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

PTWC Enhanced Products - NTWC and TER Guidance for Warning and Evacuation

Web site: http://itic.ioc-unesco.org/index.php?option=com_content&view=category&layout=blog&id=2548&Itemid=2582

Dr. Laura Kong
Director, ITIC, USA, NOAA

Dr. Charles McCreery
Director, PTWC, USA NOAA

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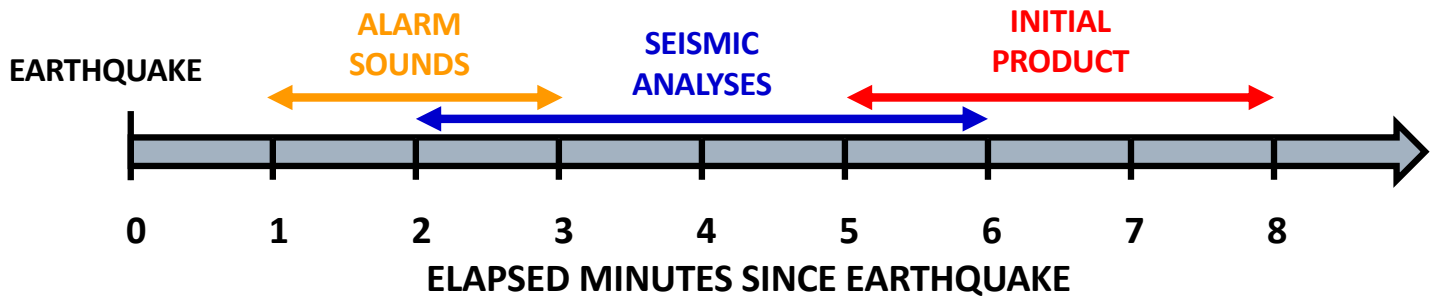
PTWC Enhanced Products
Use of Public Text Message

Charles McCreery, Stuart Weinstein
NOAA Pacific Tsunami Warning Center

Laura Kong *
UNESCO/IOC – NOAA International Tsunami Information Center

*presenter

Timeline of PTWC Activities – Initial Product



0 min	A large earthquake occurs.
1 - 3 min	Vibrations from the earthquake reach seismic stations near the earthquake epicenter, triggering event alarms at PTWC. PTWC duty analysts respond to the operations center and begin to analyze the event. [PTWC currently monitors 700+ seismic stations from around the world, with data collected at most of those stations reaching PTWC within a minute of when it is collected.]
2 - 6 min	Using a combination of automatic and interactive analyses, duty analysts complete their preliminary determination of the earthquake epicenter, depth, and magnitude.
5 - 8 min	If criteria are met, then an **initial product is issued** that is either a Tsunami Information Statement or a Tsunami Threat Message.

Public Text message

Information Statement

- **No Threat**
- **No Action**

PTWC guidance information to Country TWFP/NTWC

A. Tsunami Information Statement (no tsunami threat)

a. Initial Product (text only)

i. Text Product

```
ZCZC
WEPA42 PHEB 010008
TIBPAC

TSUNAMI INFORMATION STATEMENT NUMBER 1
NWS PACIFIC TSUNAMI WARNING CENTER EWA BEACH HI
0008 UTC WED OCT 1 2014


...TSUNAMI INFORMATION STATEMENT...


**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE *****

 THIS STATEMENT IS ISSUED FOR INFORMATION ONLY IN SUPPORT OF THE
 UNESCO/IOC PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM AND IS
 MEANT FOR NATIONAL AUTHORITIES IN EACH COUNTRY OF THAT SYSTEM.

 NATIONAL AUTHORITIES WILL DETERMINE THE APPROPRIATE LEVEL OF
 ALERT FOR EACH COUNTRY AND MAY ISSUE ADDITIONAL OR MORE REFINED
 INFORMATION.

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE *****


PRELIMINARY EARTHQUAKE PARAMETERS
---------------------------------

  * MAGNITUDE      6.7
  * ORIGIN TIME    0000 UTC OCT 1 2014
  * COORDINATES    20.0 SOUTH  173.4 WEST
  * DEPTH          178 KM / 111 MILES
  * LOCATION       TONGA


EVALUATION
----------

  * AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 6.7 OCCURRED
    IN THE TONGA ISLANDS AT 0000 UTC ON WEDNESDAY OCTOBER 1 2014.

  * BASED ON ALL AVAILABLE DATA... THERE IS NO TSUNAMI THREAT
    FROM THIS EARTHQUAKE.


RECOMMENDED ACTIONS
-------------------

  * NO ACTION IS REQUIRED.


NEXT UPDATE AND ADDITIONAL INFORMATION
--------------------------------------
```

Public Text message – Threat Message

1st Message

- Threat
- Take Action
- EQ-based

PTWC guidance information to Country TWFP/NTWC

```
TSUNAMI MESSAGE NUMBER 1
NWS PACIFIC TSUNAMI WARNING CENTER EWA BEACH HI
0005 UTC TUE SEP 8 2015

...TSUNAMI THREAT MESSAGE...

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE *****

 THIS MESSAGE IS ISSUED FOR INFORMATION ONLY IN SUPPORT OF THE
 UNESCO/IOC PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM AND IS
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 ALERT FOR EACH COUNTRY AND MAY ISSUE ADDITIONAL OR MORE REFINED
 INFORMATION.

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE *****

PRELIMINARY EARTHQUAKE PARAMETERS
---------------------------------

  * MAGNITUDE      8.2
  * ORIGIN TIME    0000 UTC SEP 8 2015
  * COORDINATES    10.0 SOUTH  165.0 EAST
  * DEPTH          20 KM / 12 MILES
  * LOCATION       SANTA CRUZ ISLANDS

EVALUATION
----------

  * AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 9.0 OCCURRED IN
    THE SANTA CRUZ ISLANDS AT 0000 UTC ON TUESDAY SEPTEMBER 8
    2015.

  * BASED ON THE PRELIMINARY EARTHQUAKE PARAMETERS... WIDESPREAD
    HAZARDOUS TSUNAMI WAVES ARE POSSIBLE.

TSUNAMI THREAT FORECAST
-----------------------

  * HAZARDOUS TSUNAMI WAVES FROM THIS EARTHQUAKE ARE POSSIBLE
    WITHIN THE NEXT THREE HOURS ALONG SOME COASTS OF

      SOLOMON ISLANDS... VANUATU... NAURU... PAPUA NEW GUINEA...
      TUVALU... KOSRAE... NEW CALEDONIA... MARSHALL ISLANDS...
      WALLIS AND FUTUNA AND HOWLAND AND BAKER
```

Public Text message – Threat Message

2nd-3rd Message

- Threat
- Take Action
- Wave Forecast

PTWC guidance information to Country TWFP/NTWC

```
TSUNAMI MESSAGE NUMBER 2
NWS PACIFIC TSUNAMI WARNING CENTER EWA BEACH HI
0025 UTC TUE SEP 8 2015

...TSUNAMI THREAT MESSAGE...

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE *****

 THIS MESSAGE IS ISSUED FOR INFORMATION ONLY IN SUPPORT OF THE
 UNESCO/IOC PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM AND IS
 MEANT FOR NATIONAL AUTHORITIES IN EACH COUNTRY OF THAT SYSTEM.

 NATIONAL AUTHORITIES WILL DETERMINE THE APPROPRIATE LEVEL OF
 ALERT FOR EACH COUNTRY AND MAY ISSUE ADDITIONAL OR MORE REFINED
 INFORMATION.

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE *****

PRELIMINARY EARTHQUAKE PARAMETERS
---------------------------------

  * MAGNITUDE      9.0
  * ORIGIN TIME    0000 UTC SEP 8 2015
  * COORDINATES    10.0 SOUTH  165.0 EAST
  * DEPTH          20 KM / 12 MILES
  * LOCATION       SANTA CRUZ ISLANDS

EVALUATION
----------

  * AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 9.0 OCCURRED IN
    THE SANTA CRUZ ISLANDS AT 0000 UTC ON TUESDAY SEPTEMBER 8
    2015.

  * BASED ON ALL AVAILABLE DATA... HAZARDOUS TSUNAMI WAVES ARE
    FORECAST FOR SOME COASTS.

TSUNAMI THREAT FORECAST...UPDATED
---------------------------------

  * TSUNAMI WAVES REACHING MORE THAN 3 METERS ABOVE THE TIDE
    LEVEL ARE POSSIBLE ALONG SOME COASTS OF

      AUSTRALIA... NEW CALEDONIA... VANUATU... SOLOMON ISLANDS...
      AND PAPUA NEW GUINEA.

  * TSUNAMI WAVES REACHING 1 TO 3 METERS ABOVE THE TIDE LEVEL ARE
    POSSIBLE ALONG SOME COASTS OF

      NEW ZEALAND... CHUUK... FIJI... KIRIBATI... TONGA... AND
```

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19-30 August 2024, Valparaiso, Chile

PTWC Enhanced Products Guidance for National Warnings and Evaluation: Land and Marine Threats and Public Safety

Charles McCreery, Stuart Weinstein
NOAA Pacific Tsunami Warning Center

Laura Kong *
UNESCO/IOC – NOAA International Tsunami Information Center

*presenter

Country NTWC tsunami event - Key SOPs:

- **Alert Criteria Table.** **Gives alert thresholds and Emergency Response actions**
  (TSP-SCS Guidance 2018; PTWC Enhanced Products User's Guide App VI, VIII)
- **Message templates and Checklists** **Facilitates quick standard responses. Checklists remind Duty Staff**
- **Communication Flow Chart.** **Shows primary agencies / stakeholders of warning chain (TSP => Natl / Local Warning / Emergency Authorities => Public)**
- **Timeline-driven SOPs. Describe by Time, Who, What, How, and To whom.**

=> Exercises practice / improve TWC / TER SOPs

Alert Criteria Table

- **Thresholds are used to assign Alert Levels (Warning, Advisory, Watch, Information)**
- **Alert Levels correspond to country's**
  - Forecast Maximum Coastal Wave Amplitude and/or Earthquake Magnitude, along with
  - Estimated time to first impact and certainty or confirmation of forecast
- **Emergency Response Actions correspond to Alert Level**

Simple Criteria Table

Countries can further customize by assigning different thresholds for different source regions. 2 cases:

- **NO TSP QUANTITATIVE FORECAST**

  TSP Information Statement or Threat Message issued within 10 minutes after M6.5+ earthquake.

- **TSP QUANTITATIVE FORECAST**

  TSP Threat Message issued 10 minutes to 1 hour after a large earthquake with tsunamigenic potential

  - **Warning / Watch Alerts (1.0 m threshold)**
  - **Warning / Advisory / Watch Alerts (0.3 / 1.0 m thresholds)**

PTWC, NWPTAC, SCSTAC
Alert Criteria Table: OT + 8-10 min – Case 1

1. CRITERIA TABLE - NO QUANTITATIVE TSP FORECAST PRODUCT

Criteria Table for NTWC tsunami alerts and emergency response actions based upon the initial TSP product, typically issued within 10 minutes of any large South China Sea region earthquake, prior to the computation of a quantitative tsunami forecast. Key criteria for each situation are indicated in bold red letters.

TSP Product Type	Earthquake Parameters	Potential Tsunami Type	Are Possible Hazardous Tsunami Waves Indicated for Your Country or Area	Threatened Coast	Time left to Initial Wave Arrival (ETA)	NTWC Alert Level for Threatened Coast	Emergency Response Action
PTWC Information **NWPTA** **SCSTAC Information**	Magnitude of 6.5-7.0, or on land, or ≥ 100 km depth	None or Very Minor	No	None	Not applicable	INFORMATION	No action required
PTWC Threat **NWPTA** **SCSTAC Threat**	**Magnitude of 7.1-7.5**, undersea or very near the sea, and < 100 km depth	Local Tsunami	**Yes**	< 300 km from earthquake	< 1 hour typical	WARNING	Evacuate threatened coast
			No	≥ 300 km from earthquake	> 1 hour typical	INFORMATION	Monitor subsequent messages
	Magnitude of 7.6 and greater, undersea or very near the sea, and < 100 km depth	Regional Tsunami	**Yes**	< 1000 km from earthquake	**< 3 hours**	WARNING	Evacuate threatened coast
			Yes	≥ 1000 km from earthquake	**3 to 6 hours**	WATCH	Prepare to evacuate
			No	≥ 1000 km from earthquake	**> 6 hours**	INFORMATION	Monitor subsequent messages

NOTES for 1., 2A, 2B:

- In a local tsunami situation, in order to provide the fastest alert, earthquake magnitude criteria should be used. Issuance of a Warning, Watch, or Information is dependent on the size of the earthquake and its closeness to coastlines. Smaller magnitude earthquakes that are closer to the coast may warrant issuance of a Warning.
- Local tsunami criteria based solely on magnitude should be determined after examining a country historical earthquake tsunami hazard. In some places, the local tsunami magnitude threshold may need to be lower than M7.1. The M7.1 threshold is used by PTWC for its Caribbean Tsunami Watch Service and was used by the PTWC for its Indian Ocean Tsunami Watch Service.
- The 3-hour time criteria is based on the amount of time required for a country to safely complete a coastal evacuation. The 3-hr threshold used by PTWC is considered a conservative, but reasonable time criteria. Historically, the value is from a requirement from Hawaii State Emergency Management Agency as the time required to safely evacuate all coasts of the State of Hawaii. Each country should consider their situation.
- The 6-hour time criteria is based on the amount of time required for a country to activate its emergency response personnel to be able to carry out an orderly evacuation. The 6-hr threshold used by PTWC is considered a conservative, but reasonable time criteria. Historically, the value is from a requirement from Hawaii State Emergency Management Agency as the time required, given the location of likely tsunami sources that will impact Hawaii. Each country should consider their situation.

PTWC, NWPTAC, SCSTAC
Alert Criteria Table: OT + 8-50 min – Case 2A

CASE 2A, 2B: TSP FORECAST AVAILABLE
Earthquake: Magnitude 7.1 or greater, undersea or very near the sea, and < 100 km depth

2.A. CRITERIA TABLE – QUANTITATIVE TSP FORECAST PRODUCT:
Warning / Watch Alerts (1.0 m threshold)

Criteria Table for NTWC tsunami alerts and emergency response actions based upon TSP messages that includes a quantitative tsunami forecast typically issued between 8 minutes to one hour after a large South China Sea region earthquake with a tsunami-genic potential. Key criteria for each situation are indicated in bold red letters. This uses the same criteria (> 1 m) used by PTWC until September 30, 2014 to designate Warning/Watch alert levels.

Threat Level Criteria Table (1m Warning threshold)

TSP Product Type	TSP Forecast of Maximum Coastal Amplitude	Country's Threat Level	Estimated Time of Wave Arrival (ETA)	Emergency Response Action
PTWC Threat NWPTA SCSTAC Threat	H >= 1 m	WARNING	< 3 hours	Evacuate tsunami evacuation zones
PTWC Threat NWPTA SCSTAC Threat	H >= 1 m	WATCH	3 to 6 hours	Prepare to evacuate
PTWC Threat NWPTA SCSTAC Threat	H >= 1 m	INFORMATION	> 6 hours	Monitor event, alert EM stakeholders
PTWC Threat or Information NWPTA SCSTAC Threat or Information	H < 1 m	INFORMATION		No Action
PTWC Threat	H >= 1 m at distant coastline	Determine from distant tsunami threat: PTWC message nbr 1	> 3 hours	Monitor event, alert EM stakeholders

PTWC, NWPTAC, SCSTAC
Alert Criteria Table: OT + 8-50 min – Case 2A

Threat Level Criteria Table (0.3m Advisory, 1m Warning threshold)

TSP Product Type	TSP Forecast Coastal Amplitude	Country's Threat Level	Estimated Time of Wave Arrival (ETA)	Emergency Response Action
PTWC Threat NWPTA SCS Threat	H >= 1 m	WARNING	< 3 hours	Evacuate tsunami evacuation zones
PTWC Threat NWPTA SCS Threat	0.3 m <= H < 1 m	ADVISORY	< 3 hours	Clear Beaches, low lying coastal areas, harbors, waterways
PTWC Threat NWPTA SCSTAC Threat	H >= 0.3 m	WATCH	3 to 6 hours	Prepare to evacuate
PTWC Threat NWPTA SCSTAC Threat	H >= 0.3 m	INFORMATION	> 6 hours	No Action
PTWC Information NWPTA SCSTAC Information	H < 0.3 m	INFORMATION		No Action
PTWC Threat	H >= 1 m at distant coastline	Determine from distant tsunami threat: PTWC message nbr 1	> 3 hrs	Monitor event, alert EM stakeholders

2.B. CRITERIA TABLE – QUANTITATIVE TSP FORECAST PRODUCT:
Warning / Advisory Watch Alerts (0.3 / 1.0 m thresholds)

Criteria Table for NTWC tsunami alerts and emergency response actions based upon TSP messages that includes a quantitative tsunami forecast typically issued between 8 minutes to one hour after a large South China Sea region earthquake with a tsunami-genic potential. Key criteria for each situation are indicated in bold red letters. This adds another NTWC alert level; the Advisory corresponds to a lower level of Warning, and calls for evacuating the beaches and harbors only.

Laboratory studies complementing empirical structural damage and casualty data collected from recent tsunamis show that tsunami inundation or flow depths of less than one meter, and as small as tens of centimeters, can be dangerous and destructive (e.g., Arikawa et al., 2006; Suppasri et al., 2013)[1,2]. The data suggest that a lower level of warning for a marine threat may be desirable. The response to this lower level of warning would be for people to avoid beaches and low-lying coastal areas, and for vessels in harbors and waterways to take precaution against unusually strong water currents. This lower level of warning is used in the United States, and is termed an Advisory. In an Advisory status, a full scale land

ENHANCED PRODUCTS GUIDANCE: FORECAST => WARNING => EVACUATION

- **Amplitude ≥ 3 m WARNING**
  => Major Land Threat:
  Evacuate Tsunami Coastal Evacuation Zones
- **1 m ≤ Amplitude < 3 m WARNING**
  => Land Threat:
  Evacuate Tsunami Coastal Evacuation Zones
- **0.3 m ≤ Amplitude < 1 m ADVISORY**
  => Marine Threat:
  Clear beaches, harbors, low lying coastal areas
- **Amplitude < 0.3 m** *=> No Threat, No Evacuation*
- **Value not computed** *=> Monitor Event*

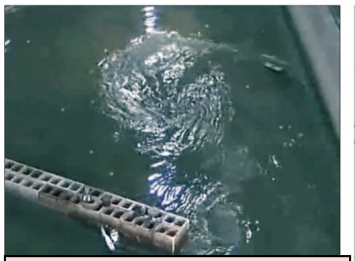
ADVISORY - Marine Threat – CLEAR BEACH

Eddies generated by the interactions of tsunami waves as they hit the coast of Sri Lanka, 26 December 2004. Photo courtesy of Digital Globe.

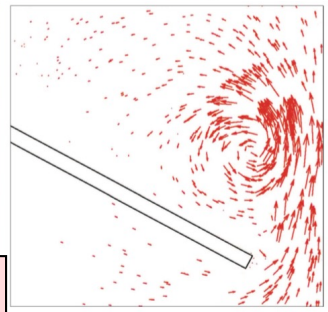
ADVISORY – Marine Threat - Harbors

2011 Japan tsunami
Crescent City, CA
USA

Crescent City, California boat harbor damage after the 2011 Japan tsunami. Strong wave currents entering the enclosed harbor (from top of photo) formed an eddy, which was left in the sediment swirls. The tsunami caused USD $55 million in damage to moorings and vessels in two dozen harbors in California. (Credit: R. Hiser and L. Dengler)

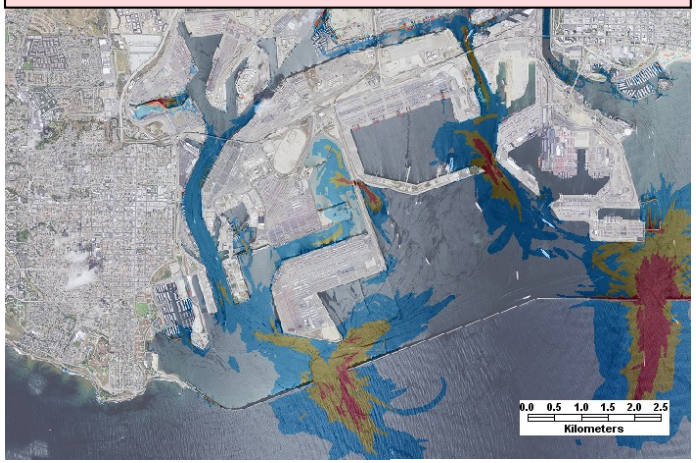


Wave Tank - modeling



Numerical model of eddy forming around breakwater long pier. The length of each arrow is proportional to the current speed. (Credit: Univ. of Southern California)

M9.2 Alaska-Aleutian Scenario
Los Angeles / Long Beach, CA USA



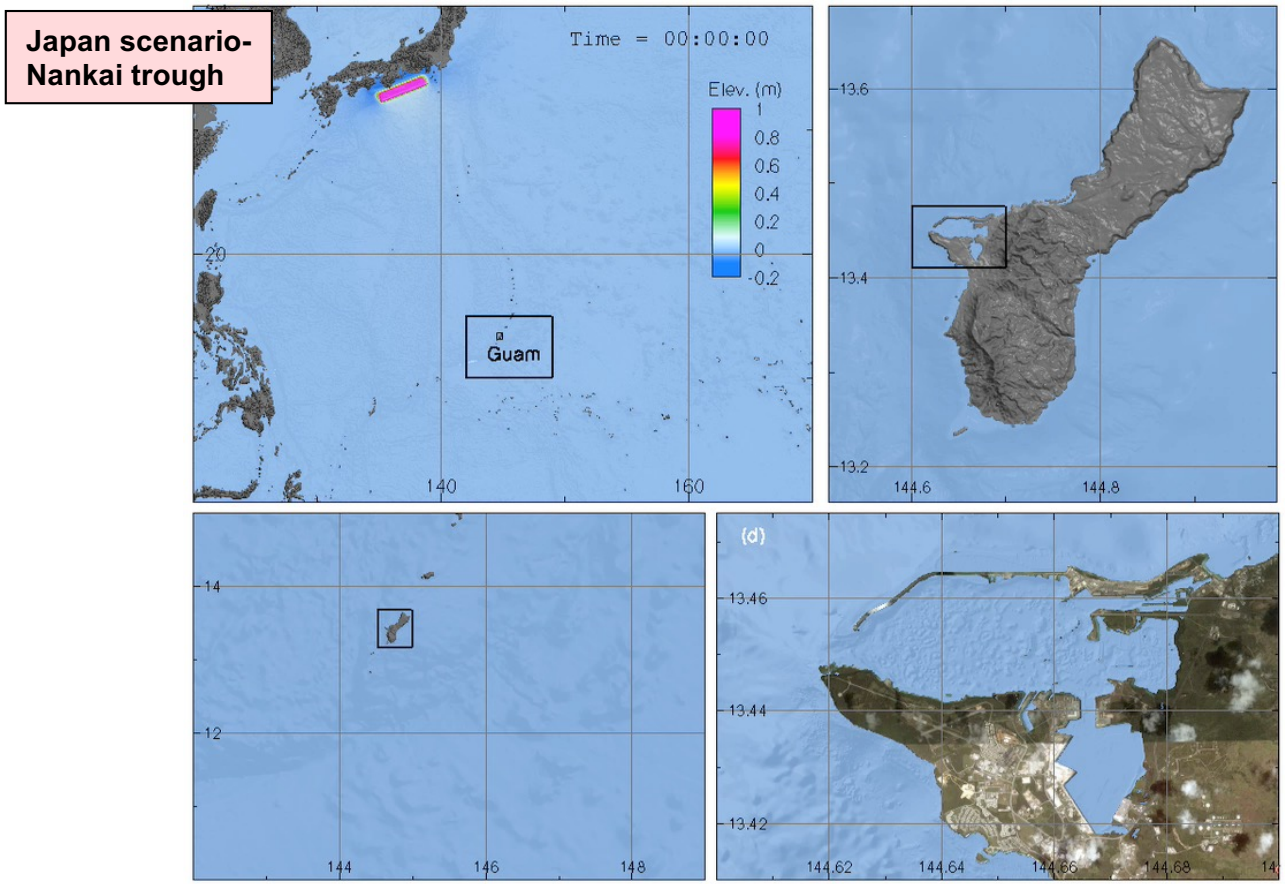
Wilson et al, US NTHMP (2016)

Current Thresholds for Potential Damage

- Minor to moderate damage
- Moderate to major damage
- Major damage/complete destruction

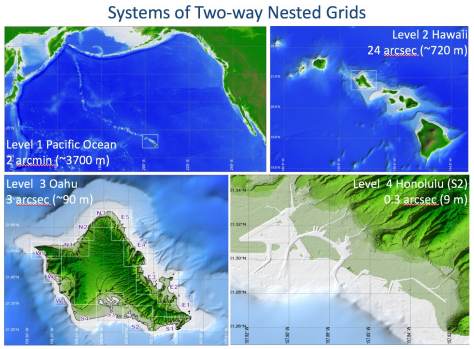
Pacific Tsunami Warning System:
A Half-Century of Protecting the Pacific (1965-2015)
NOAA, ITIC, NCEI, 2015

Apra Harbor, Guam – modeling wave ampl

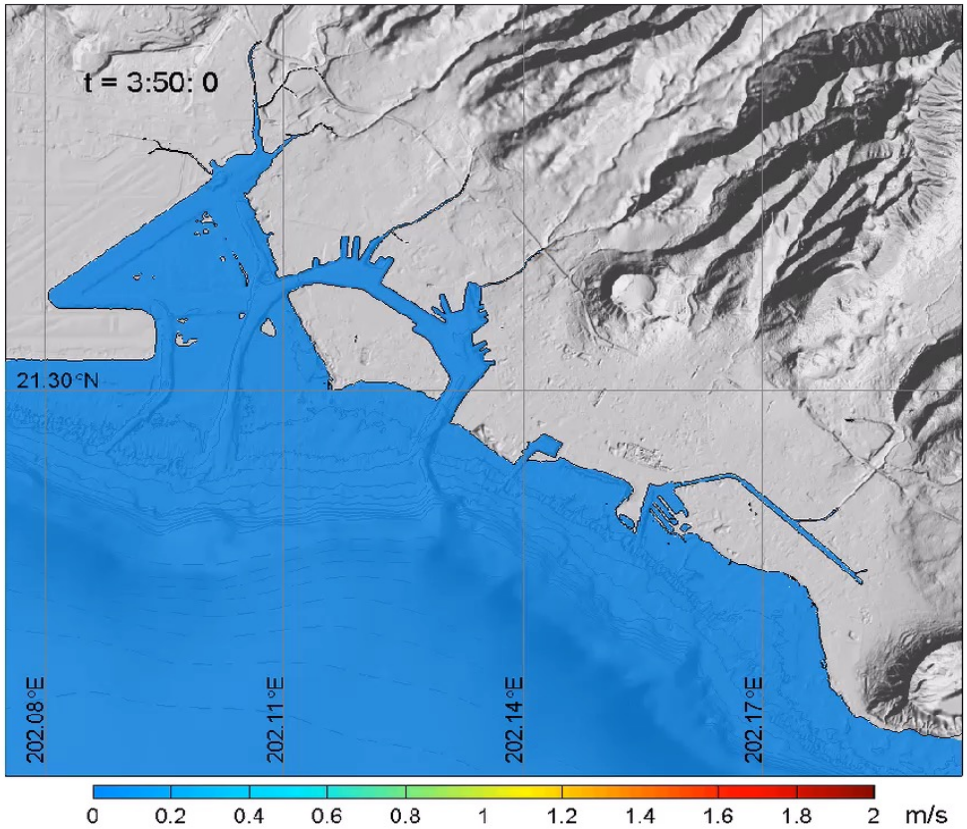


Kwok Fai Cheung, Univ of Hawaii

Honolulu Harbor, Hawaii – modeling currents



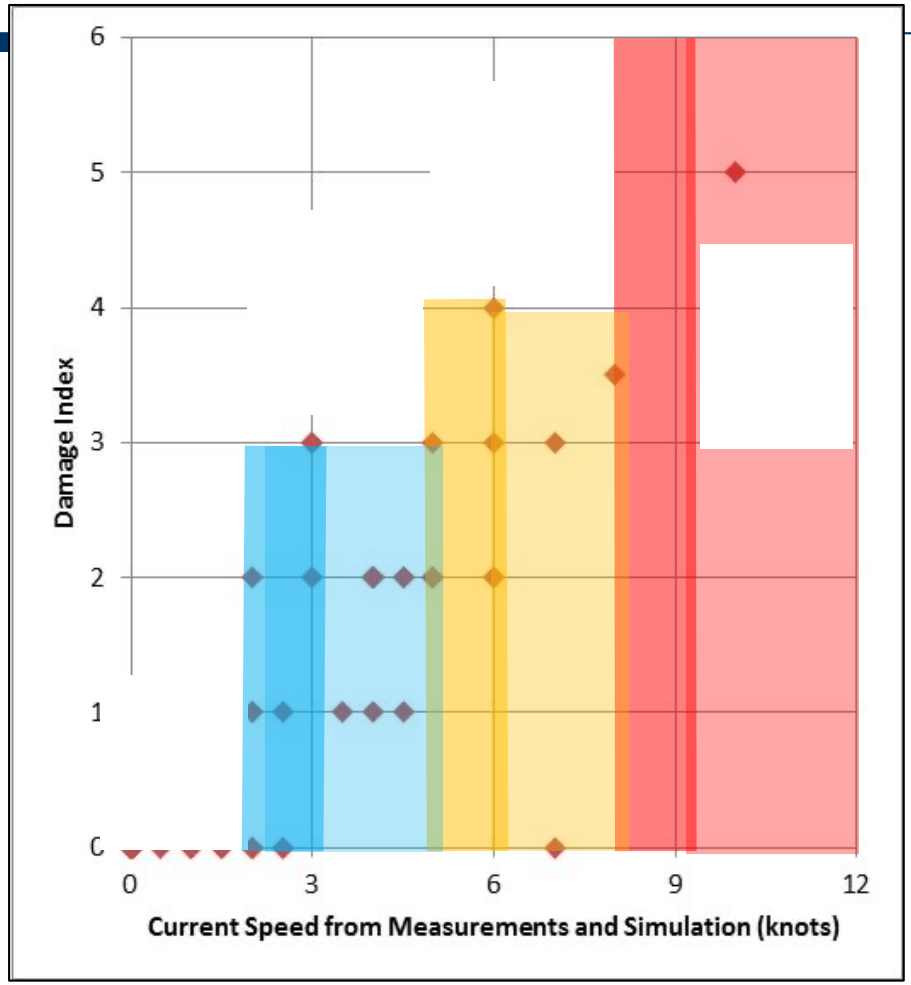
Aleutian scenario M9.3



Kwok Fai Cheung, Univ of Hawaii

Tsunami Current Hazard

Damage Index:	Damage Type:
0	no damage
1	small buoys moved
2	1-2 docks/small boats damaged, large buoys moved
3	Moderate dock/boat damage, mid-sized vessels off moorings
4	Major dock/boat damage, large vessels off moorings
5	Complete destruction



Lynett et al. (2013)

WARNING - Minor Land Threat – EVACUATE

WARNING - Major Land Threat - EVACUATE

Message Products for Alert Levels

- **User's Guide – Appendix VII**
- **Emphasize NTWC and NDMO/DMO are authorities,** not PTWC or other international
- **Create Templates for easy fill-in** (or automatically fill-in with incoming PTWC message). Basic text does not change. Duty Staff only need to fill in event information.
- **Include Review option:** If automated process or GUI used, need to make sure there are 'REVIEW BEFORE SEND' and 'MANUAL ENTRY' options

Message Products for Alert Levels

- **Mimic PREVIOUS PTWC Text Bulletin (Warning, Watch, Information)**
- **Structure**: Header, EQ Info, Evaluation, Forecast (if applicable), Recommended Actions (depending on Threat Level), ETA, Potential Impacts, Tsunami Observations, Next Update and Additional Info
- **Customize for country**
  - Use Local Time
  - Replace PTWC with Country's NTWC
  - Retain only country locs (for threat, ETA). Delete other
  - Specify Local Authority for Public Safety Action (Evacuation), Contact info / how to obtain evac status
  - Specify update schedule

New Products – Sharing of TWFP products

Decide whether to share Graphical Products (currently only to TWFP by email)

- Which Products to share
- To Whom
- Should products be adjusted / customized before sharing?
- Need to socialize/train for shared products

NTWC – TER SOPS

- **Identify Stakeholders. Specify roles.**
- **Describe end-to-end (detection to evacuation)**
- **Warning Communication Flow Chart**
  - Who does What
  - Distant / Regional – Local
  - Warning, Watch, Information Alerts
- **Timeline-driven SOPs**
  - Who does What and When
  - Time, Products, Actions

Final Guidance

- Remember Goal: Early warning to save lives
- Successful warning must be in time, understood, and actionable (e.g., Warning => Evacuate)
- For local threat (< 30-45 min), Education priority.
  People must: 1. Act on Natural Warnings,
  2. Self-Evacuate - do not wait for NTWC warning
- NTWC issue Alert using pre-determined criteria.
  Duty Staff know what to look for in PTWC products
- NTWC can decide Alert Level using only Public Text
  (e.g., map forecast height to Warning).
  NTWC does NOT need to use all products
  (these add value, further detail).

unesco
Intergovernmental
Oceanographic
Commission

Thank You

Dr. Laura Kong
Director, ITIC, USA, NOAA

Dr. Charles McCreery
Director, PTWC, USA NOAA

USAID
FROM THE AMERICAN PEOPLE