Report of the Task Team on Enhancing PTWS Tsunami Warning Products

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Chair
NOAA Pacific Tsunami Warning Center
Why Enhanced Products?

Existing Procedures and Products

• Last major revision in 2001 (change from Ms to Mw)
• Criteria are based primarily on historical data
• Initially puts areas into a Warning or Watch based on:
  1. earthquake magnitude and
  2. estimated time left to tsunami impact or
  3. distance from earthquake epicenter
• Entire Pacific put in Warning if big tsunami confirmed
• Very conservative - so much over-warning
• PTWC alert confused with NTWC alerts
• Primarily for regional and basin-wide tsunamis - no timely guidance for local tsunamis
• Text product only
Why Enhanced Products?

Enhanced Procedures and Products

• Based primarily on numerical tsunami forecast
• Initial forecast based on preliminary earthquake parameters (hypocenter and magnitude)
• Initial products issued in less than 10 min – helpful for local tsunami threat
• Later forecasts constrained by earthquake mechanism (W-CMT) and sea level readings
• No alert levels, only 3 general threat levels:
  a. 0.3-1m
  b. 1-3m
  c. >3m
• Should reduce conflict with NTWC alert levels
Why Enhanced Products?

Enhanced Procedures and Products (continued)

• Still conservative but should greatly reduce over-warning
• Provides estimated level of impact
• Includes graphical as well as text products
• Includes “kmz” file of forecast points to facilitate drilling-down to finer spatial resolution.
# Sample Timeline

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h00m</td>
<td>A large earthquake occurs in the Pacific region.</td>
</tr>
<tr>
<td>00h02m</td>
<td>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 over 400 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>00h08m</td>
<td>Using a combination of automatic and interactive analyses, duty analysts complete their preliminary determination of the earthquake epicenter, depth, and magnitude. These parameters are used to initiate a RIFT numerical tsunami forecast model run for a limited region near the epicenter.</td>
</tr>
</tbody>
</table>
# Sample Timeline

| 00h10m | **Initial Product.** The type of product issued will depend on the estimate threat  
A. If there is no tsunami threat because the earthquake is too small or too deep inside the earth or inland, then the initial product will just be an Information Statement without the suite of graphical and other products.  
B. If there is a potential tsunami threat, then the initial product may either be  
   1. The entire suite of products with the initial forecast amplitudes or  
   2. A text product only containing the earthquake parameters and a statement to the effect that earthquakes of this size and location typically pose a tsunami threat but that it has not yet been quantified and the forecast will follow later.  

*Option B.2 may be necessary to indicate a potential threat as quickly as possible but avoid issuing a misleading forecast if it is too poorly constrained with the initial seismic data.* |
## Sample Timeline

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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</thead>
<tbody>
<tr>
<td>00h15m</td>
<td>The seismic analyses continue as data from additional seismic stations arrive and are processed.</td>
</tr>
<tr>
<td>00h20m</td>
<td><strong>Supplemental Product with Updated Earthquake Parameters.</strong> If the earthquake parameters change significantly from what was in the initial bulletin then RIFT is re-run. If there is a significant change in the forecast then appropriate supplemental products, similar to those described above, are issued.</td>
</tr>
<tr>
<td>00h25m</td>
<td>For earthquakes above about magnitude 7.0, the preliminary W-phase Centroid Moment Tensor (WCMT) analysis based upon broadband seismic data completes. The WCMT analysis not only gives a more accurate estimate of the earthquake location, depth and magnitude, but also an estimate of the earthquake’s mechanism – the angle of the fault plane projected along the surface of the earth relative to north (strike), the angle of the fault plane relative to a horizontal plane (dip), and the direction of slip along the fault relative to horizontal (rake). These parameters help constrain the estimate of seafloor deformation that is used to drive a subsequent run of RIFT that covers the entire Pacific.</td>
</tr>
</tbody>
</table>
# Sample Timeline

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<tbody>
<tr>
<td>00h35m</td>
<td><strong>Supplemental Product with WCMT-based Forecast.</strong> For events with a tsunami threat, a supplemental message is issued based upon the earthquake mechanism given by the WCMT analyses that includes the along with accompanying maps, table, and kmz file that cover the entire Pacific region and marginal seas of the PTWS. This second set of products will be based on this updated RIFT tsunami forecast that will be much better constrained by the seismic data and analyses. It will also cover most coasts within the Pacific.</td>
</tr>
<tr>
<td>00h30m to 02h00m</td>
<td>Sea level gauges are monitored for tsunami signals. Within the first 30 minutes to 2 hours, and depending upon where the earthquake occurs, the tsunami will arrive and be measured on the nearest one or two coastal gauges and one or two deep-ocean gauges.</td>
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</table>
## Sample Timeline

<table>
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<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01h00m to 03h00m</td>
<td><strong>Supplemental Products with Observation-Constrained Forecasts.</strong> As observations of tsunami waves become available, they will be used to compare with existing forecasts and to adjust those forecasts when necessary. Typically, the forecast will become stable after a few readings from deep-ocean gauges and not require further adjustment. Products will be issued at least once an hour with any updated forecasts.</td>
</tr>
<tr>
<td>Beyond 3h</td>
<td>The tsunami is monitored on coastal and deep-ocean sea-level gauges as it advances. Reports from Member States and the media may also be received.</td>
</tr>
<tr>
<td>Beyond 3h</td>
<td><strong>Supplemental and Final Products.</strong> Products are issued at least once an hour with updated observations from coastal and deep-ocean gauges and other reliable sources. When it is clear there is no longer a significant tsunami threat or the tsunami has crossed the entire Pacific then a final product is issued.</td>
</tr>
</tbody>
</table>
Sample Text Product

ZCZC  
WEPA40 PHEB 150008  
TSUPAC  

EXPERIMENTAL TSUNAMI MESSAGE NUMBER 1  
NOT FOR DISTRIBUTION  
NWS PACIFIC TSUNAMI WARNING CENTER EWA BEACH HI  
0008 UCT THU AUG 15 2013  

...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 TSUNAMI THREAT AND  
APPROPRIATE LEVEL OF ALERT FOR EACH COUNTRY.  

**** NOTICE **** NOTICE **** NOTICE **** NOTICE **** NOTICE *****
Sample Text Product

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

* MAGNITUDE      8.6
* ORIGIN TIME    0000 UTC AUG 15 2013
* COORDINATES    14.3 SOUTH  166.2 EAST
* DEPTH          20 KM / 12 MILES
* LOCATION       VANUATU

EVALUATION
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* AN EARTHQUAKE WITH A PRELIMINARY MAGNITUDE OF 8.6 OCCURRED IN THE VANUATU ISLANDS AT 0000 UTC ON THURSDAY AUGUST 15 2013.

* BASED ON THE PRELIMINARY EARTHQUAKE PARAMETERS... HAZARDOUS TSUNAMI WAVES ARE FORECAST FOR SOME COASTS.

* 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
Sample Text Product

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

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

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

  AUSTRALIA... NEW CALEDONIA... MARSHALL ISLANDS... FIJI...
  SAMOA... KIRIBATI... AND WALLIS AND FUTUNA.

* TSUNAMI WAVES REACHING 0.3 TO 1 METERS ABOVE THE TIDE LEVEL ARE POSSIBLE FOR SOME COASTS OF

  NEW ZEALAND... AMERICAN SAMOA... TOKELAU... NAURU...
  HOWLAND AND BAKER... TONGA... TUVALU... AND NIUE.

* FOR OTHER AREAS COVERED BY THIS PRODUCT A FORECAST HAS NOT YET BEEN COMPUTED. THE FORECAST WILL BE EXPANDED AS NECESSARY IN SUBSEQUENT PRODUCTS.
Sample Text Product

RECOMMENDED ACTIONS

* GOVERNMENT AGENCIES RESPONSIBLE FOR THREATENED COASTAL AREAS SHOULD TAKE ACTION TO INFORM AND INSTRUCT ANY COASTAL POPULATIONS AT RISK IN ACCORDANCE WITH THEIR OWN EVALUATION... PROCEDURES AND THE LEVEL OF THREAT.

* PERSONS LOCATED IN THREATENED COASTAL AREAS SHOULD FOLLOW INSTRUCTIONS FROM NATIONAL AND LOCAL AUTHORITIES.
ESTIMATED TIMES OF ARRIVAL

* ESTIMATED TIMES OF ARRIVAL -ETA- OF THE INITIAL TSUNAMI WAVE FOR POINTS WITHIN THREATENED REGIONS ARE GIVEN BELOW. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN WAVES CAN BE FIVE MINUTES TO ONE HOUR.

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>REGION</th>
<th>COORDINATES</th>
<th>ETA(UTC)</th>
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<td>ESPERITU SANTO</td>
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<td>15.1S 167.3E</td>
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<tr>
<td>SANTA CRUZ ISLA</td>
<td>SOLOMON ISLANDS</td>
<td>10.9S 165.9E</td>
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<td>KIRAKIRA</td>
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<td>ANATOM ISLAND</td>
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<td>AUKI</td>
<td>SOLOMON ISLANDS</td>
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<td>SOLOMON ISLANDS</td>
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<tr>
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<tr>
<td>PANGGOE</td>
<td>SOLOMON ISLANDS</td>
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<tr>
<td>FALAMAE</td>
<td>SOLOMON ISLANDS</td>
<td>7.4S 155.6E</td>
<td>0204 08/15</td>
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<tr>
<td>NOUMEA</td>
<td>NEW CALEDONIA</td>
<td>22.3S 166.5E</td>
<td>0208 08/15</td>
</tr>
<tr>
<td>NAURU</td>
<td>NAURU</td>
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<td>KIETA</td>
<td>PAPUA NEW GUINEA</td>
<td>6.1S 155.6E</td>
<td>0216 08/15</td>
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</table>
POTENTIAL IMPACTS

* A TSUNAMI IS A SERIES OF WAVES. THE TIME BETWEEN WAVE CRESTS CAN VARY FROM 5 MINUTES TO AN HOUR. THE HAZARD MAY PERSIST FOR MANY HOURS OR LONGER AFTER THE INITIAL WAVE.

* IMPACTS CAN VARY SIGNIFICANTLY FROM ONE SECTION OF COAST TO THE NEXT DUE TO LOCAL BATHYMETRY AND THE SHAPE AND ELEVATION OF THE SHORELINE.

* IMPACTS CAN ALSO VARY DEPENDING UPON THE STATE OF THE TIDE AT THE TIME OF THE MAXIMUM TSUNAMI WAVES.

* PERSONS CAUGHT IN THE WATER OF A TSUNAMI MAY DROWN... BE CRUSHED BY DEBRIS IN THE WATER... OR BE SWEPT OUT TO SEA.
NEXT UPDATE AND ADDITIONAL INFORMATION
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* THE NEXT MESSAGE WILL BE ISSUED IN ONE HOUR... OR SOONER IF THE SITUATION WARRANTS.

* AUTHORITATIVE INFORMATION ABOUT THE EARTHQUAKE FROM THE U.S. GEOLOGICAL SURVEY CAN BE FOUND ON THE INTERNET AT EARTHQUAKE.USGS.GOV/EARTHQUAKES -ALL IN SMALL LETTERS-.

* THIS MESSAGE AS WELL AS ADDITIONAL INFORMATION ABOUT THIS EVENT MAY BE FOUND AT WWW.TSUNAMI.GOV.

* AUTHORITY NATIONAL WARNINGS CAN BE FOUND AS SOON AS AVAILABLE AT: ***

(INCL IN PTWS-XXV RECOMMENDATION THAT: IOC TO ASK ALL COUNTRIES IF THEY WANT TO ADD A URL TO THIS LIST)

$$
PTWC Deep-Ocean Tsunami Amplitude Forecast

(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.)

Model
Run 1

Earthquake:
15 Aug 2013
00:00:00 Z
Lat: 14.30° S
Lon: 166.20° E
Depth: 20 km
$M_w$: 8.60

Assumed Earthquake Mechanism

Maximum Amplitude (m)

- 4.54
- 1.00
- 0.75
- 0.50
- 0.25
- 0.10
- 0.05
- 0.01
- 0.00

model run at:
09 Aug 2013
12:59:41 Z
PTWC Coastal Tsunami Amplitude Forecast

(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.)
PTWC Coastal Tsunami Amplitude Forecast

(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.)
Earthquake:  02/08/2013 11:12 UTC  33.7S 72.3W  20km  Mw=8.9
Table of Zone Statistics

<table>
<thead>
<tr>
<th>Coastal Forecast (meters)</th>
<th>Offshore Forecast (meters)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum</td>
<td>Mean</td>
<td>Median</td>
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<tr>
<td>13.68</td>
<td>3.78</td>
<td>2.94</td>
</tr>
<tr>
<td>7.21</td>
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<td>1.16</td>
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<td>4.20</td>
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Recommendation of Task Team

Upon review of the aforementioned, the Task Team recommends to the ICG to

- Move forward with the product’s full implementation in 2014,
- Set the target changeover date to be 1 October 2014,
- At a minimum, provide the Text Message as a public product, and
- Disseminate the remaining non-public products
  - Only to country National Tsunami Warning Centers (NTWCs) via their Tsunami Warning Focal Points (TWFPs), and
  - At a minimum, only by electronic mail.
Thank You