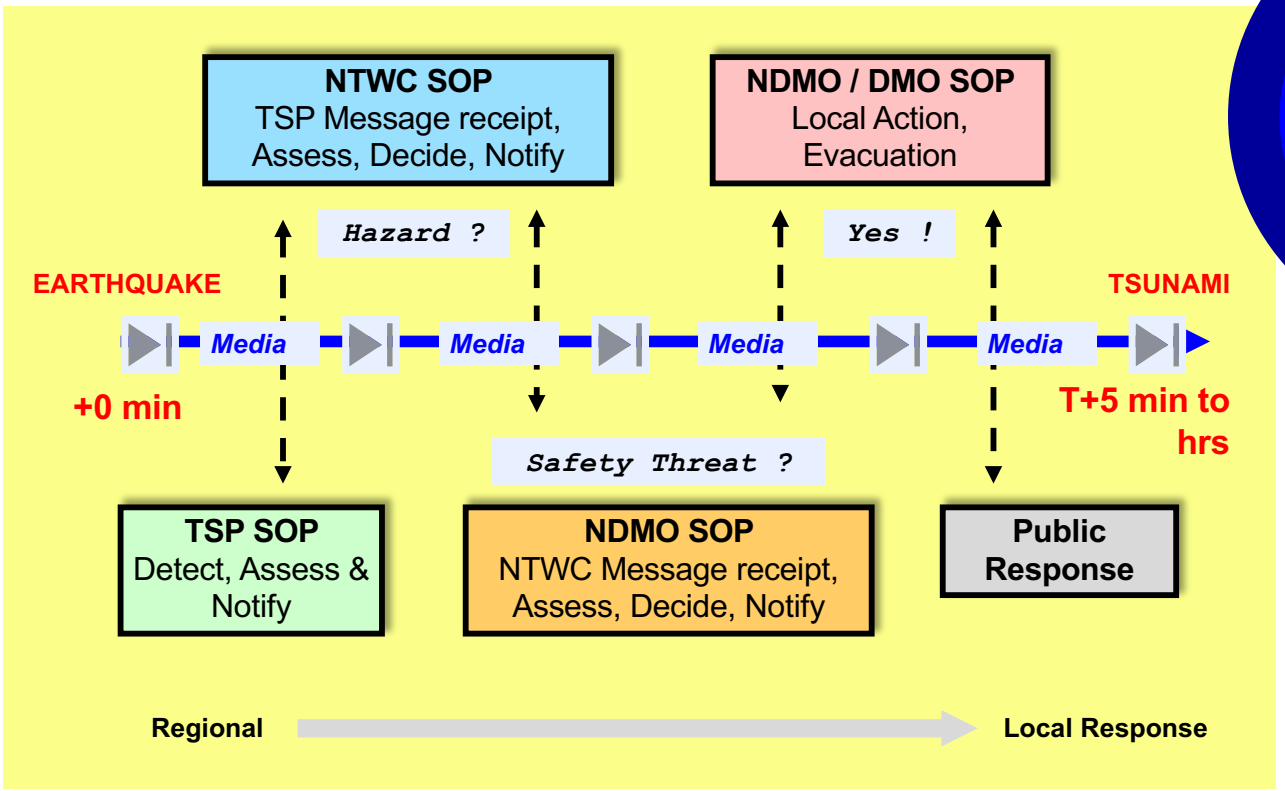
Tsunami Warning Center SOPs

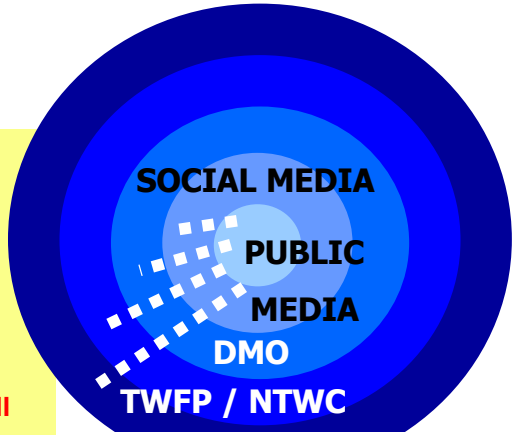
Concept of Operations, Overview of Routine and Event Operations, Flow Charts, Timelines and Checklists

Dr. Laura Kong
Director, ITIC

Dr. Charles McCreery
Director, PTWC

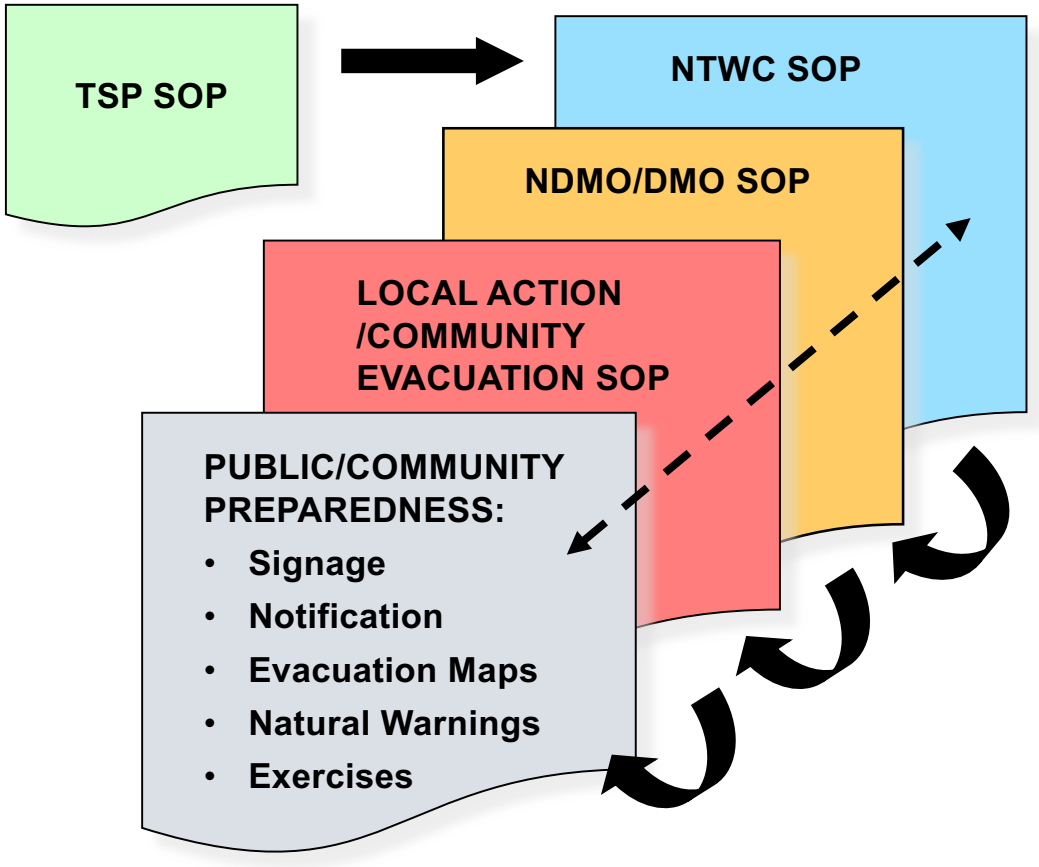
End-to-End Warning Chain





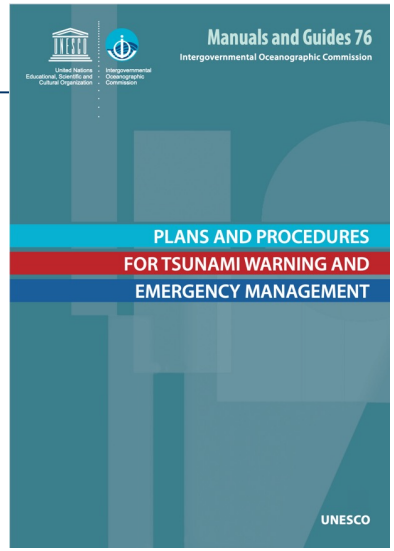
TSP(PTWC, NWPTAC, SCSTAC, CATAC)

Warning Chain – set of linked SOPs



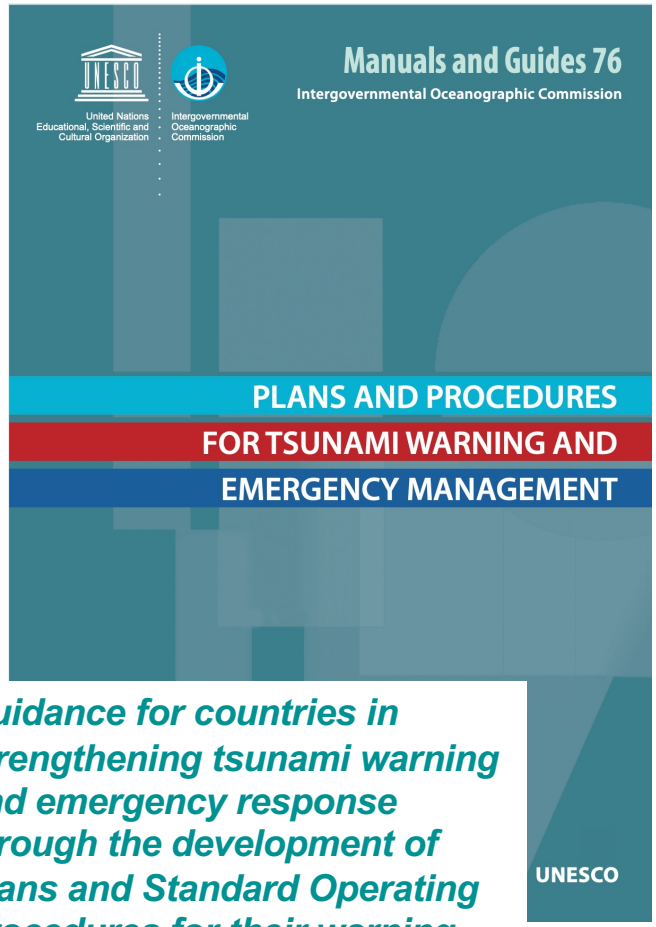
TEWS Course Materials

- TWC/TER SOPs: IOC MG 76 (2017) Plans and Procedures for Tsunami Warning and Emergency Management



- Evacuation Planning: IOC MG 82 (2019) Preparing for Community Tsunami Evacuations: from inundation to evacuation maps, response plans and exercises

TWC and TER Standard Operating Procedures



Guidance for countries in strengthening tsunami warning and emergency response through the development of Plans and Standard Operating Procedures for their warning and emergency management authorities

SOP Working Definition

"A description and procedure on agreed steps by institutions used in coordinating the 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

What are SOPs?

- Set of written instructions for routine/repetitive organization activities. Procedures followed in an emergency.
- Detail work processes conducted/followed within organization.
- Document way activities are performed for consistent conformance to system requirements and organization's mission.

Based on US Environmental Protection Agency Manual

Why are SOPs important?

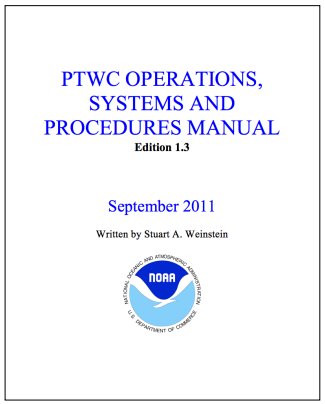
- **Foundation of effective, reliable warning system to protect assets and save lives**
- **All warning systems require SOPs, but for tsunami, essential for rapid response (evaluation / warning / messaging / response)**
- **In an end-to-end system, communications links between stakeholders must be robust or warning chain will be broken**
- **SOPs developed, practiced and modified as necessary – a "living document"**

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/TER 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


PTWC OPERATIONS, SYSTEMS AND PROCEDURES MANUAL
Edition 1.3

September 2011

Written by Stuart A. Weinstein

- **Station Duty Manual**
  - Duty Staff Performance Expectations
  - Maintained by TWC Management
  - Includes Tasks outside Crisis Operations
  - Formal Review / Change Process with Staff

Concept of Operations - Roles and Responsibilities Transmission / Dissemination of Warning

JMA…

- ✓ Issues tsunami warning
- ✓ Disseminates warning to public with media cooperation

Local governments…

- ✓ Disseminate warning to residents
- ✓ Warn residents and relevant organizations to take actions against expected impacts

Concept of Operations - Operation 24 hrs/day, 7 days/week ...

Succession of Operation

- ✓ Morning/Evening Briefings -
  overlap in 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

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/TER SOP and what to expect (Users Guide)

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)

For Warning Centers, SOPs are not just on what to do in an Earthquake.

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

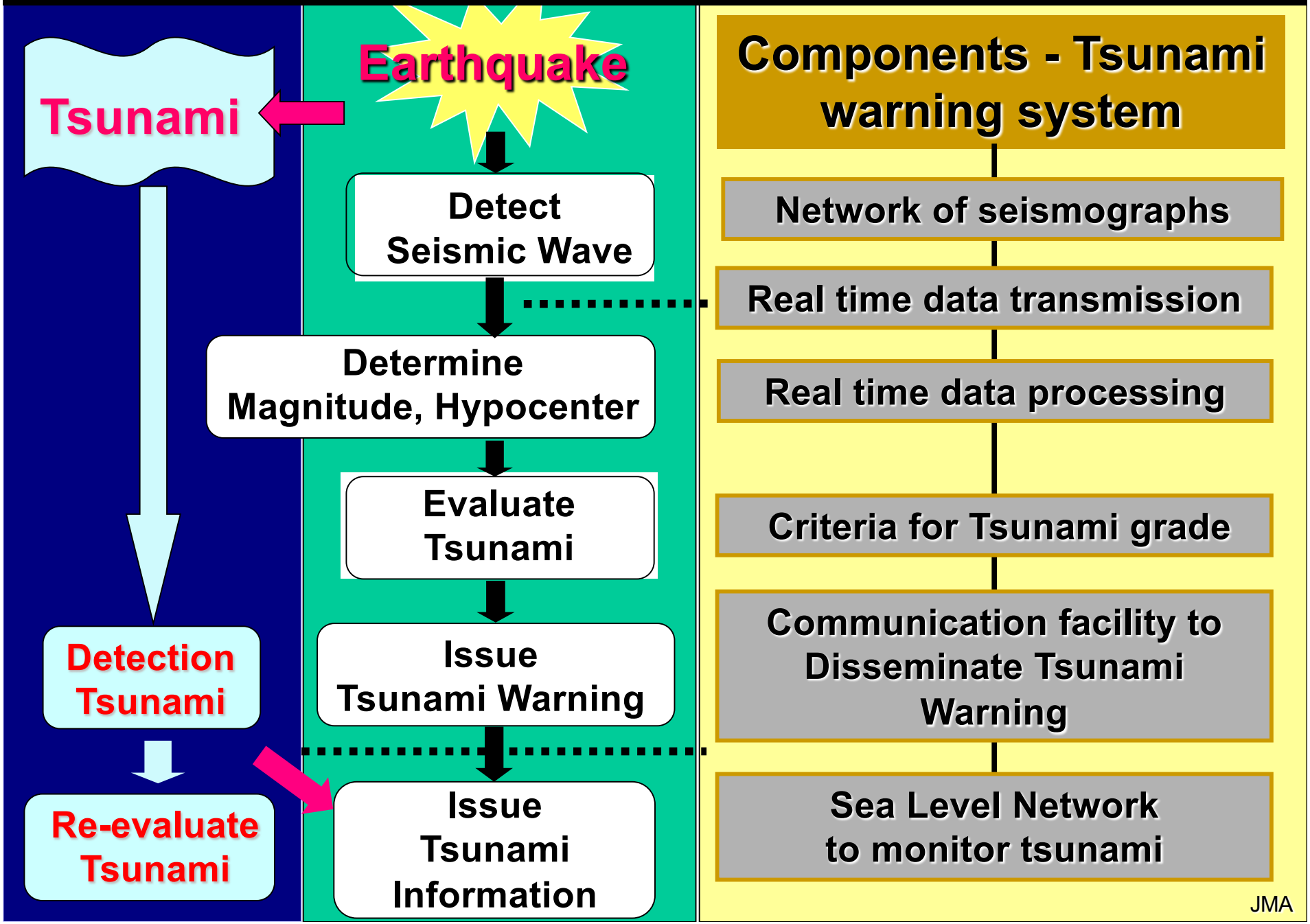
Long Term Readiness:

1. Communication Tests
2. Table-top Exercises

TWC Operations
What should SOPs cover:

- **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

Tsunami Warning - REQUIREMENTS



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/TER SOP and what to expect (Users Guide)

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)

General TWC SOP during an Event

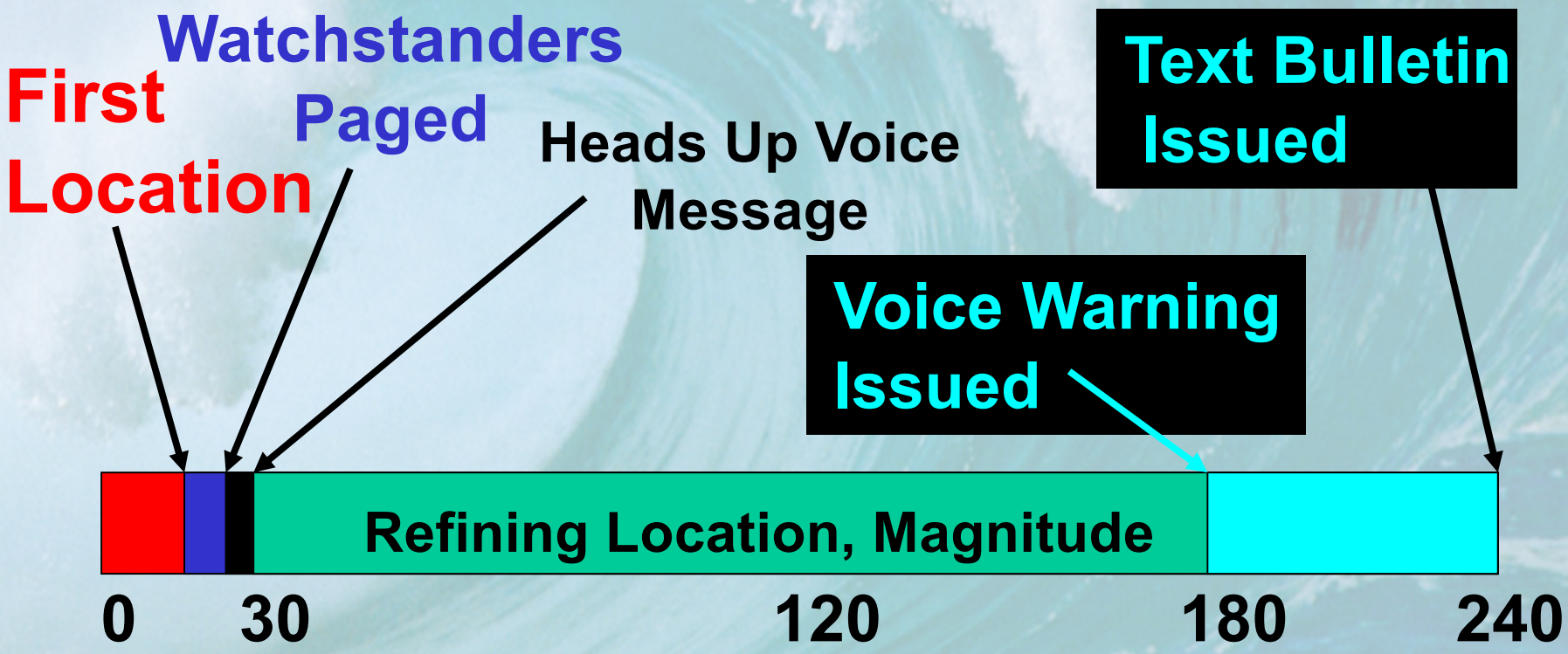
0. EQ!!! - Digital Alarm - Duty Staff paged
1. Detect and Analyze Large Earthquake
2. Determine Tsunami Hazard based on Pre-Determined Criteria
3. Issue Initial Message
4. Further Seismic Analyses
5. Create Forecast if needed, issue 2nd Mess.
6. Detect and Analyze Tsunami Signals
7. Re-evaluate Tsunami Hazard
8. Issue Additional Message
9. Repeat Steps 6-8 until Threat Passed
10. Cancellation or Final Message

Event Operations - Local Event - TIMELINE-DRIVEN

STEP	TIME since EQ*	ACTIVITY	ACTION AND PROCEDURES
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.
8	Hours	Cancellation	• If tsunami threat no longer exists, tsunami warning cancellation is issued.
9	Days to weeks	Tsunami site survey	• Survey of tsunami run-up, inundation, and eyewitness observation along coastal area. • Survey of tsunami disaster on people, structures, geology, and social impact and early warning response
10	Week to months	Summary report	• Analysis of the warning center and emergency response operational procedures • Revision and update of SOP as required

Earthquake in Hawaii Region

Timeline to Issue Initial Warning Bulletin



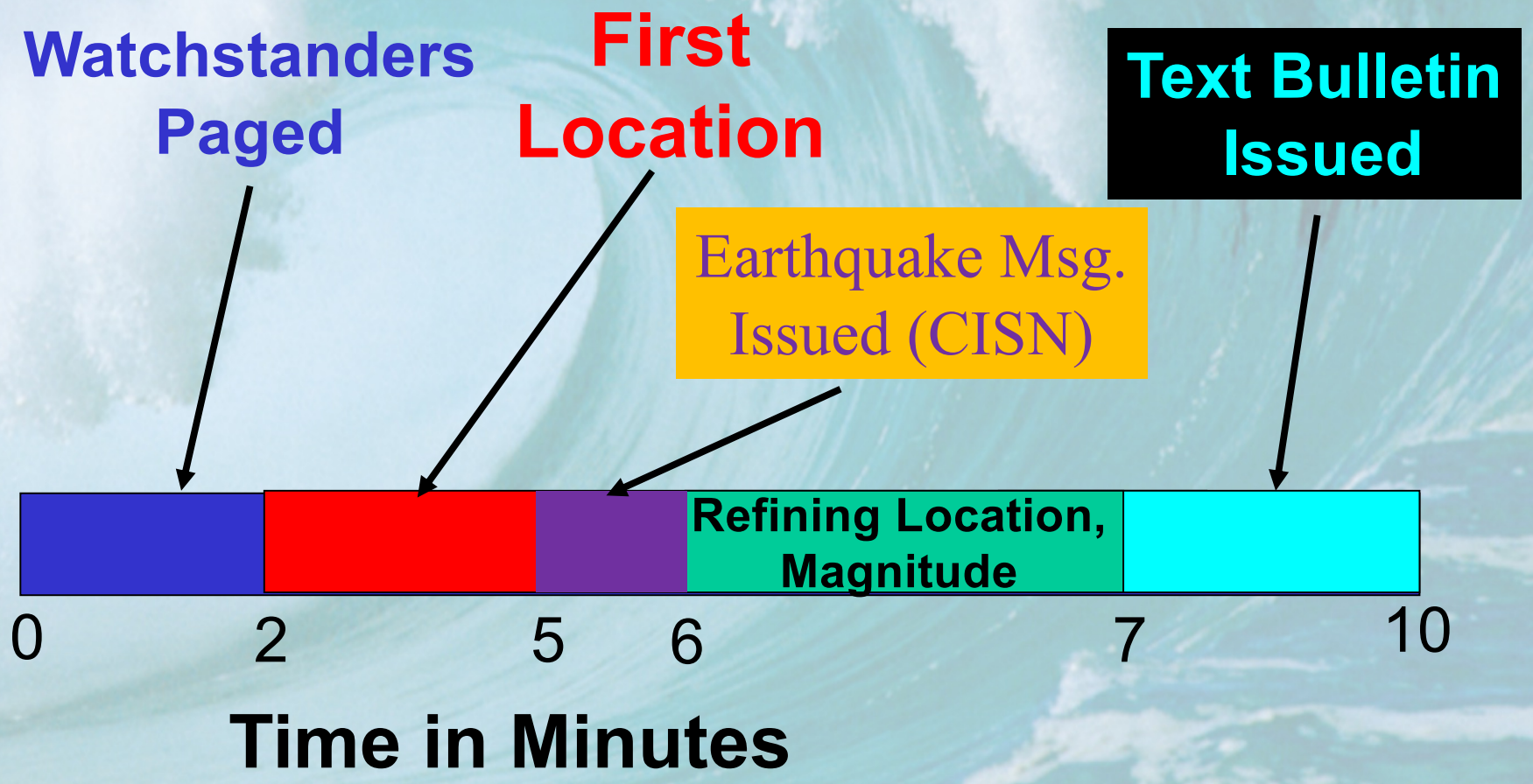
Time in Seconds

Event Operations - Distant Event - TIMELINE-DRIVEN

STEP	TIME since EQ*	ACTIVITY	ACTION AND PROCEDURES
1	3 min	Seismic Alarm Trigger	• Alarm sounds from an automatic seismic processing system • Information provided by international centers; PTWC, WC/ATWC, JMA, WDC-Seismology-NEIC, GFZ??
2	10 min	Earthquake Review and Sea Level monitoring for tsunami generation	• Review/update automatic phase picks and solution, including addition of other international seismic stations • Calculation to tsunami travel times to nearest international sea level stations and national territory • If tsunami travel time to the national territory is within the predefined time, GO to STEP 3. • Continue to monitor sea level data located at near epicenter. • If there is enough time, NTWC shall issue Information that event is under evaluation for the tsunami threat to the national territory. • (If no tsunami is observed in the near source region, Information is issued that there is no tsunami threat.)
3	13 min	Tsunami Threat Decision Making	• Decide on tsunami threat (height and area) based on pre-decided criteria, depending on whether tsunami simulation database exists or not; estimated tsunami • If tsunami is observed at nearby sea level stations, evaluate a tsunami magnitude based on distance and observed tsunami height.
4	15 min to hours	Issue warning and related information	• If warning thresholds (for earthquake magnitude or expected tsunami height) are exceeded, issue warning to tsunami-threatened areas immediately. • If very distant, advise and wait until threat closer for warning.
5	30 min to hours	Re-analysis	• Monitor sea level data (coastal run-up, coastal sea-level, deep-ocean gauges) • Re-evaluation of focal parameter (Step 2) using additional data • Comparison to focal parameters and tsunami forecasts provided by international/regional centers (PTWC, JMA, NEIC)
6	30 min to hours	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 observed.)
7	30 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.
8	Hours	Cancellation	• If tsunami threat no longer exists, tsunami warning cancellation is issued.
9	Days to weeks	Tsunami site survey	• Survey of tsunami run-up, inundation, and eyewitness observation along coastal area. • Survey of tsunami disaster on people, structures, geology, and social impact and early warning response
10	Week to months	Summary report	• Analysis of the warning center and emergency response operational procedures • Revision and update of SOP as required

Earthquake Outside Hawaii Region

Timeline to Issue Initial Bulletin



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 .....O
- Message Type ..... O .....O
- Which Places in Warning/Watch and Hawaii Status ..... O .....O
- Add Statement for Anything Unusual ..... O .....O
- Earthquake Parameters ..... O .....O
- Estimated Arrival Times ..... O .....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

CRITERIA TABLES – ACTIONS
(depends on Location, Magnitude, AOR)

PTWS MESSAGE ISSUANCE GENERAL SUMMARY
PTWC, NWPTAC for the issuance of bulletins.

CRITERIA	PTWC, NWPTAC ACTIONS
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

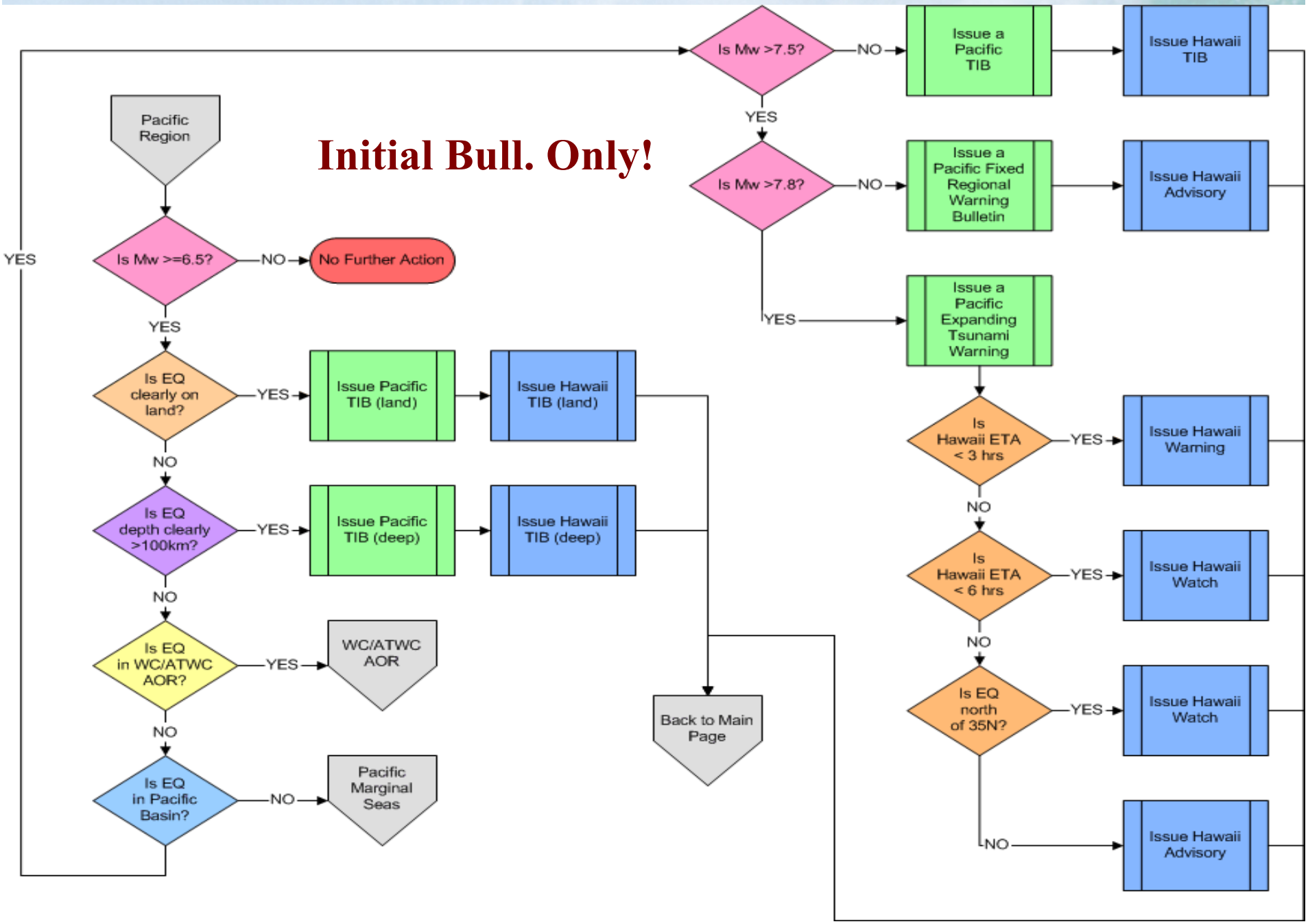
Effective Way of Presenting SOPs

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

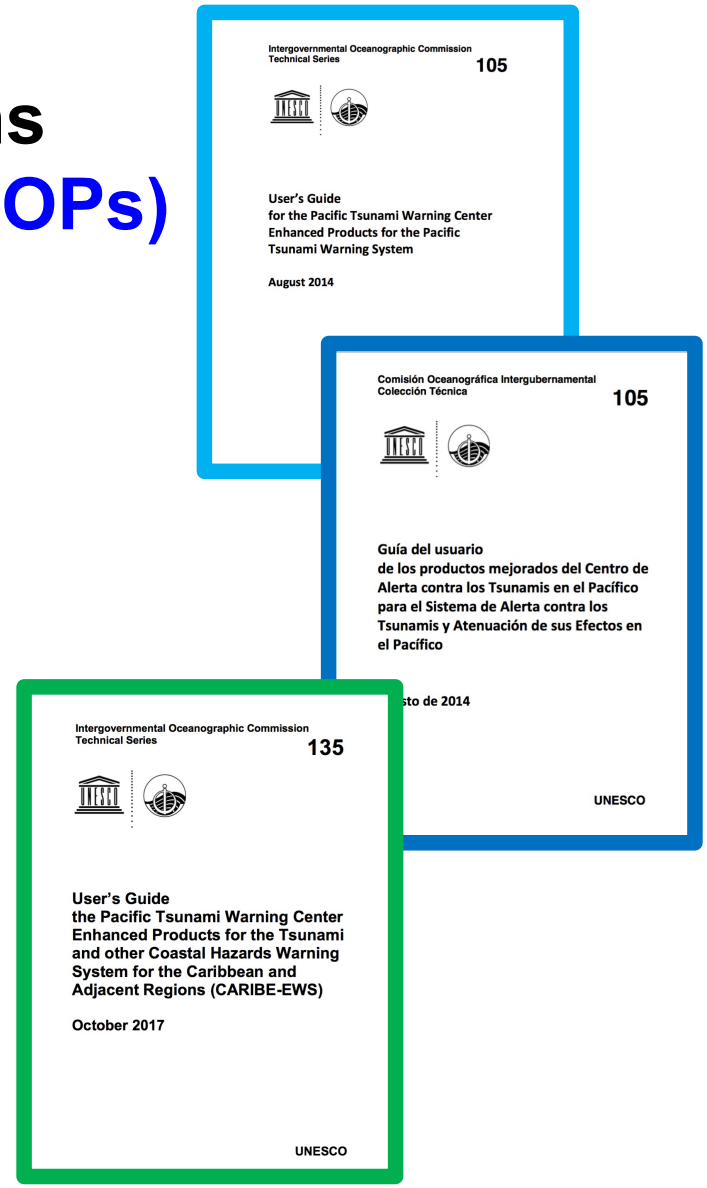


Different Types of SOP Documents

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/TER SOP and what to expect (Users Guide)

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

unesco
Intergovernmental
Oceanographic
Commission

Thank You
Muchas Gracias

Dr. Laura Kong
Director, ITIC

Dr. Charles McCreery
Director, PTWC

USAID
FROM THE AMERICAN PEOPLE

SMART CABLES
Earth's Pulse