PTWC Response to
16 September 2015 Tsunami
from Mw 8.3 Chile Earthquake

Charles McCreery
NOAA Pacific Tsunami Warning Center
Historical Tsunamis in the Chile Region

- 2015 – Mw 8.3
- 2007 – Mw 8.0
- 2001 – Mw 8.4
- 2014 – Mw 8.2
- 1995 – Mw 8.0
- 2010 – Mw 8.8
- 1960 – Mw 9.5
Seismic Stations Monitored by the TWCs

EARTHQUAKE
Big Seismic Signals Trigger TWC Alarms
1 Minute After Earthquake

The seismic signals, as they arrived one-by-one, were analyzed by TWC duty staff to determine the earthquake location, depth and magnitude.
Location is Off Coast of Central Chile
Depth is Shallow
Magnitudes from First Seismic Signals
Preliminary Magnitude is 7.9
Elapsed Time: 6 Minutes
Initial TWC Products Issued

- Potential Immediate Tsunami Threat to Chile and Peru. Threat to Other Pacific Countries Under Evaluation
- Hawaii Tsunami Watch while Threat Evaluated
- American Samoa Information while Threat Evaluated
- Guam/CNMI Information while Threat Evaluated
- Alaska, BC & West Coast Information while Threat Evaluated
Regional Forecast based on EQ Mechanism

- >3 m: Chile
- 1-3m: None
- 0.3-1m: Peru, Ecuador
- Other Pacific Countries: Still Under Evaluation

Tsunami Watch:
- Hawaii
- American Samoa
- Guam/CNMI

Information while Threat Evaluated

- Alaska, BC & West Coast
- American Samoa
- Guam/CNMI

Elapsed Time: 28 Minutes
Ocean Forecast

Earthquake:
16 Sep 2015
22:55:22 Z
Lat: 31.20°S
Lon: 72.05°W
Depth: 30 km
Mw: 8.27

Determined Earthquake Mechanism:

Maximum Amplitude (m):
- 3.00
- 0.40
- 0.30
- 0.20
- 0.10
- 0.05
- 0.03
- 0.01
- 0.00

Model run at:
29 Sep 2015
15:38:29 Z
Polygons Forecast


Maximum Amplitude (m)

- > 3 m
- 1 - 3 m
- 0.3 - 1 m
- < 0.3 m

Threat Not Computed

model run at:
18 Sep 2015
23:27:33 Z
South America Coastal Forecast

Earthquake:
- Date: 16 Sep 2015
- Latitude: 31.20° S
- Longitude: 72.06° W
- Depth: 59 km
- Magnitude: 8.27

Determined Earthquake Mechanism:

Maximum Amplitude (m):
- 7.40
- 3.00
- 1.00
- 0.30
- 0.00

Model run at:
- Date: 16 Sep 2015
- Time: 23:27:33 Z
Elapsed Time: 52 Minutes
Forecast based on EQ Mechanism

- >3 m: Chile
- 1-3m: Fr. Polynesia
- 0.3-1m: Peru, Ecuador, Japan, Russia, and many other places

- Hawaii Tsunami Watch
- Alaska, BC & West Coast Information while Threat Evaluated
- American Samoa Information while Threat Evaluated
- Guam/CNMI No Threat
- Chile
- Fr. Polynesia
- Peru, Ecuador
- Japan, Russia
- and many other places
Real-Time Reporting Sea Level Gauges
Real-Time Reporting Deep-Ocean Gauges (DARTs)
Elapsed Time: +02:29
Forecast based on EQ Mechanism

Hawaii
Tsunami Advisory

American Samoa
Information while Threat Evaluated

Guam/CNMI
No Threat

Information while Threat Evaluated

Alaska, BC & West Coast

>3 m: Chile
1-3m: Fr. Polynesia
0.3-1m: Many Countries
Elapsed Time: +02:48
Considering Data and Model Forecasts

- **West Coast**
  Tsunami Advisory from San Onofre to Ragged Point, CA

- **Hawaii**
  Tsunami Advisory

- **American Samoa**
  Information while Threat Evaluated

- **Chile**: >3 m
- **Fr. Polynesia**: 1-3 m
- **Many Countries**: 0.3-1 m
Considering Data and Model Forecasts

- West Coast Tsunami Advisory from San Onofre to Ragged Point, CA
- Hawaii Tsunami Advisory
- American Samoa Tsunami Advisory
  - $>3$ m: Chile
  - $1-3$ m: Fr. Polynesia
  - $0.3-1$ m: Many Countries

Elapsed Time: +03:14
## Confirmation of Tsunami, Evaluation of Threat, and US Alerts

<table>
<thead>
<tr>
<th>Elapsed</th>
<th>Place</th>
<th>Event</th>
<th>Max Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:10-01:29</td>
<td>Quintero, Chile</td>
<td>Gauge Reading</td>
<td>1.77 m</td>
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<tr>
<td>00:21-00:29</td>
<td>Coquimbo, Chile</td>
<td>Gauge Reading</td>
<td>4.72 m</td>
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<tr>
<td>00:51-01:03</td>
<td>Chanaral, Chile</td>
<td>Gauge Reading</td>
<td>1.14 m</td>
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<tr>
<td>00:25-00:39</td>
<td>DART 32402</td>
<td>Gauge Reading</td>
<td>0.10 m</td>
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<td></td>
<td>TWCs</td>
<td>Models Constrained with DART Data</td>
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</tr>
<tr>
<td>01:31-01:46</td>
<td>DART 32401</td>
<td>Gauge Reading</td>
<td>0.05 m</td>
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<td></td>
<td>TWCs</td>
<td>Confidence in All Model Results</td>
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<tr>
<td>02:29</td>
<td>Hawaii</td>
<td>Advisory</td>
<td>0.3-1 m</td>
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<tr>
<td>02:29</td>
<td>Guam/CNMI</td>
<td>No Threat</td>
<td>&lt;0.3 m</td>
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<tr>
<td>02:48</td>
<td>S. California</td>
<td>Advisory</td>
<td>0.3-1 m</td>
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</table>
## Summary of Forecast and Observations

<table>
<thead>
<tr>
<th>PLACE</th>
<th>FORECAST</th>
<th>ALERT</th>
<th>MAXIMUM ON GAUGE</th>
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</thead>
<tbody>
<tr>
<td>Chile</td>
<td>&gt;3 m</td>
<td>N/A</td>
<td>4.72 m (Coquimbo)</td>
</tr>
<tr>
<td>Fr. Polynesia</td>
<td>1-3 m</td>
<td>N/A</td>
<td>1.40 m (Nuku Hiva)</td>
</tr>
<tr>
<td>Peru</td>
<td>0.3-1 m</td>
<td>N/A</td>
<td>0.52 m (Callao)</td>
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<tr>
<td>Ecuador</td>
<td>0.3-1 m</td>
<td>N/A</td>
<td>0.18 m (Baltra)</td>
</tr>
<tr>
<td>Japan</td>
<td>0.3-1 m</td>
<td>N/A</td>
<td>0.80 (Kuji)</td>
</tr>
<tr>
<td>Russia</td>
<td>0.3-1 m</td>
<td>N/A</td>
<td>0.44 m (Shikotan Is.)</td>
</tr>
<tr>
<td>Hawaii</td>
<td>0.3-1 m</td>
<td>Advisory</td>
<td>0.85 m (Hilo)</td>
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<tr>
<td>West Coast</td>
<td>0.3-1 m</td>
<td>Advisory</td>
<td>0.33 m (Ventura)</td>
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<td>Am. Samoa</td>
<td>0.3-1 m</td>
<td>Advisory</td>
<td>0.63 m (Pago Pago)</td>
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<tr>
<td>Guam/CNMI</td>
<td>&lt;0.3 m</td>
<td>None</td>
<td>&lt;0.03 m (Apra Harbor)</td>
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</tbody>
</table>
Elapsed Time: +18:39

Considering Local Observations

- **American Samoa**
  - Tsunami Advisory Cancelled

- **Hawaii**
  - Tsunami Advisory Cancelled

- **West Coast**
  - Tsunami Advisory Cancelled

- >3 m: Chile
- 1-3m: Fr. Polynesia
- 0.3-1m: Many Countries

- West Coast Tsunami Advisory Cancelled

- Hawaii Tsunami Advisory Cancelled

- American Samoa Tsunami Advisory Cancelled

- >3 m: Chile
- 1-3m: Fr. Polynesia
- 0.3-1m: Many Countries
Elapsed Time: +20:24
Considering Local Observations

West Coast
Tsunami Advisory
Cancelled

>3 m: Chile
1-3m: Fr. Polynesia
0.3-1m: Many Countries
Elapsed Time: +24:10
Considering All Observations

Final Pacific Threat Message
Summary of Casualties and Damages (Earthquake and Tsunami)

- All major effects happened in Chile
- Over 1 million were evacuated from the coast
- 13 deaths and 14 injuries (most or all from earthquake)
- 6 persons missing as of 24 September
- 55 persons in shelters
- 13427 without housing
- 816 homes destroyed
- 1011 homes uninhabitable
- Most tsunami damage around Coquimbo and Tongoy
- Most earthquake damage around Salamanca and Illapel

Particulars Courtesy of ONEMI and SHOA
Coquimbo Sea Level Gauge (+4.72 m)

Photo Courtesy of SHOA
Multiple Ships Aground at Coquimbo

Photo Courtesy of SHOA
Summary of Event Response

- TWCs Responded Quickly
- Preliminary and Later Seismic Analysis was Accurate
- Judgment of Potential Tsunami Threat was Accurate
- Three Tsunami Forecast Models Used
  - Seismic and Sea Level Model Constraints were Sufficient
  - All Models Gave Consistent and Accurate Forecasts
  - Appropriate Alert and Threat Levels Issued
- Domestic and International Systems Worked Well
Gracias

Laura Kong
UNESCO/IOC – NOAA International Tsunami Information Center

Charles McCreery
NOAA Pacific Tsunami Warning Center