PTWC New Enhanced Products for Pacific countries: Overview

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Outline of Presentation

• PTWC Services Summary
• PTWC New Enhanced Products
PTWC Activity: Jan 2013 – May 2014 (17 mo)

- 2000+ Alarms (~120/mo, M4+) by EQs worldwide
- ~500 Observatory Msgs (~30/mo, M5.5+) (=> CISN)

FROM PACIFIC TSUNAMI WARNING CENTER

THIS IS PRELIMINARY DATA, NOT FOR PUBLIC DISSEMINATION. COMPLETE INFORMATION CAN BE OBTAINED FROM THE USGS/NEIC TELEPHONE (303) 273-8500.

H 08:24:47Z MAY 24 2014Z LAT 16.3N LONG 98.2W DEPTH 16.2km Mwp 5.7 (5 STATIONS)

NEAR THE COAST OF GUERRERO, MEXICO

PNIG  P 082452.2  PNIG  S 082456.7  UNM  P 082535.0  CUIG  P 082535.0
LVIG  P 082542.5  PCIG  P 082600.1  TGIG  P 082600.5  ZAIG  P 082638.8
LNIG  P 082650.0  TEIG  P 082713.5  TGUH  P 082722.7  HKT  P 082808.5

- 68 Tsunami Information Bulletins (4/mo, M6.5+) (no tsunami threat) issued for PTWS
- 6 Tsunami Warnings (3/yr, M7.6+) issued for PTWS
## Warnings: January 2013 – May 2014

<table>
<thead>
<tr>
<th>Time (UTC)</th>
<th>Lat</th>
<th>Lon</th>
<th>Dep (km)</th>
<th>Region</th>
<th>PTWC Mw</th>
<th>USGS Mw</th>
<th>1st Msg (min)</th>
<th>Cancel (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>02/06/13 0112</td>
<td>10.9S</td>
<td>165.1E</td>
<td>33</td>
<td>Santa Cruz Islands</td>
<td>8.0</td>
<td>8.0</td>
<td>6</td>
<td>155</td>
</tr>
<tr>
<td>04/01/14 2347</td>
<td>19.8S</td>
<td>70.8W</td>
<td>10</td>
<td>Northern Chile</td>
<td>8.0</td>
<td>8.2</td>
<td>8</td>
<td>296</td>
</tr>
<tr>
<td>04/03/14 0243</td>
<td>20.4S</td>
<td>70.1W</td>
<td>20</td>
<td>Northern Chile</td>
<td>7.8</td>
<td>7.7</td>
<td>8</td>
<td>76</td>
</tr>
<tr>
<td>04/12/14 2015</td>
<td>11.3S</td>
<td>162.3E</td>
<td>10</td>
<td>Solomon Islands</td>
<td>8.3</td>
<td>7.6</td>
<td>5</td>
<td>81</td>
</tr>
<tr>
<td>04/13/14 1236</td>
<td>11.5S</td>
<td>162.1E</td>
<td>20</td>
<td>Solomon Islands</td>
<td>7.7</td>
<td>7.4</td>
<td>10</td>
<td>126</td>
</tr>
<tr>
<td>04/19/14 1328</td>
<td>6.7S</td>
<td>155.0E</td>
<td>10</td>
<td>Solomon Islands</td>
<td>7.8</td>
<td>7.5</td>
<td>9</td>
<td>71</td>
</tr>
</tbody>
</table>

Warnings: January 2013 – May 2014
For Tsunami Warning - 3 Basic Needs

- VERY RAPID (sec-min) EARTHQUAKE EVAL
- VERY RAPID TSUNAMI (min-hr) SEA LEVEL EVAL
- VERY RELIABLE COMMUNICATIONS
  
  e.g., Multi-national, global data networks with real-time transmission and free/open data sharing

- ALL REQUIRED FOR TIMELY WARNING
In 2015, PTWC receiving data from ~600 broadband stations in real time

=> Earthquake location & magnitude in 10s sec - minutes
In 2015, PTWC receiving data from > 600 stations (coastal, deep-ocean) in real time

=> Confirm tsunami within 1 hr locally
Earthquakes:
Denser Networks, Higher Quality Data, Better and Faster Methods => Faster Detection & Response

Average:
2005 ~ 15 min
mid-2015 ~ 7 min
Pre-2014 PTWC Products

- Public Text product only (disseminated by GTS, AFTN, fax, email, EMWIN, website, SMS)

- Product Content
  - Places assigned to be in a Warning or Watch (alert status)
  - Forecast of tsunami arrival times given at designated forecast points
  - Measurements of observed tsunami waves
  - General response guidance

- Issued hourly, or sooner if new information
## Previous PTWC Products – Criteria Table

<table>
<thead>
<tr>
<th>Earthquake</th>
<th>Product Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnitude 6.5-7.5 or &gt;6.5 and &gt;100km depth or far inland</td>
<td>Information Bulletin</td>
<td>No Tsunami Threat or only small Local Tsunami Threat</td>
</tr>
<tr>
<td>Magnitude 7.6-7.8 and &lt;100 km depth and under sea or near sea</td>
<td>Regional Warning</td>
<td>Warning to 1000km from epicenter</td>
</tr>
<tr>
<td>Magnitude &gt;7.8 and &lt;100km depth and under sea or near sea</td>
<td>Expanding Warning</td>
<td>Warning if &lt; 3 hours to impact, Watch if 3-6 hours to impact</td>
</tr>
<tr>
<td>Confirmed major tsunami</td>
<td>Pacific-wide Warning</td>
<td>Confirmed tsunami with widespread destructive threat</td>
</tr>
</tbody>
</table>
Limitations of Previous Procedures

• Last major revision in 2001 (change Ms to Mw)
• Very conservative for safety. Based primarily on limited historical data. Resulted in significant over-warning
• Initially puts areas in Warning or Watch based on:
  o Earthquake magnitude
  o Estimated time left to tsunami impact or
  o Distance from earthquake epicenter
• Timely Alert for regional and basin-wide tsunamis. Not timely for local tsunamis.
• No information on forecast levels of wave impact (hgt)
• PTWC warning advice caused confusion with Country’s authoritative warning
• Text product only
PTWC New Enhanced Products - Timeline

- **History** – in discussion and requested since 2007
  - ICG/PTWS-XXIII, 2011: approved for development
  - Exercise Pacific Wave 2011, 2013 – introduce, feedback
  - ICG/PTWS XXIV, 2013: approved for changeover
  - July 11, 2014: PTWS Steering Committee final review of progress requirements – approved changeover date

- **Changeover:** October 1, 2014, 0000Z
  - PTWC stopped Alert Levels; Started wave height forecasts
  - Countries decide and issue own Alert Levels

- **Exercise Pacific Wave 2015** – February 2-6, 2015
  - Validate New Products
Product Changes – Procedures, Products

- Base threat on wave forecast models, not on pre-determined magnitude threshold
- Forecasts constrained by EQ mechanism (W-CMT) and sea level readings
- Public Text Msg continues – Summary Information
- Graphical forecasts and Statistics table only to Country Tsunami Warning Focal Points (TWFP):
  - Coastal Tsunami Amplitude Forecast Polygon Map - Overview
  - Deep-Ocean Tsunami Amplitude Forecast Map – Pacific-wide
  - Coastal Tsunami Amplitude Forecast Map – Pacific-wide and Regional, with Tsunami Travel Times
  - Coastal Tsunami Amplitude Forecast KMZ– input to Google Earth
  - Table of Forecast Statistics for Regional Polygons
Product Changes - Threat Levels

• No Warning / Watch Alert Levels

• **Instead, issue Threat Levels:**
  4 categories based forecast maximum coastal tsunami wave amplitudes
  • < 0.3m (no Threat)
  • 0.3 to < 1m
  • 1 to 3m
  • > 3m
  • Other: Forecast not yet computed
Benefits

- Reduce conflict with Country NTWC Alert levels
- Still conservative, but greatly reduce over-warning
- Provides estimated level of impact
- Provide Country NTWC with additional decision-making information
  - Graphical, as well as text products
  - “kmz” file of forecast points allows drilling-down to finer spatial resolution
  - Real-time model handles earthquake locations and mechanisms anywhere, not just shallow-thrust events in subduction zones (limitation of SIFT / ATFM models)
  - RIFT model provide Green’s Law coastal forecast for all coasts.
• **Update / New Terms and Definitions**

- **National Tsunami Warning Centre (NTWC):**
  A centre officially designated by the government to monitor and issue tsunami warnings and other related statements within their country according to established National Standard Operation Procedures (SOPs)

- **Tsunami Warning Focal Point (TWFP):**
  A 24 x 7 point of contact (office, operational unit or position, not a person) officially designated by the NTWC or the government to receive and disseminate tsunami information from an ICG Tsunami Service Provider according to established National Standard Operation Procedures. The TWFP may or not be the NTWC

• **Member States update TWFP data to IOC**
  (esp for PTWC New Products to start October 1, 2014)
IOC / ITIC / PTWC working together to:

- **Conduct In-Region, Regional Training (2014):**
  - South China Sea region, Dec 2013
  - Pacific Island Countries, May 2014, **2016**
  - Latin America (C Amer, Mexico, S Amer), Jun 2014

- **Conduct ITP-Hawaii 2014 – New Products SOPs**
  - 2 weeks, Hawaii, August 18-29, 2014
  - 30 participants (80% NTWC), 16 countries

- **Conduct Country Training, on request**
  - 2014: Micronesia (FSM), Palau, Marshall Islands
  - **2015-16:** Tonga, Solomons, Colombia, Cook Islands, Peru
  - **2016:** Regional PIC (Qtr 1?), ITP-Hawaii (Aug)
PTWC Enhanced Products
Event timeline, Product Staging

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Dr. Laura Kong
Director, International Tsunami Information Center

Dr. Stuart A. Weinstein
Deputy Director, Pacific Tsunami Warning Center
### Timeline of PTWC Activities in Response to an Earthquake/Tsunami

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h00m</td>
<td>A large <strong>earthquake occurs</strong> in the Pacific region.</td>
</tr>
<tr>
<td>00h02m</td>
<td>Vibrations from the earthquake reach seismic stations near the earthquake epicenter, triggering <strong>event alarms at PTWC</strong>. PTWC duty analysts respond to the operations center and begin to analyze the event. [PTWC currently monitors ~ 600 seismic stations from around the world, with data collected at most of those stations reaching PTWC within a minute of when it is collected.]</td>
</tr>
<tr>
<td>00h05 to 08m</td>
<td>Using a combination of automatic and interactive analyses, duty analysts complete their <strong>preliminary determination of the earthquake epicenter, depth, and magnitude</strong>.</td>
</tr>
</tbody>
</table>
Based on the preliminary earthquake parameters, for any Pacific-region earthquake with a magnitude of 6.5 or above, initial text products are generated and issued according to the following general procedures that are similar to procedures used prior to the enhanced products. Some deviation from these procedures may occur based upon the scientific judgments of the duty staff. A quantitative forecast is not issued yet due to having too little information this early on to properly constrain such a forecast.

1. If the EQ is too deep within the earth (≥100km depth) or is located too far inland to significantly displace the seafloor, then a Tsunami Information Statement (TIS) will be issued indicating no tsunami threat.

2. If the EQ is shallow (<100km depth) and undersea and has a magnitude of 6.5 to 7.0, then a Tsunami Information Statement (TIS) will be issued indicating no tsunami threat but with minor sea level fluctuations possible.

3. If the EQ is shallow (<100km depth) and undersea and has a magnitude of 7.1 to 7.5, then a Tsunami Threat Message (TTM) will be issued indicating a possible tsunami threat to coasts located w/i 300km of the epicenter.

4. If the EQ is shallow (<100km depth) and undersea and has a magnitude of 7.6 to 7.8, then a Tsunami Threat Message (TTM) will be issued indicating a possible tsunami threat to coasts located w/i 1000km of the epicenter.

5. If the EQ is shallow (<100km depth) and undersea and has a magnitude of 7.9 or greater, then a Tsunami Threat Message (TTM) will be issued indicating a possible tsunami threat to coasts located w/i 3 hours tsunami travel time.
<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Activity Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h15m to 20m</td>
<td>Seismic analyses continue as data from additional seismic stations arrive and are processed. If the earthquake parameters change significantly based on these analyses then the appropriate supplemental text product will be issued, using the procedures described above.</td>
</tr>
<tr>
<td>00h20m to 30m</td>
<td>For earthquakes with a tsunami threat, the <strong>W-phase Centroid Moment Tensor (WCMT)</strong> analysis is triggered with results typically available about 20-25 minutes after the earthquake. The WCMT analysis not only gives a more accurate estimate of the earthquake’s location, depth and magnitude, but also an estimate of the earthquake’s faulting mechanism – the strike angle of the fault, the dip angle of the fault, and the direction and amount of slip along the fault. These parameters are critical to constrain the estimate of seafloor deformation that is the tsunami source. They are used to drive a run of the tsunami <strong>forecast</strong> model covering the region nearest the epicenter. For events with <strong>forecast coastal amplitudes</strong> above <strong>0.3 m</strong> anywhere within the PTWC area of responsibility, a Tsunami Threat Message (<strong>TTM</strong>) is issued along with accompanying <strong>graphical maps</strong>, <strong>statistics table</strong>, and <strong>KMZ file</strong> that covers the affected region.</td>
</tr>
<tr>
<td>00h30m to 45m</td>
<td>The <strong>forecast</strong> model is run for the <strong>entire Pacific region</strong> unless it is necessary or appropriate to run it over a smaller domain, possibly with a smaller grid spacing. Products are then issued.</td>
</tr>
</tbody>
</table>
Timeline of PTWC Activities in Response to an Earthquake/Tsunami

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h15m to 02h00m</td>
<td><strong>Sea level gauges are monitored</strong> for tsunami signals. Within the first 30 minutes to an hour the tsunami may arrive on the nearest one or two coastal gauges and one or two deep-ocean gauges. Tsunami amplitudes are measured and compared, when possible, with forecast amplitudes produced by the models. The <strong>model forecast may be adjusted to be more consistent with observations.</strong></td>
</tr>
<tr>
<td>Beyond 2h</td>
<td>The process of refining the earthquake parameters and collecting additional sea level observations continues, with that information used to constrain the forecast if necessary. The tsunami is monitored as it advances. <strong>When it is likely that there is no longer a significant continuing tsunami threat for most areas</strong> then a <strong>final product</strong> is issued. Due to resonances in enclosed bays, and to tsunami energy that gets trapped around islands and along continental shelves or is re-energized by reflections, some areas may continue to experience hazardous sea level oscillations. It is <strong>up to local officials to determine when coasts are safe, persons can return to evacuated areas, and normal activities may resume.</strong></td>
</tr>
</tbody>
</table>
PTWC Enhanced Products:
Public Text Product - Example
Public Text message

Information Statement

• No Threat
• No Action

A. Tsunami Information Statement (no tsunami threat)

   a. Initial Product (text only)

      i. Text Product

         PCWC
         WEMA42 PHEB 010009
         TIBFAC

         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.
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 *****

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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
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
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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
PTWC Enhanced Products:
TWFP Products - Examples
Graphical Product: Deep-Ocean Forecast

- Tsunami Travel Time contours (assumes point source)
- Color range scaled so red/white show maxima
- Shaded textures show energy distribution
Green’s Law used to propagate off-shore, deep-ocean to coast

Tsunami Travel Time contours (assumes point source)

Tsunami Wave Amplitudes at designated coastal forecast points (Green’s Law)

Shaded textures show energy distribution

Pacific-wide, sub-region plots
Graphical Product: Forecast Polygon

PTWC Coastal Tsunami Amplitude Forecast Polygons

Actual amplitudes at the coast may vary from forecast amplitudes due to uncertainties in the forecast and local features. In particular, maximum tsunami amplitudes on atolls will likely be much smaller than the forecast indicates.

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.

- Threat level for designated forecast zones (based on geographical, geopolitical)
- Grey-shaded textures shows energy distribution
### Text File: Forecast Polygon Table

- Coastal and Deep-Ocean Forecasts for polygons
- Includes statistics giving uncertainty / quality estimate.
- E.g., for each polygon (comprised of # forecast points), max / mean / median / standard deviation of coastal and offshore (deep-ocean) wave amplitude for that polygon
- Complements GoogleEarth .kmz tool - can show value variation from point-to-point.

**PTWC TABLE OF FORECAST STATISTICS FOR REGIONAL POLYGONS - RUN ID 20150918200043**
(for internal use only - not for distribution)

Earthquake - Origin: 09/08/2015 00:00:00 UTC  Coordinates: 46.5N 124.5W  Depth: 020km  Magnitude: 9.0

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Actual amplitudes at the coast may vary from forecast amplitudes due to uncertainties in the forecast and local features. In particular, maximum tsunami amplitudes on atolls will likely be much smaller than the forecast indicates.

<table>
<thead>
<tr>
<th>Region_Name</th>
<th>Coastal Forecast (meters)</th>
<th>Offshore Forecast (meters)</th>
<th>Total</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW_Hawaiian_Islands</td>
<td>4.8</td>
<td>3.50</td>
<td>1.20</td>
<td>4</td>
</tr>
<tr>
<td>Midway_Island</td>
<td>3.6</td>
<td>3.10</td>
<td>0.64</td>
<td>3</td>
</tr>
<tr>
<td>Bougainville_Papua_New_Guinea</td>
<td>3.1</td>
<td>1.70</td>
<td>1.30</td>
<td>75</td>
</tr>
<tr>
<td>Hawaii</td>
<td>3.0</td>
<td>1.60</td>
<td>1.50</td>
<td>147</td>
</tr>
<tr>
<td>Marie_Byrd_Land_Coast_of_Antarctica</td>
<td>2.5</td>
<td>1.40</td>
<td>0.42</td>
<td>806</td>
</tr>
<tr>
<td>Choisel_to_Philip_Solomon_Islands</td>
<td>2.4</td>
<td>1.30</td>
<td>1.20</td>
<td>339</td>
</tr>
<tr>
<td>Victoria_Oates_and_George_V_Coast_of_Antarctica</td>
<td>1.8</td>
<td>0.95</td>
<td>0.68</td>
<td>629</td>
</tr>
<tr>
<td>Pacific_Coast_of_the_Philippines</td>
<td>1.8</td>
<td>0.84</td>
<td>0.76</td>
<td>350</td>
</tr>
<tr>
<td>Solomon_Sea_Coast_of_Papua_New_Guinea</td>
<td>1.8</td>
<td>1.00</td>
<td>0.86</td>
<td>141</td>
</tr>
</tbody>
</table>
Sample of kmz file in GoogleEarth

Cascadia, Pacific Northwest: Earthquake: 46.5N 124.5W Depth: 020km Magnitude: 9.0

Mouse-over balloon gives value of forecast point.

Forecast computed for model grid points nearest the coast.

Color-scale indicates values of forecast points.

Zoom in to area of interest.
Thank You

Dr. Charles McCreery
Director, Pacific Tsunami Warning Center

Dr. Laura Kong
Director, International Tsunami Information Center

Dr. Stuart A. Weinstein
Deputy Director, Pacific Tsunami Warning Center
Saving Lives:
End-to-End Tsunami Warning

Additional Slides

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End-to-End Tsunami Warning

Tsunami Awareness

UNESCO/IOC-NOAA International Tsunami Information Center

EQ Tsunami

TSUNAMI WARNING!
EVACUATE

Country Alert System

Emergency Alert System & Mass Media

DMO – Public Safety Evacuate / All-Clear

Natl / Local Govt

Public

TWC - Science

Intl / Natl

ITIC, SeismicReady Consulting 2009 after Japan Cabinet Office 2005
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

**TSP SOP**
- Detect
- Assess & Notify

**NDMO SOP**
- NTWC Message receipt
- Assess
- Decide
- Notify

- Hazard ?
- Safety Threat ?
- Yes !

- Public Response

- Regional

- Local

- +0 min

- T+15
Tsunami Early Warning: Science and Public Safety

Science

Earthquake

Tsunami or not

Evacuation or not

No casualties

Public Safety

Monitoring

Processing

Disseminate

Evacuate

Preparedness

Decision Point

Response

ITIC, BMKG, 2009
Saving Lives:
End-to-End Tsunami Warning

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