State of California's Update to the Tsunami Inundation Maps for Evacuation Planning

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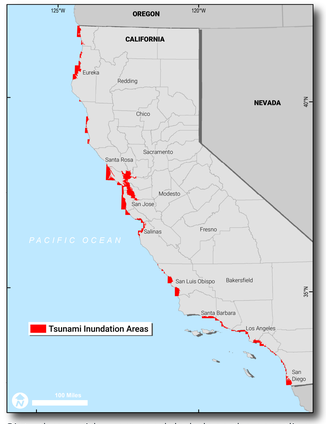
State's Update To the Existing Tsunami Inundation Maps

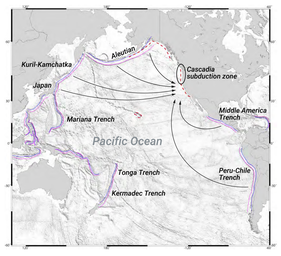
The California Geological Survey (CGS) and the California Governor's Office of Emergency Services (Cal OES) are in the process of generating the third generation of statewide tsunami inundation maps for evacuation planning. National Tsunami Hazard Mitigation Program (NTHMP) guidelines recommend re-evaluating the tsunami hazard every 5-10 years or when significant development in modeling capability or data quality are available. Over the past 10 years, significant advances in tsunami source characterization and computer modeling have been made.



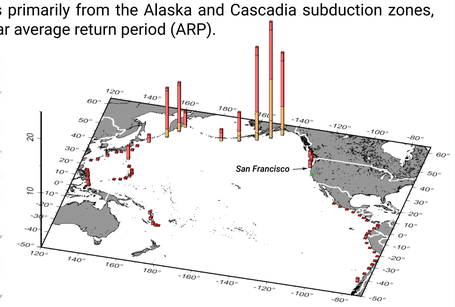
Sixty-three grids were modeled along the coastline using 10-meter resolution data.

Third-Generation State Inundation Maps

The second-generation State inundation maps were commissioned by CGS and Cal OES, completed by the University of Southern California, and covered all low-lying, populated areas of California's coastline. These maps, published in 2009, were modeled at a 30-to-90m resolution for various local and distant tsunami sources. New modeling results, commissioned by CGS and completed by AECOM, use 10-m resolution data and are part of a probabilistic tsunami hazard analysis (PTHA). The tsunami sources selected for inclusion in development of the new maps represent large, realistic events primarily from the Alaska and Cascadia subduction zones, equivalent to a baseline of the 975-year average return period (ARP).



Tsunami sources from 2014 science and/or knowledge. Cascadia source characterization in line with National Seismic Hazard Mapping sources.



Source and magnitude deaggregation for San Francisco, 975-year ARP. The Alaska subduction zone dominates the hazard south of Cape Mendocino, California (Thio and others, 2010).

Maximum Tsunami Inundation Line

Delineating the landward extent of inundation uses a conservative, hybrid approach of combining the 2009 local- and distant-source models with the new and improved model results. The extent was further augmented using high-resolution data and GIS tools available for tsunami inundation line enhancement. A set of rules were developed to better define the maximum inland inundation line including a method to remove artifacts such as islands and holes from the modeled data and to smooth the final inundation line. The final inundation map results were digitally reviewed, and modified areas were verified in the field by CGS, Cal OES, and local agencies.

Comparing unprocessed PTHA results (blue blocky area) to the post-processed results (red filtered and smoothed area). Post-processed results on the right are prepared using a semi-automated filtering process that removed holidays and applied a smoothing algorithm to create a more realistic looking inundation boundary.

Photos of several levees in Long Beach (A), Seal Beach (B), and Foster City (C) where tsunami model results were checked in the field. Levee heights from 1-meter LiDAR were compared with tsunami amplitude results. Corrections to the final inundation results were made if the model predicted flooding but levee heights were higher.

Map showing the locations where tsunami model results overflowed levees in Long Beach and how those were corrected in the final tsunami inundation area.

The **California Geological Survey** and the **Governor's Office of Emergency Services** are **updating** the **State's tsunami inundation areas** using **higher-resolution modeling** for all **low-lying**, **populated areas** to assist **local agencies** in **evacuation planning**.

The State is engaging communities to discuss the new evacuation maps and other products available in their tsunami response toolbox.

TSUNAMI INUNDATION INFORMATION

This Poster | Overview | FAQs

TO LEARN MORE, DOWNLOAD THESE DOCUMENTS

Using the Updated Inundation Maps to Create Evacuation Areas

Map of Avalon on Santa Catalina Island, California showing the inundation and draft evacuation line for locals to review.The updated inundation area is based on science (i.e., tsunami modeling), whereas the evacuation line is typically drawn further inland to an easily identifiable geographic feature, such as a road. However, each local agency ultimately determines where their evacuation line will be drawn based on their emergency response needs.

Steps To Update Local Agency Evacuation Plans

- The State will meet with communities to discuss the new inundation maps, compare these maps to existing community evacuation maps, and make recommendations as to how communities should update their evacuation plans, if needed.
- The final State inundation maps will be made available to local agencies prior to being made public online at the State's Tsunami website → www.tsunami.ca.gov
- Response decision-support tools, such as the tsunami evacuation "playbook" products (e.g., the maximum evacuation phase map), will also be updated by the State with this new information.

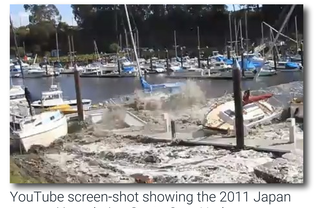
Regional and Local Lessons Learned

Regional Lesson from the Japan Tohoku Tsunami of March 11, 2011

Japan's evacuation maps underestimated tsunami threat by 2-3x because they were based on historical events (past 100-500 years). However, there is geologic evidence for larger events occurring on 1000-year basis; the 2011 Japan tsunami was one of those 1000-year events.

Lessons Learned in California

- inconsistent response activities.
- If…When…Where to reposition boats?
- How to better educate boat owners about tsunami hazards to help them make better decisions?
- What can be done to improve tsunami resistance and resiliency in harbors?
- Inconsistent evacuation/response statewide.
- All or nothing for evacuation?
- What to do in a minor "Warning" level alert incorporating tides and other existing ocean water levels?



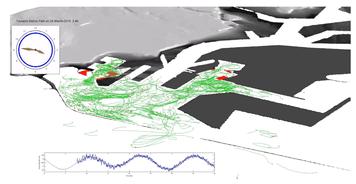
YouTube screen-shot showing the 2011 Japan tsunami inundating Santa Cruz Harbor.

Tsunami Response TOOLBOX

(Additional Tsunami Products Available to Local Agencies)

- **Tsunami**Clear **maps/brochures/kiosks**
- **Tsunami Sign Plan and tsunami signs**
- **Debris/scour modeling**

(Above) Example tsunami evacuation route map and kiosk developed using TsunamiClear visual standards intended for the public that ensures a cohesive visual identity specific to tsunami evacuation (Chapman University).



(Left) Debris movement within Port of Los Angeles during 2-3m tsunami generated by large Alaska earthquake. Debris from small-boat basins may impact large ships and clog main channels.

- **Harbor hazard maps (current vs. damage)**
- **Evacuation/Response Decision Support Tools**

Local Agency Support Tool for Less Than "all-or-nothing" Scenario using real-time information= **FASTER**approach Forecast Amplitudes, Storm and Tidal conditions, potential tsunami forecast Errors, and site-specific tsunami Run-up potential on land.

Land-Based Playbook

Scenario-Based Evacuation Playbook: Local, regional, or distant-source events with little time to prepare (*tsunami travel time less than 3-4 hours*)

Elevation-Based Evacuation Playbook (Phase 1-to-Max.): Smaller distant-source events with time to prepare secondary/smaller evacuation; like March 11, 2011 event (*more than 3-4 hours to prepare*)

Maritime Playbook

Scenario-Based Evacuation Playbook: Local, regional, or distant-source events that show anticipated tsunami peak velocity, duration of strong currents, areas of potential damage (based on current thresholds), and safe areas for repositioning vessels (based on community input). Maps are FEMA RiskMAP products.

(Below) Harbor hazard map showing potential damage based on current velocity.