January, 2014
NTHMP meeting

Real-time Evacuation Response

How to better tie the local response to the threat at-hand

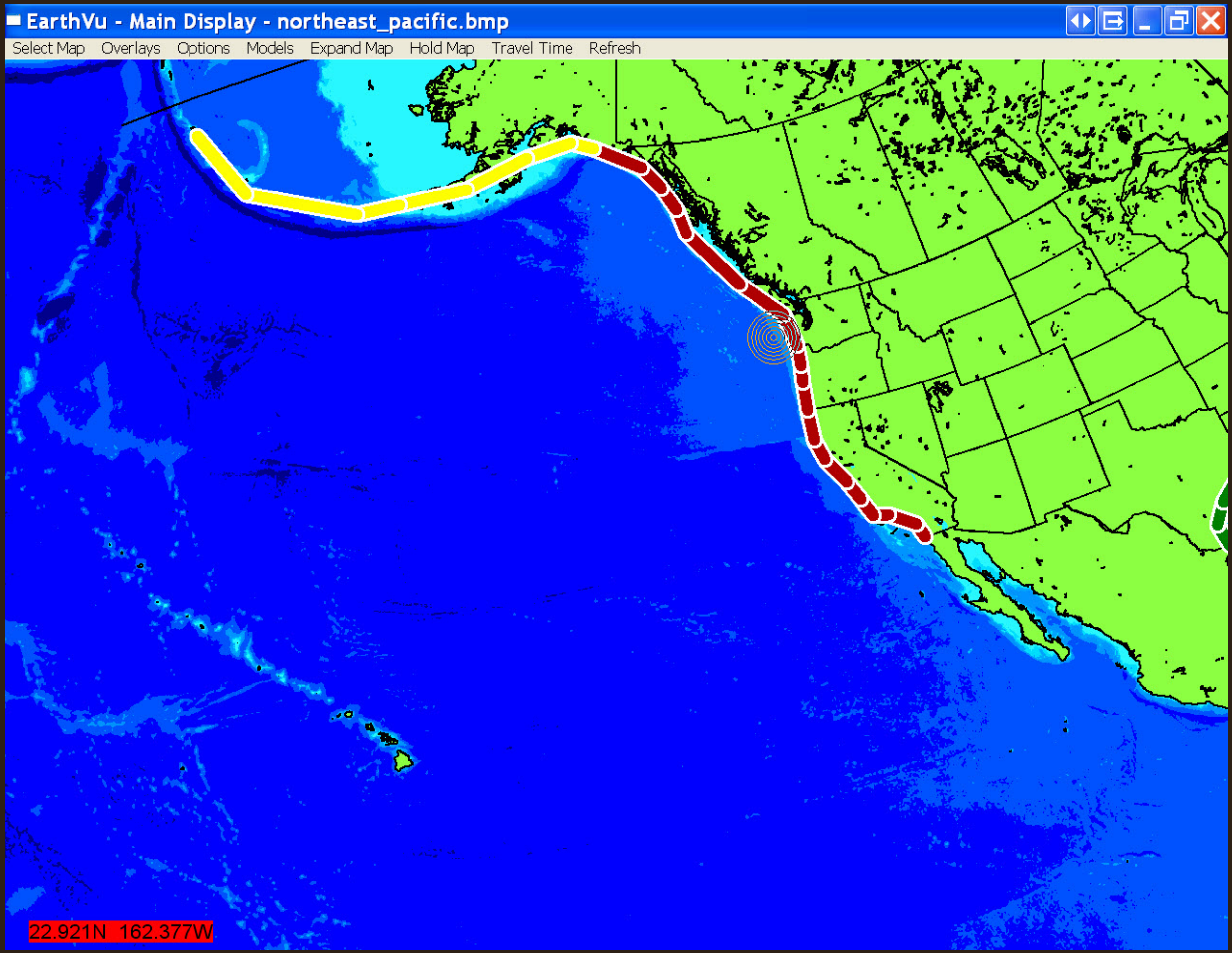
Problem

- There is a reasonably good tsunami threat characterization available for regional-to-distant source events along US/Canada shores.
- How can EMOs better use this information to tailor response considering:
  - Expected height
  - Expected spatial variations
- TWCs issue warning or advisory – actual threat level can not be determined from just these two alert levels

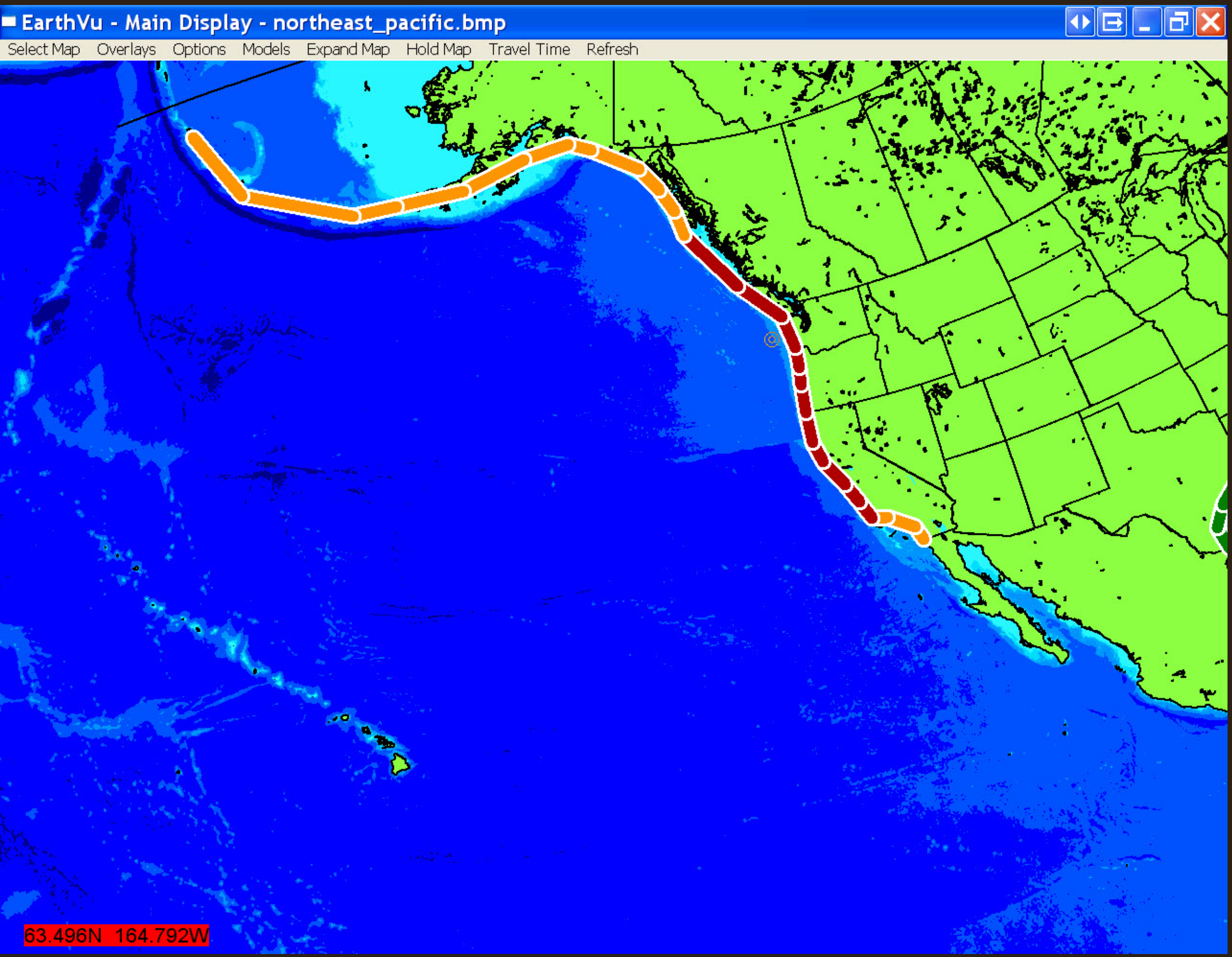
Discussion

- A potential event case study - Cascadia.
- A historic event case study – Haida Gwaii
- Possible solutions – playbooks and other ideas

What will be issued for a large Cascadia event? – last year



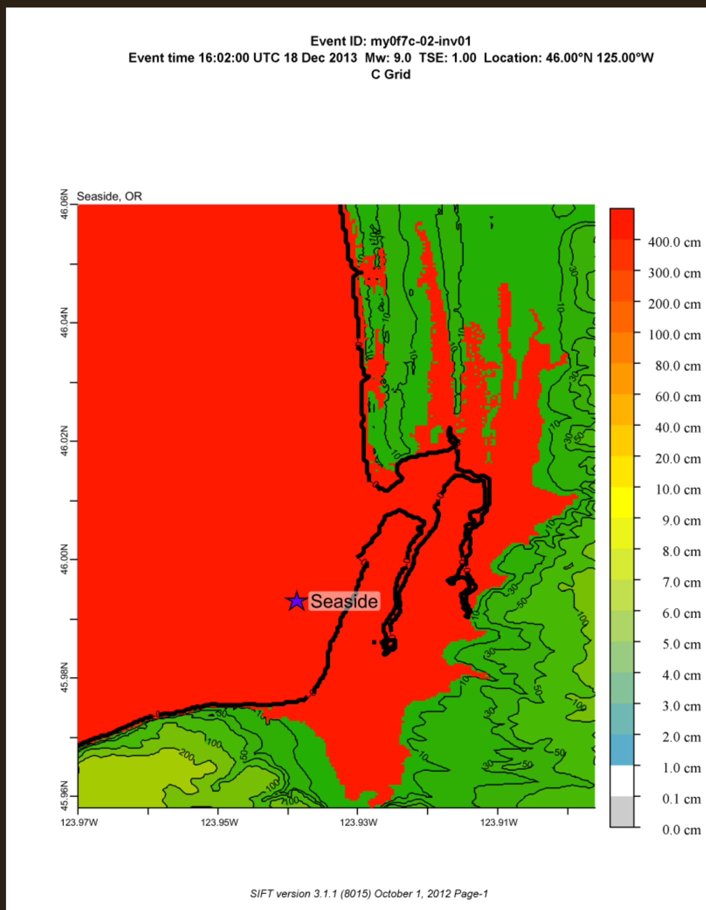
What will be issued for a large Cascadia event? – this year

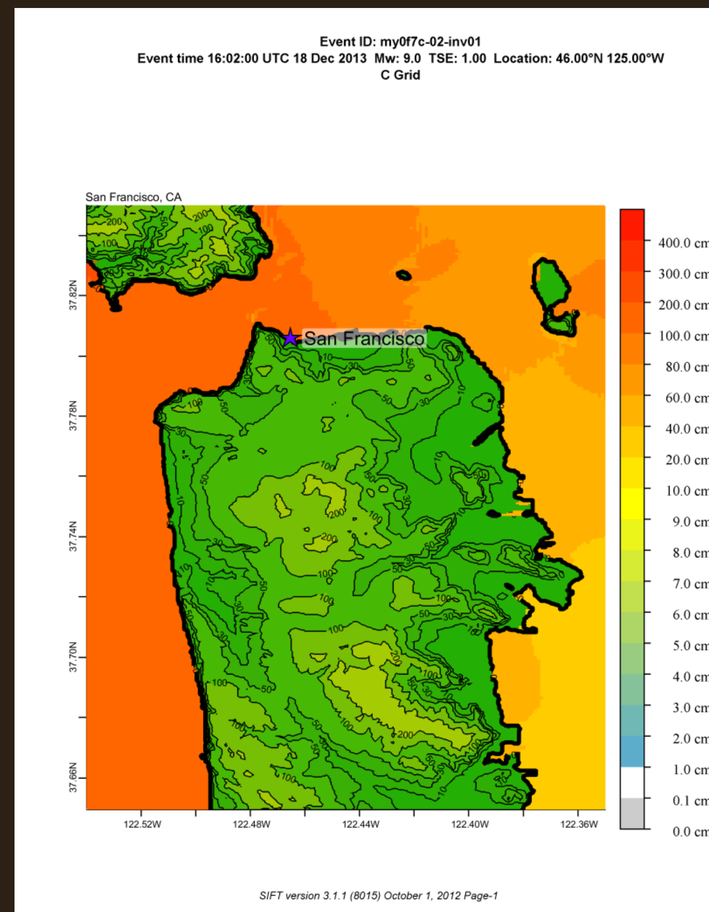


- 7.9 and above
- Must assume that TWC will underestimate size at first.
- Uses present thresholds for warning/advisory

Discussion

- For Cascadia, at present San Francisco will be in the same level of alert as Seaside.

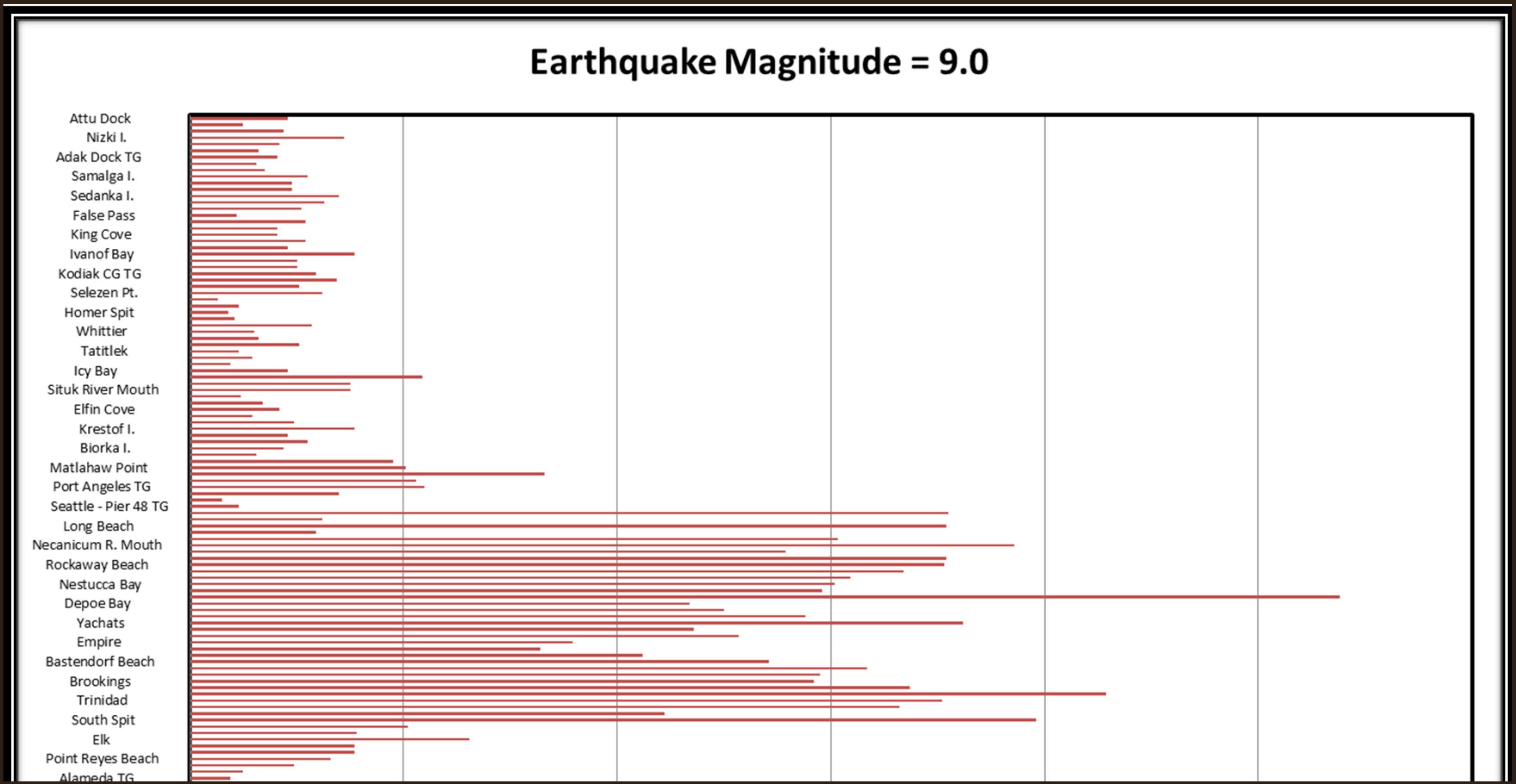




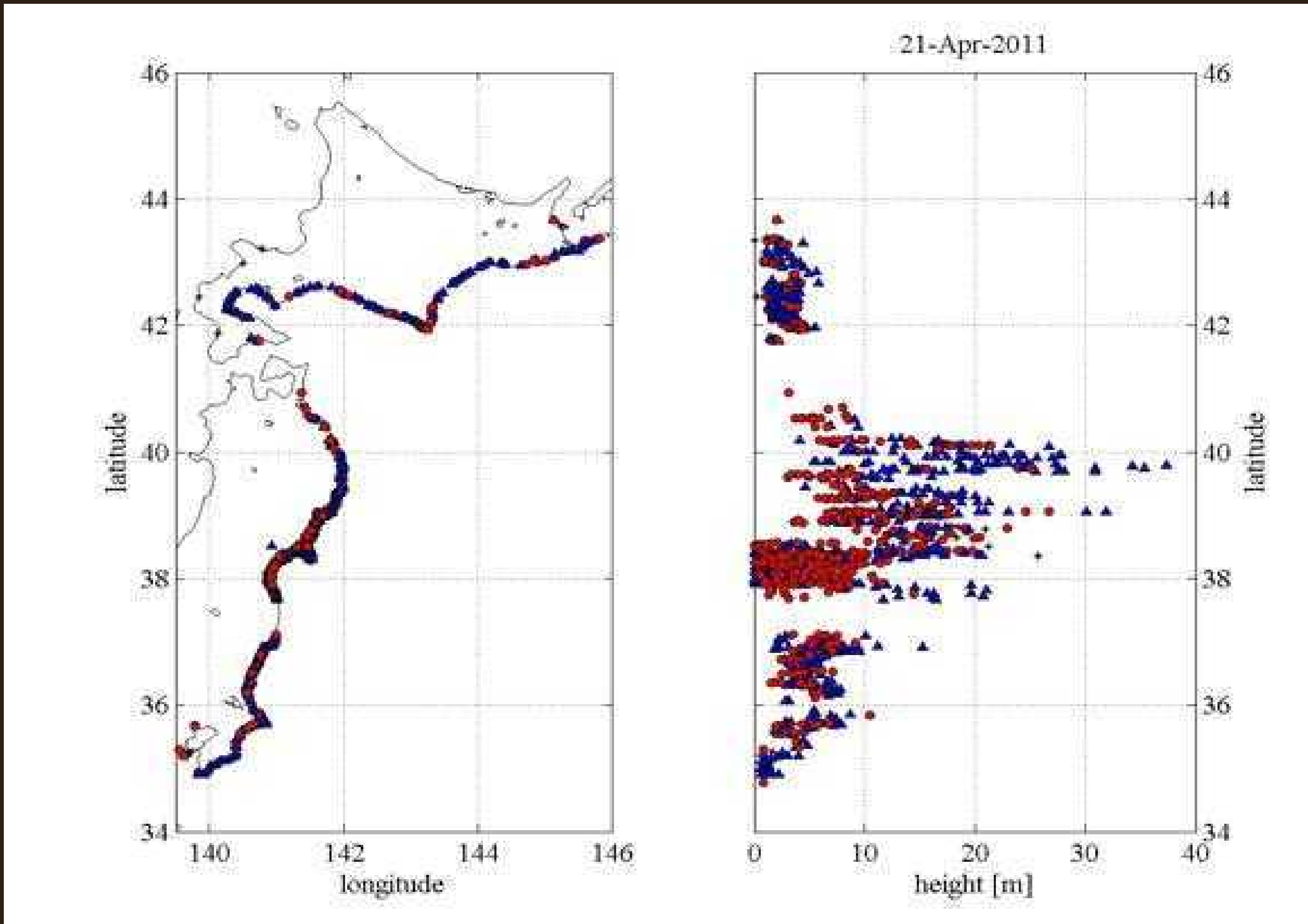
What could be issued for a large Cascadia event? – future

- Should alert levels be dropped; expanded; left with the understanding that more detailed info is available on web?
- How do zones of threat get communicated?

Why Really Red?



Historic example - Japan



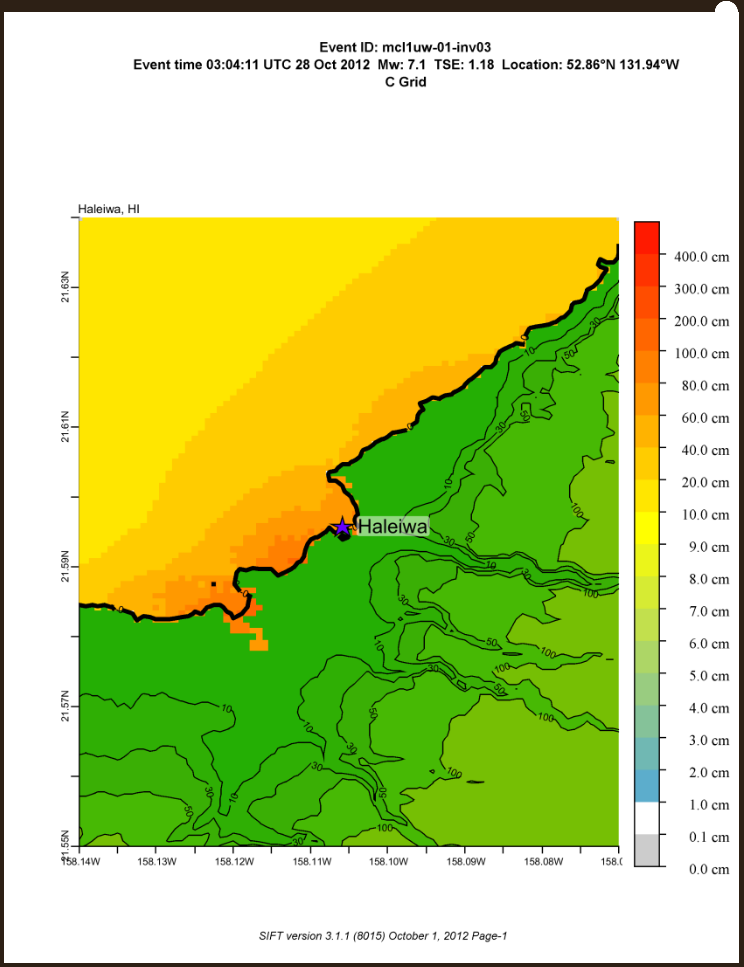
What was issued for the Haida Gwaii event in Hawaii in 2012?

- SIFT forecasts put Hawaii over the warning threshold in a few locations.
- Forecasts were high, but not too far off (~40% error).
- Hawaii placed in warning –max inundation was assumed in response for entire state

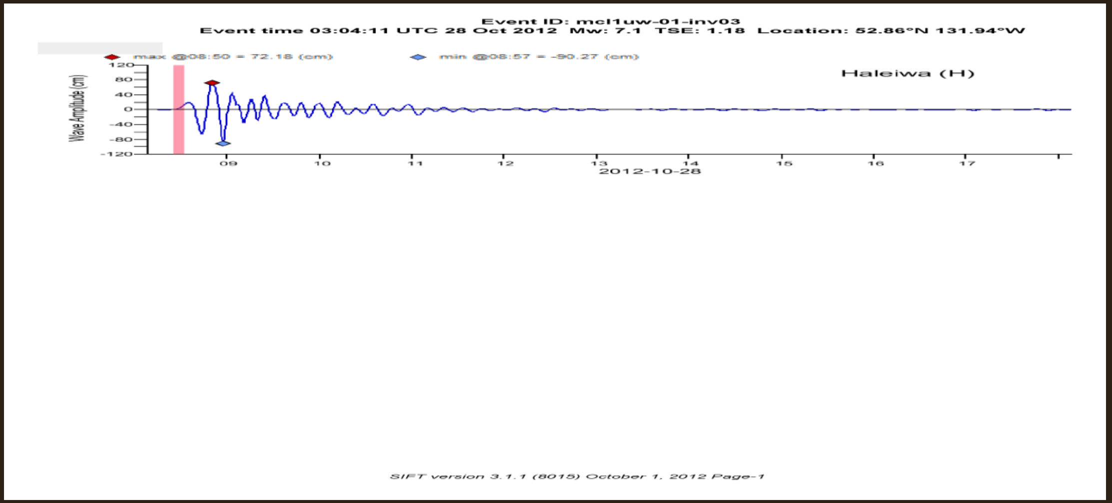
Event ID: mcl1uw-01-inv03
Event time 03:04:11 UTC 28 Oct 2012 Mw: 7.1 TSE: 1.18 Location: 52.86°N 131.94°W

Model	Region	Arrival Time (UTC)	C Grid Max (cm)	C Grid Min (cm)	Gauge Max (cm)	Gauge Min (cm)	Flooding	Model Ended (UTC)
Port Alexander,...	Alaska	03:49 2012-10-28	11.233	-11.318	6.006	-7.248	No	05:00 2012-10-28
Sitka, AK	Alaska	04:05 2012-10-28	32.511	-19.215	13.168	-16.210	No	05:12 2012-10-28
Craig, AK	Alaska	04:08 2012-10-28	40.498	-43.015	33.415	-30.138	No	04:56 2012-10-28
Elfin Cove, AK	Alaska	04:15 2012-10-28	7.271	-6.742	6.641	-6.266	No	05:07 2012-10-28
La Push, WA	West Coast	04:45 2012-10-28	31.774	-78.000	20.466	-14.830	No	19:58 2012-10-29
Neah Bay, WA	West Coast	04:49 2012-10-28	35.369	-27.643	6.914	-9.207	No	04:59 2012-10-28
Yakutat, AK	Alaska	05:03 2012-10-28	27.598	-27.562	10.831	-13.134	No	04:54 2012-10-28
Seaside, OR	West Coast	05:05 2012-10-28	33.547	-39.015	23.825	-29.782	No	19:55 2012-10-29
Westport, WA	West Coast	05:09 2012-10-28	26.664	-32.629	11.994	-9.753	No	05:28 2012-10-28
Garibaldi, OR	West Coast	05:10 2012-10-28	35.880	-28.942	4.226	-5.262	No	19:44 2012-10-29
Port Orford, OR	West Coast	05:14 2012-10-28	38.114	-41.750	15.592	-19.187	No	05:12 2012-10-28
Newport, OR	West Coast	05:18 2012-10-28	22.176	-32.686	10.585	-7.155	No	19:48 2012-10-29
Toke Point, WA	West Coast	05:20 2012-10-28	18.501	-20.832	11.486	-8.117	No	19:41 2012-10-29
Crescent City, CA	West Coast	05:37 2012-10-28	44.110	-52.858	40.877	-49.657	No	04:59 2012-10-28
Florence, OR	West Coast	05:38 2012-10-28	34.416	-23.738	17.495	-8.990	Yes	19:35 2012-10-29
Eureka, CA	West Coast	05:42 2012-10-28	34.039	-29.388	15.099	-13.349	No	19:38 2012-10-29
Seward, AK	Alaska	05:44 2012-10-28	20.148	-33.146	13.772	-22.741	No	04:48 2012-10-28
Arena Cove, CA	West Coast	05:53 2012-10-28	37.693	-36.727	15.680	-16.799	Yes	19:41 2012-10-29
Kodiak Island, AK	Alaska	06:03 2012-10-28	42.750	-37.943	34.160	-36.398	No	04:56 2012-10-28
Cordova, AK	Alaska	06:19 2012-10-28	7.544	-63.863	5.033	-7.069	No	04:52 2012-10-28
Point Reyes, CA	West Coast	06:22 2012-10-28	34.586	-31.552	28.740	-19.295	No	19:45 2012-10-29
Monterey, CA	West Coast	06:22 2012-10-28	16.050	-16.325	11.172	-10.816	No	19:40 2012-10-29
Sand Point, AK	Alaska	06:42 2012-10-28	12.210	-10.659	11.668	-8.235	No	05:03 2012-10-28
San Francisco, ...	West Coast	06:44 2012-10-28	25.829	-23.640	10.404	-9.719	No	19:39 2012-10-29
Chignik Bay, AK	Alaska	06:50 2012-10-28	20.383	-25.449	14.908	-18.771	No	05:09 2012-10-28
Port San Luis, CA	West Coast	06:53 2012-10-28	51.325	-43.116	39.389	-39.442	No	20:06 2012-10-29
King Cove, AK	Alaska	06:54 2012-10-28	7.692	-5.412	6.620	-5.373	No	05:03 2012-10-28
Homer, AK	Alaska	07:00 2012-10-28	7.097	-3.967	2.652	-3.331	No	04:52 2012-10-28
Nikolski, AK	Alaska	07:02 2012-10-28	10.413	-11.529	8.893	-10.654	No	02:45 2013-04-20
Unalaska, AK	Alaska	07:06 2012-10-28	8.899	-8.581	5.480	-5.409	No	05:03 2012-10-28
Santa Barbara, ...	West Coast	07:12 2012-10-28	10.878	-8.330	9.616	-8.174	No	19:57 2012-10-29
Atka, AK	Alaska	07:24 2012-10-28	11.690	-13.264	11.088	-10.395	No	05:09 2012-10-28
Santa Monica, CA	West Coast	07:26 2012-10-28	23.752	-12.387	7.185	-9.551	No	19:43 2012-10-29
Los Angeles, CA	West Coast	07:30 2012-10-28	31.145	-19.881	4.402	-4.534	No	19:36 2012-10-29
Adak, AK	Alaska	07:36 2012-10-28	7.431	-7.900	6.667	-6.850	No	04:54 2012-10-28
San Diego, CA	West Coast	07:55 2012-10-28	11.258	-11.486	3.282	-4.549	No	19:46 2012-10-29
Shemya, AK	Alaska	08:23 2012-10-28	5.955	-5.660	2.626	-3.238	No	05:16 2012-10-28
Hanalei, HI	Hawaii	08:27 2012-10-28	145.900	-110.395	67.477	-86.049	Yes	19:25 2012-10-29
Haleiwa, HI	Hawaii	08:28 2012-10-28	131.647	-96.873	72.183	-90.267	Yes	19:15 2012-10-29
Nawiliwili, HI	Hawaii	08:29 2012-10-28	65.207	-37.798	19.644	-24.663	No	19:30 2012-10-29
Kahului, HI	Hawaii	08:37 2012-10-28	140.303	-248.844	110.979	-133.154	Yes	05:09 2012-10-28
Hilo, HI	Hawaii	08:37 2012-10-28	124.219	-204.228	93.716	-93.434	Yes	19:29 2012-10-29
Kawaihae, HI	Hawaii	08:40 2012-10-28	38.497	-45.536	29.241	-37.528	Yes	19:40 2012-10-29
Kailua-Kona, HI	Hawaii	08:40 2012-10-28	28.845	-29.073	3.269	-4.257	No	02:33 2013-04-20
Honolulu, HI	Hawaii	08:40 2012-10-28	43.949	-36.045	27.887	-27.435	No	19:24 2012-10-29
Keauhou, HI	Hawaii	08:41 2012-10-28	8.751	-4.664	3.894	-3.880	No	19:43 2012-10-29
Lahaina, HI	Hawaii	08:41 2012-10-28	34.905	-26.271	16.301	-18.912	No	19:31 2012-10-29
Pearl Harbor, HI	Hawaii	08:44 2012-10-28	75.403	-75.073	64.000	-57.913	No	19:36 2012-10-29
Kihei, HI	Hawaii	08:48 2012-10-28	54.695	-45.264	18.903	-31.552	Yes	19:47 2012-10-29
Midway, UM	Oceania	09:01 2012-10-28	46.704	-29.863	12.373	-21.035	No	02:39 2013-04-20
Wake Island, UM	Oceania	11:07 2012-10-28	6.687	-3.548	3.046	-1.685	No	02:38 2013-04-20
Apra Harbor, GU	Oceania	13:45 2012-10-28	17.225	-14.201	3.709	-5.709	No	02:20 2013-04-20
Pago Pago, AS	Oceania	13:48 2012-10-28	4.427	-5.671	3.328	-4.117	No	02:20 2013-04-20

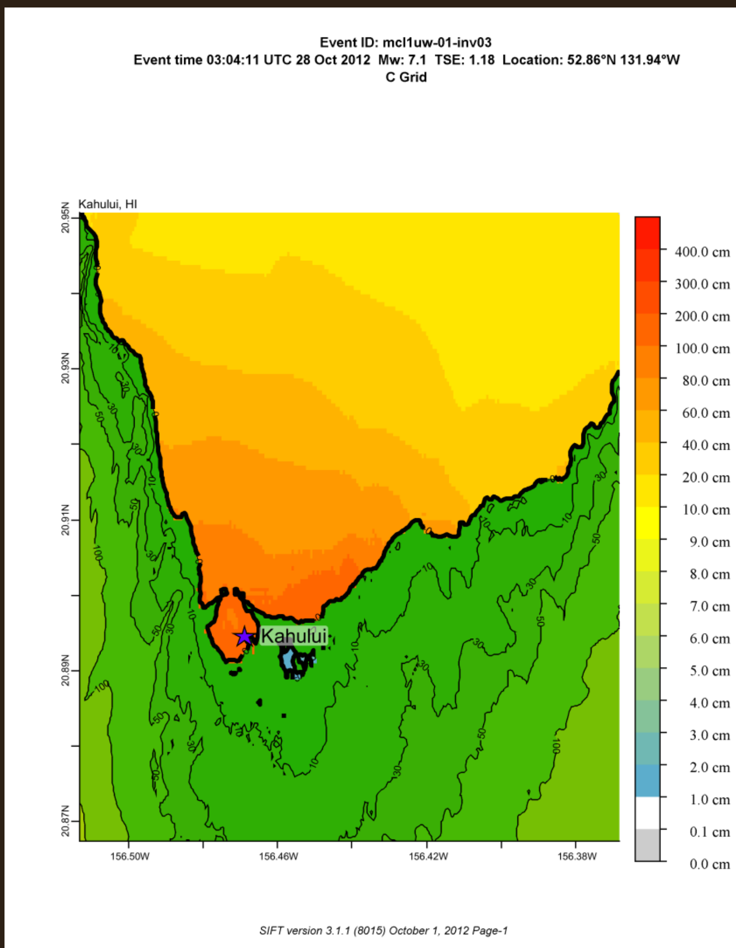
Hawaii Forecasts available at time of warning issuance



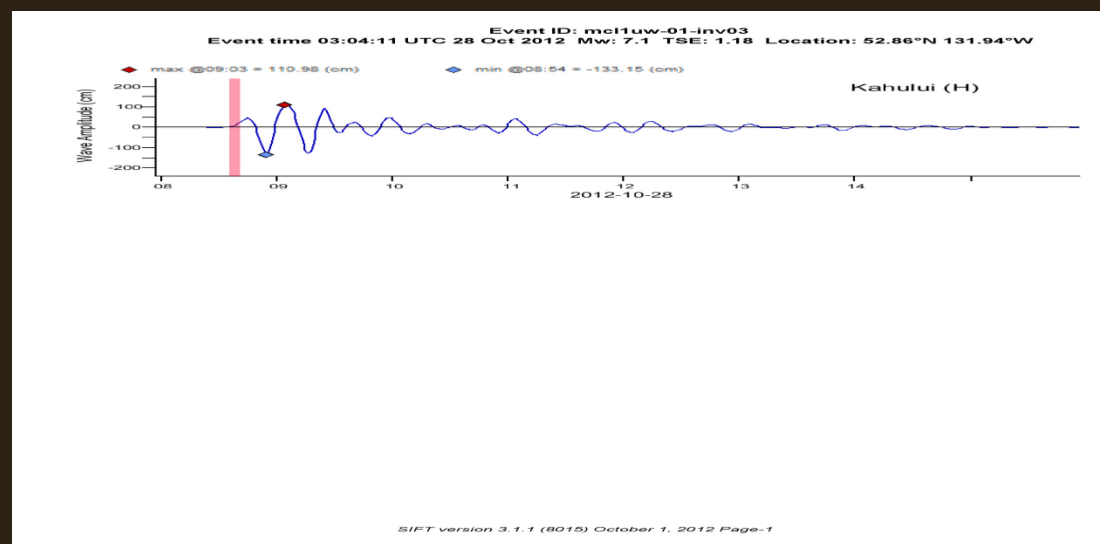
Haleiwa, HI – highest on Oahu – peak at about 1.3m; 0.7m at tide gage (0.43m recorded)



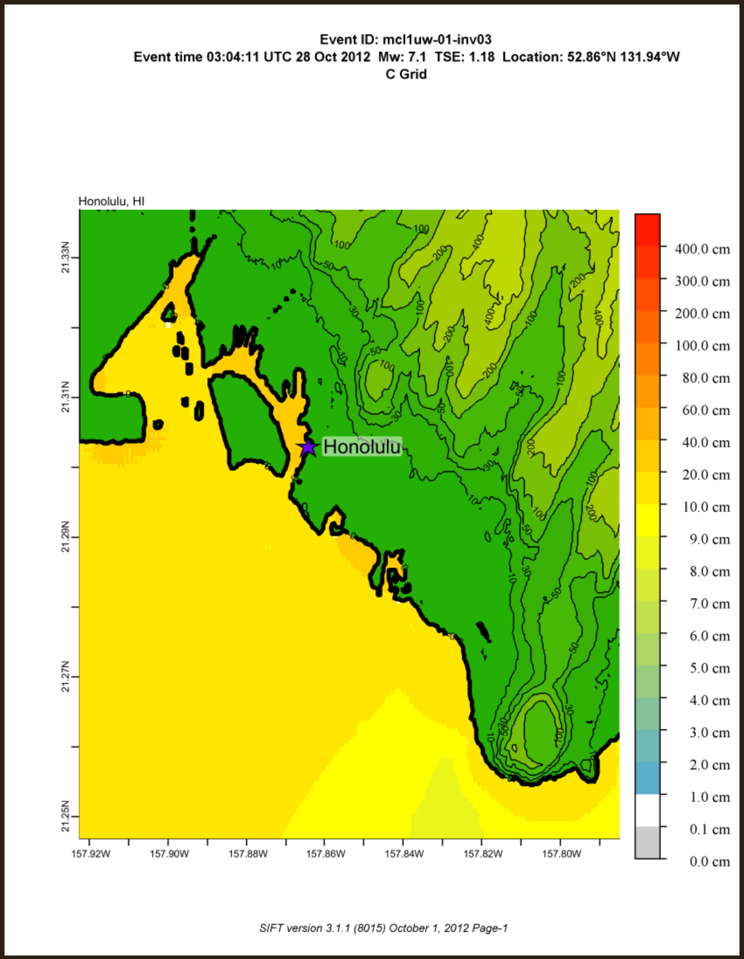
Hawaii Forecasts available at time of warning issuance



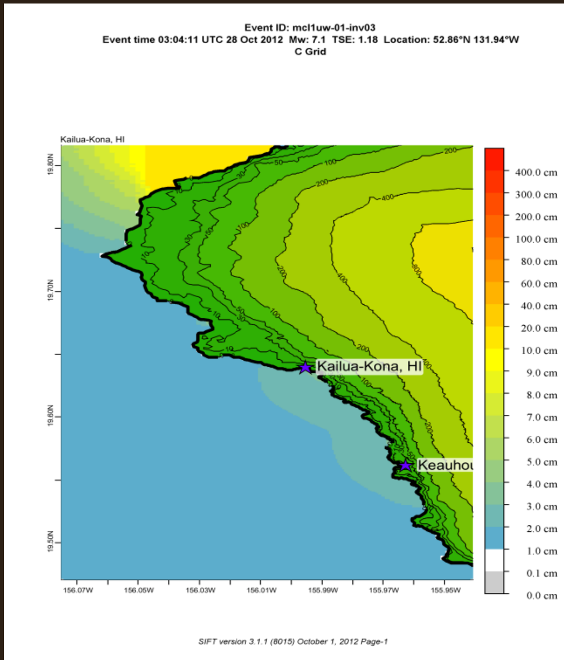
- Kahului, HI – highest in all of Hawaii – peak at about 1.5m; 1.1m at tide gage (0.79m recorded)



Hawaii Forecasts available at time of warning issuance



- Other areas not at warning level
  - Honolulu and Waikiki – max 40cm.
  - Kona - < 10cm



Discussion

- How can we better tie the response to the threat at hand?
  - California example – Playbooks
  - Oregon – local/distant lines of threat
  - More finely grained levels of alert?
  - Eliminate levels of alert and use something else?

DRAFT - Tsunami Evacuation Playbook San Diego County

Purpose and Use of this Tsunami Playbook

PURPOSE: **NOTE: Emergency managers should become familiar with this Playbook plan prior to use.** A significant issue for emergency managers is that existing tsunami evacuation plans call for evacuation of the predetermined tsunami evacuation zone (typically at a 30- to 50-foot elevation) during a "Warning" level event; the alternative is to not call an evacuation at all. A solution to provide more detailed information has been the development of tsunami evacuation "Playbooks" to plan for tsunami scenarios of various sizes and source locations. NOAA-issued Tsunami Alert Bulletins received in advance of a distant event will contain a tsunami alert level, forecasted tsunami amplitude (or wave height) and arrival time for a number of locations along the coastline. Elevation "playbook" evacuation lines can be useful for partial tsunami evacuations when information about forecasted tsunami amplitudes and arrival times is available to coastal communities and there is sufficient time to implement a partial evacuation. Provision for multiple elevation evacuation lines and response plans for those lines enables planning for different evacuation scenarios based on the forecast tsunami amplitude, potentially alleviating the need for an "all or nothing" decision with regard to evacuation.

USE: This playbook is designed to help the emergency managers with tsunami evacuation and response activities. First, it requires that the emergency manager become familiar with the information herein, especially the "Tsunami Response Decision Tree" (Page 2), the overall Playbook approach, and FASTER calculation (Page 3). When a distant-source tsunami is occurring**, fill out the information on Page 2 regarding the earthquake (magnitude, location) and tsunami (alert level, forecasted amplitude and arrival time).** Keep in mind that this information can change during the first hour or two after the earthquake occurs.

Use this information to determine which branch of the decision tree applies to the event. Refer to information on Page 3 regarding the "Elevation Evacuation Playbook," the "Scenario Evacuation Playbook," and the FASTER calculation value. FASTER will be calculated and provided to each community by the county or regional Weather Forecast Office. Each scenario Playbook will be accompanied by a digital file identifying the full evacuation zone for a community. This file should be referenced and used during an event. Communities may wish to use these maps to establish "reverse 911" calling areas.

Table of Contents – Tsunami Response Plan Playbooks

Tsunami Alert Bulletins: During the typical tsunami alert, the Warning Center provides information about the tsunami in "bulletins" to the state and local jurisdictions. There are four levels of "alert" that can be sent by the NTWC (from least to greatest significance):

Tsunami Information Statement - Issued to inform and update emergency managers and the public that an earthquake has occurred, or that a tsunami Watch, Advisory or Warning has been issued elsewhere in the ocean.

Tsunami Watch - Issued to alert emergency managers and the public of an event which may later impact the Watch area. May be upgraded to an Advisory or Warning - or canceled - based on updated information and analysis.

Tsunami Advisory - Issued due to the threat of a tsunami which may produce strong currents or waves dangerous to those in or near the water; typically called when forecasted tsunami amplitudes are between 0.3m and 1m (1ft and 3ft) above existing tidal conditions are expected. Coastal communities are advised that beach and harbor areas could expect rapid, moderate tidal changes and strong currents.

Tsunami Warning - Issued when a tsunami with significant widespread inundation is imminent or expected; typically called when forecasted tsunami amplitudes are equal to or greater than 1m (3ft). Coastal communities are advised to evacuate people from low-lying areas identified as vulnerable to tsunamis.

Quick Reference Page for Determining Real-Time Tsunami Response Activities

NOTE: It is important to review all sections of this Playbook prior to using it during a tsunami emergency. When a Tsunami Alert is issued, fill out the Quick Reference page below under Step 1 and follow steps on the right side of the page to determine response activities for the harbor:

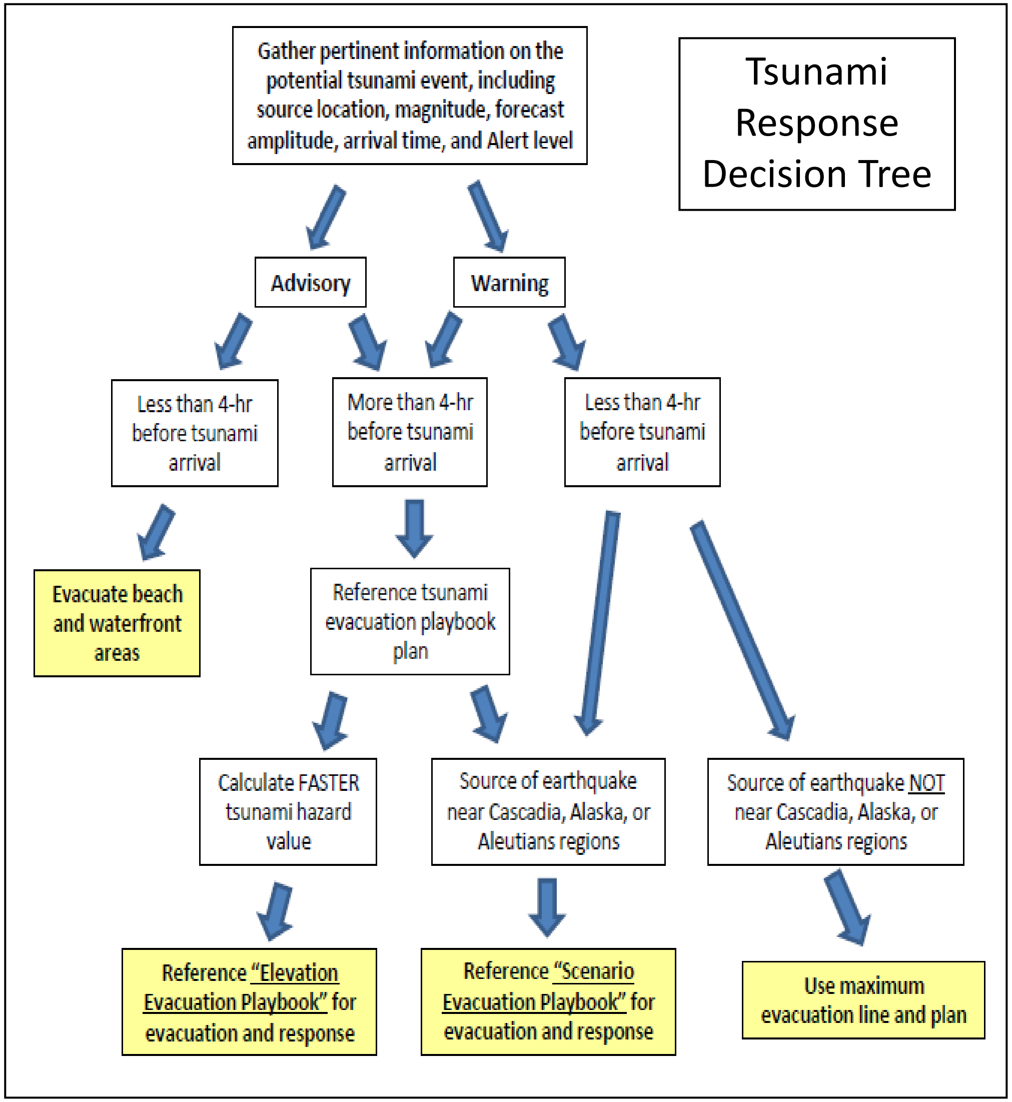
Step 1: Obtain information about earthquake and tsunami from National Tsunami Warning Center in Alaska, regional NOAA-Weather Forecast Office, and/or county emergency manager. The explanation of the FASTER calculation is provided on Page 3. The FASTER value is used to determine which Playbook scenario to use.

Earthquake location ______________________________
Earthquake magnitude ____________________________
Tsunami Alert level _______________________________
Forecasted tsunami amplitude/wave height _______________
Forecasted tsunami arrival time ____________________
Highest projected tidal height (above Mean Sea Level) for first 5 hrs after arrival
____
Ambient ocean/storm conditions for first 5 hrs after arrival:
____
Calculate/obtain FASTER tsunami run-up value in first 5 hours: _____________
Calculate/obtain FASTER tsunami run-up value at highest tide ______________

Step 2: Compare the information from Step 1 to the Tsunami Response Decision Tree on the right. Select the decision tree branch that best fits the forecast tsunami information.

Step 3: Go to Page 3 "Playbook reference" page and utilize the appropriate Playbook or strategy for evacuation and response.

A set of digital evacuation maps and response instructions will accompany each of the Elevation Evacuation Playbook scenarios. These files can be used to develop "reverse 911" calling areas prior to the event.



Real-time Playbook Evacuation and FASTER Calculation Reference Page

FASTER Analytical Tool: To determine the full impact of the tsunami, other variables such as tidal and storm conditions must be considered. An analytical method has been created which incorporates important variables that will impact the ultimate tsunami flood level. The FASTER calculation, which will be provided to communities by the county or regional NWS Weather Forecast Office during a tsunami event, is used to help determine if inundation of dry land will occur. Communities can use the FASTER value to match which evacuation "playbook" to use. The simplified components of the calculation are as follows:

Working example: Formula for determining playbook evacuation line to use (FA-S-T-E-R):

FA: Forecasted Amplitude (Wave Height) from Warning Center

+

S: Storm surge or existing ocean conditions

+

T: Maximum tidal height (first 5 hours of tsunami)

+

E: Forecast error potential (30%; analysis of 2010-11 events)

+

R: Site amplified run-up potential (from existing modeling, unique to each location; applied if inundation expected)

= Maximum tsunami run-up height

= Playbook elevation line

Elevation Evacuation Playbook: The table below can be used to select the appropriate elevation evacuation playbook response plan. Once the FASTER value is obtained, it should be compared to the appropriate playbook reference page for evacuation and response activities.

Reference Pages for Detailed Evacuation and Response Information	Community Evacuation Name for Playbook Evacuation Zones	Recommended FASTER Expected Flood Level Value (METERS)	Recommended FASTER Expected Flood Level Value (FEET)	Anticipated NOAA Tsunami Alert Level	Community recommended areas to evacuate (local decision)
Page 4	Level/Stage/ Phase 1	less than 1.00m	less than 3.3ft	Advisory	beaches, docks, waterfront areas
Page 5	Level/Stage/ Phase 2	1.00m to 1.50m	3.3ft to 5.0ft	Warning	Stage1/Phase 1 and low-lying areas prone to normal flooding
Page 6	Level/Stage/ Phase 3	1.50m to 2.50m	5.0ft to 8.2ft	Warning	Areas mapped as Stage 3 (if applicable)
Page 7	Level/Stage/ Phase 4	2.50m to 3.50m	8.2ft to 11.5ft	Warning	Areas mapped as Stage 4 (if applicable)
Page 8	Level/Stage/ Phase 5	3.50m to 4.50m	11.5ft to 14.8ft	Warning	Areas mapped as Stage 5 (if applicable)
Page 9	Maximum Phase (as recommended by existing NOAA protocol)	more than 4.50m	more than 14.8ft	Warning	Evacuate to maximum evacuation zone

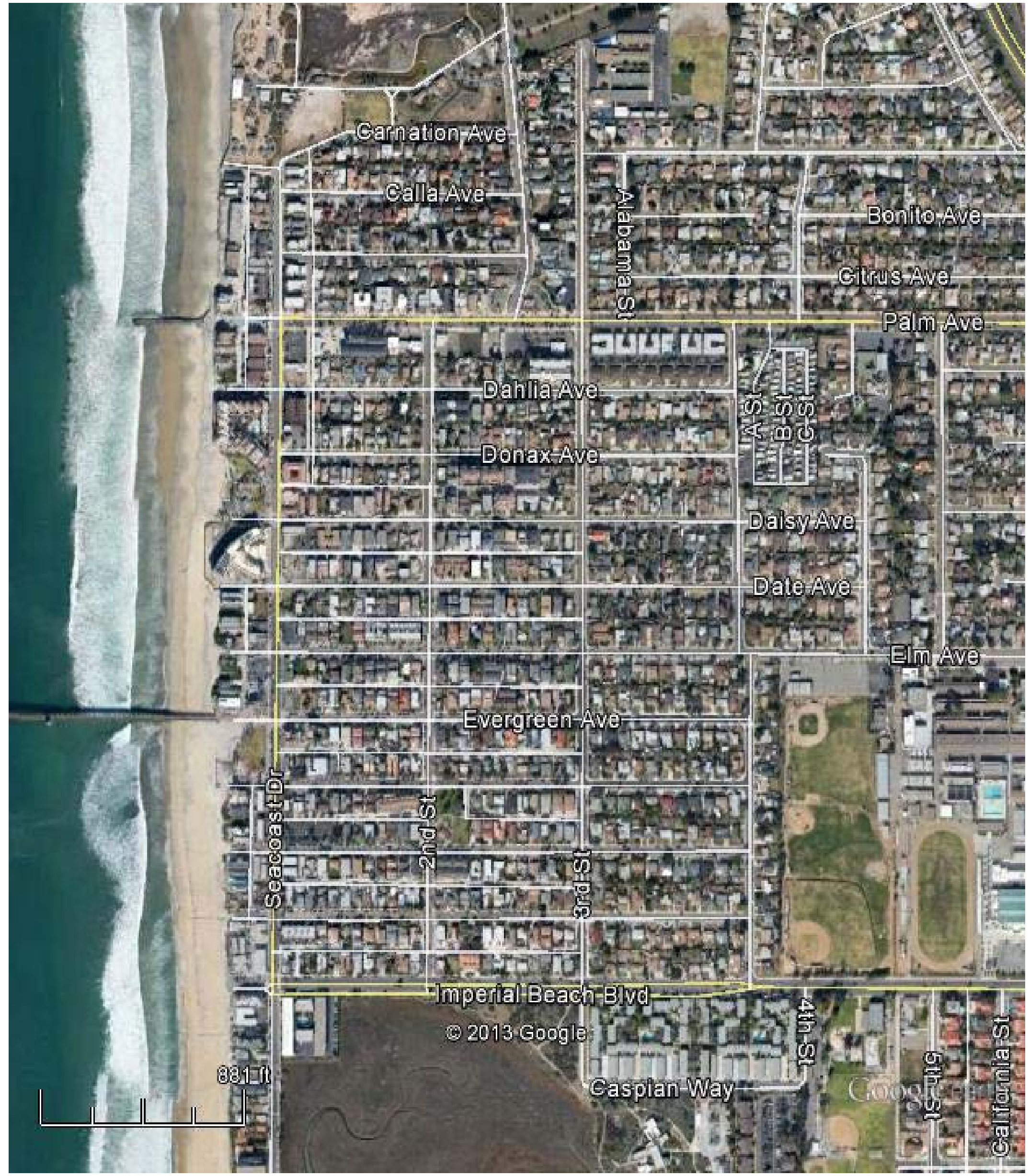
Scenario Evacuation Playbook:
Scenario tsunami playbooks and guidance have been developed for maximum local and distant tsunamis, and for tsunamis coming from the Cascadia subduction zone toward central and southern California. Scenario playbook information about the expected tsunami amplitude and travel time is available from the numerical modeling results for these sources. These are important scenarios for emergency managers to prepare for as there could only be tens of minutes to evacuate or just a few hours to conduct response or evacuation activities before the tsunami arrives. Because of the short time for making response decisions, the following evacuation and response plans are recommended for all of San Diego County:

Scenarios with short tsunami arrival times	Shortest tsunami travel time to San Diego County after earthquake	Suggested Scenerio Playbook Response Plan
Local coastal earthquake >M6.5	10-15 minutes	Maximum evacuation zone
Cascadia subuduction zone >M8.5	2 hours	Level/State/ Phase 3 Elevation Playbook
Alaska or Aleutians subduction zone >M8.5	6 hours	Maximum evacuation zone

Level/State/Phase 1
(example from Imperial Beach)

Background Information:
Alert level = Advisory
FASTER tsunami value = less than 1.0m (3.3 ft)

Specific Instructions:
- Follow general guidance for Advisory-level tsunamis (Page 1)
- Consider evacuating beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
- A digital file showing evacuation maps and response instructions is available for use.
- Specific evacuation and response instructions…… (completed with the community input)

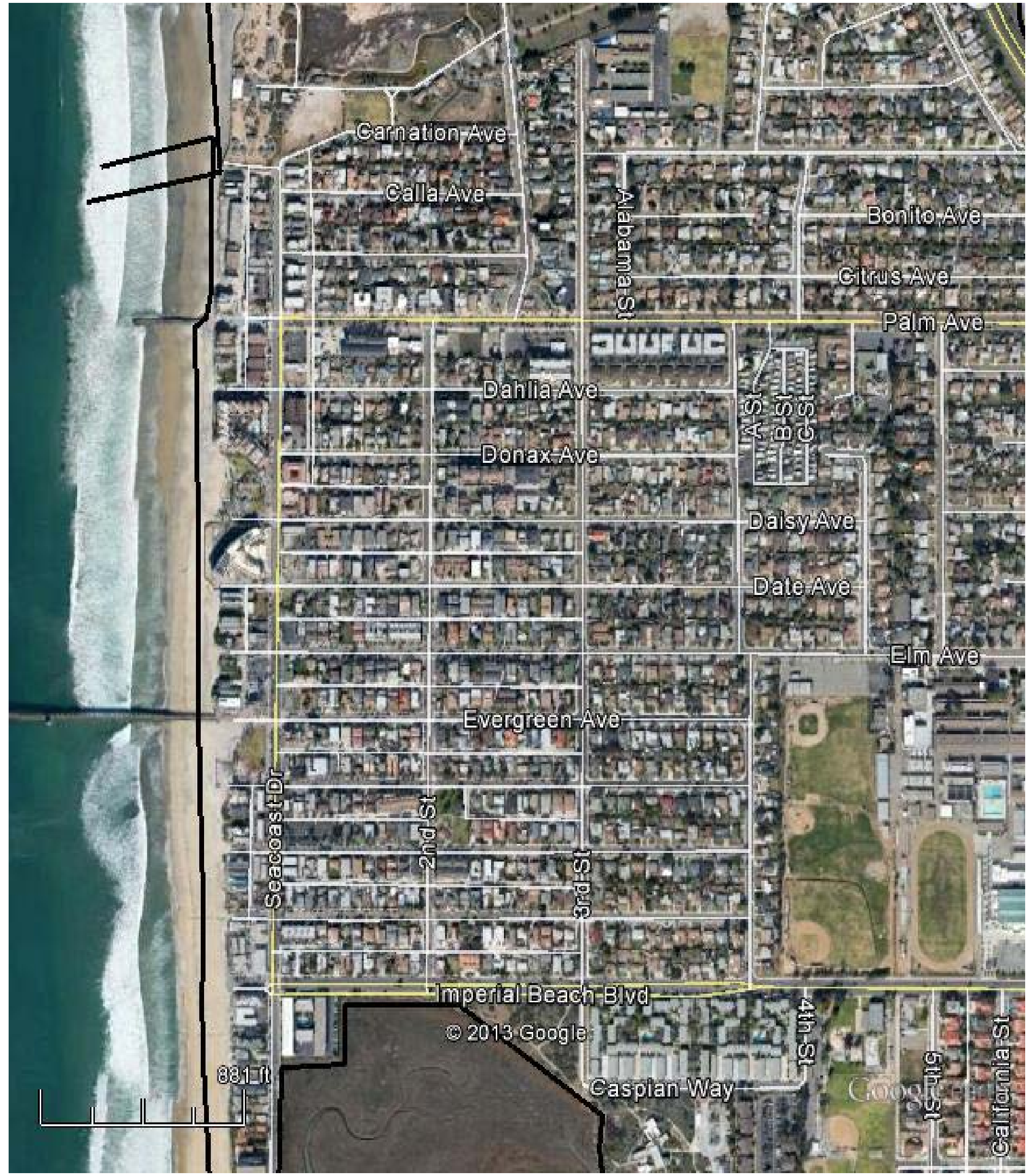


Level/State/Phase 2
(example from Imperial Beach)

<u>Background Information:</u>
Alert level = Warning
FASTER tsunami value = between 1.0m (3.3 ft) and 1.5m (5.0ft)

<u>Specific Instructions:</u>

- Follow general guidance for Warning-level tsunamis (Page 1)
- Consider evacuating of areas outlined by the black line, including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
- A digital file showing evacuation maps and response instructions is available for use.
- Specific evacuation and response instructions…… (completed with the community input)



Level/State/Phase 3 (example from Imperial Beach)

<u>Background Information:</u>
Alert level = Warning
FASTER tsunami value = between 1.5m (5.0ft) and 2.5m (8.2ft)

<u>Specific Instructions:</u>

- Follow general guidance for Warning-level tsunamis (Page 1)
- Consider evacuating of areas outlined by the gold line, including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
- A digital file showing evacuation maps and response instructions is available for use.
- Specific evacuation and response instructions…… (completed with the community input)

Level/State/Phase 4
(example from Imperial Beach)

<u>Background Information:</u>
Alert level = Warning
FASTER tsunami value = between 2.5m (8.2ft) and 3.5m (11.5ft)

<u>Specific Instructions:</u>

- Follow general guidance for Warning-level tsunamis (Page 1)
- Consider evacuating of areas outlined by the purple line, including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
- A digital file showing evacuation maps and response instructions is available for use.
- Specific evacuation and response instructions…… (completed with the community input)

Level/State/Phase 5
(example from Imperial Beach)

<u>Background Information:</u>
Alert level = Warning
FASTER tsunami value = between 3.5m (11.5ft) to 4.5m (14.3ft)

<u>Specific Instructions:</u>

- Follow general guidance for Warning-level tsunamis (Page 1)
- Consider evacuating of areas outlined by the red line (the maximum tsunami evacuation zone), including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
- A digital file showing evacuation maps and response instructions is available for use.
- Specific evacuation and response instructions…… (completed with the community input)

Level/State/Phase 6
(example from Imperial Beach)

<u>Background Information:</u>
Alert level = Warning
FASTER tsunami value = greater than 4.5m (14.3ft)

<u>Specific Instructions:</u>

- Follow general guidance for Warning-level tsunamis (Page 1)
- Consider evacuating of areas outlined by the red line (the maximum tsunami evacuation zone), including beaches, piers, and harbor docks and boats. Strong currents and potential scour may be expected in harbors.
- A digital file showing evacuation maps and response instructions is available for use.
- Specific evacuation and response instructions…… (completed with the community input)

Reference Material: Notable Historical Tsunamis and State Tsunami Program Modeling Results

Notable Historical Tsunamis: The following table provides very basic information about historical tsunami events; not all tsunamis are represented, especially minor or small tsunamis. Note that the largest, most damaging tsunamis in San Diego County history have come from large earthquakes in the Alaska-Aleutian Islands region and the Chile region. Although the potential for local tsunamis exists, they are much less frequent than distant source tsunamis.

Notable Historical Tsunamis in San Diego County

Date	Magnitude-Source area	Tsunami location	Run-Up/Amp	Remarks (NDR = no damage reported)
5/27/1862	M5.9 - local EQ	San Diego	4 ft	Possibly caused by cliff failure near Pt Loma
8/13/1868	M8.5 - Chile	San Diego	1 ft	NDR
11/11/1922	M8.5 - Chile	San Diego	1 ft	NDR
4/1/1946	M8.8 – Aleutian Islands	La Jolla	1 ft	NDR
		San Diego	1 ft	NDR
11/4/1952	M9.0 - Kamchatka	La Jolla	1 ft	NDR
		San Diego	1 ft	NDR
3/9/1957	M8.6 - Aleutian Islands	La Jolla	1 ft	NDR
		Shelter Isl	2 ft	North island: $5k in damage to docks/boats
		San Diego	1 ft	NDR
5/22/1960	M9.5 - Chile	Mission Bay	-	100-ton barge damaged bridge; month repair
		Shelter Isl	-	South island: Significant damage to docks and boats
		San Diego	4 ft	$22k in damage; ferry moved 1 mile off course
3/28/1964	M9.2 – Alaska	La Jolla	2 ft	NDR
		Shelter Isl	4 ft	North island: strong currents, broken moorings
2/27/2010	M8.8 – Chile	Oceanside	2 ft	Minor dock damage
		La Jolla	2 ft	NDR
		Mission Bay	-	Sail boat swamped
		Shelter Isl	3-4 ft	North island; moderate damage to docks, boats
		San Diego	1 ft	NDR
3/11/2011	M9.0 - Japan	Oceanside	2 ft	NDR
		La Jolla	3 ft	NDR
		Mission Bay	3 ft	$136k in damage to bait dock, 13 boats, 26 piles
		Shelter Isl	3 ft	South island: $110k damage to docks, boat sunk
		San Diego	2 ft	damage to docks

- Run-up amplitude, in feet, above normal tide conditions

- Distant Source - Tsunamis without felt earthquakes

- Local Source - Earthquake and tsunami together

NDR = no specific reports of effects or damage

THE NATIONAL TSUNAMI HAZARD MITIGATION PROGRAM (U.S.)

Modeled Tsunami Scenarios: Because very large tsunamis are infrequent and the likelihood that the largest potential tsunamis have not yet occurred in the San Diego County area, the state tsunami program developed a suite of maximum credible tsunami scenarios as part of their tsunami inundation mapping project for local evacuation planning. The general tsunami wave height for key locations from these scenarios are provided below. As identified in the historical tsunami table, the largest tsunamis could occur from large earthquakes in the Alaska-Aleutian Islands region and the Chile region, or from a large submarine landslide offshore from the Bay.

Tsunami Source Scenario Model Results for San Diego County

Location	Max Onshore Runup (elev.)	1964 Alaska Earthquake	Alaska-Aleutians 1	Alaska-Aleutians 2	Alaska-Aleutians 3	Cascadia	Chile-North	1960 Chile Earthquake	1952 Kamchatka Earthquake	Japan 2	Kuril Isl 2	Kuril Isl 3	Kuril Isl 4
San Onofre State Beach	11	5	4	3	8	4	4	4	3	2	2	2	2
Oceanside	16	8	6		13								
Carlsbad	10	6	4		7								
Encinitas	10	6	4		8								
Del Mar	11	5	4		8								
La Jolla	12	4	4	3	8	4	4	3		3	3	3	3
Mission Bay	12	4	5	3	7	3	4	3		3	3	3	3
Shelter Island (north SD Bay)	7	4	4	3	5	3	4	4		3	3	3	3
San Diego/National City	9	4	7	7	8	6	8	7		3	3	3	3
Coronado	12	4	4	3	9	3	4	3		3	3	3	3
Imperial Beach	10	5	4	3	7	3	3	3		3	3	3	3

Location	Max Onshore Runup (elev.)	Catalina Fault	San Mateo Thrust	Lausen Knoll Fault	San Clemente Island Fault	San Clemente Fault Bend Region	Carlsbad Thrust Fault	Coronado Canyon Landslide	Coronado Bank Fault
San Onofre State Beach	18	8	16	4					
Oceanside	14	7	12				7		
Carlsbad	14	7	7				12		
Encinitas	21	7	7				16		
Del Mar	19	7	6				16		
La Jolla	17	5		4	3	5	14	13	6
Mission Bay	13	7		4	3	4	8	10	10
Shelter Island (north SD Bay)	8	4		3	3	4	5	5	6
San Diego/National City	8	3		3	2	2	3	4	7
Coronado	14	9		4	3	6	5	10	7
Imperial Beach	18	9		3	3	4	7	16	12

Near shore tsunami heights and on-shore tsunami runup for both local and distant sources scenarios, in feet above Mean Sea Level

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Additional information about the length of activity for recent events: Tsunamis activity can last for many hours after first wave arrival. The table to the right shows nearby tide gauge information (San Diego) for several recent, real events on the timing of the various tsunami peaks, i.e. how many hours after arrival did the maximum positive wave occur, the maximum negative wave and the maximum peak to trough wave. This information shows that peak/maximum tsunami conditions can occur nearly 14 hours after first arrival.

San Diego Tide Gauge Information	Arr. Time	Max. Amp.	Assoc. Trough	Height	Hrs after arrival	Max Peak to Trough	Hrs After arrival	Max SL	Hrs After Arrival
2009 Samoa									
2010 Chile	13.7	0.36	-0.28	0.64	1.2	0.64	4.3	1.26	20.2
2011 Japan	11.4	0.6	-0.44	1.04	14.3	1.04	14.3	1.12	14.3