



California
Department of
Conservation

California Geological Survey Seismic
Hazards | Tsunami Unit

City of Alameda Tsunami Hazards, Vulnerabilities, and Risks Maritime Communities

Rick Wilson, California Geological Survey

Yvette LaDuke and Kevin Miller, California Governor's Office of
Emergency Services



Laurie
Johnson
Consultants

AECOM



FEMA



Planning for the Next Tsunami



City of Alameda
Robert W. Crown Memorial State
Beach

Photo credit: marmas.com

Planning for the Next Tsunami



City of Oakland
Port of Oakland

Photo credit: amercanhour.com

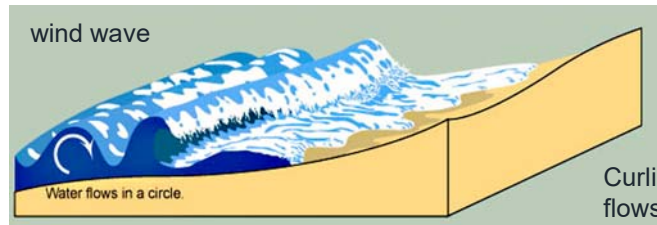
Planning for the Next Tsunami



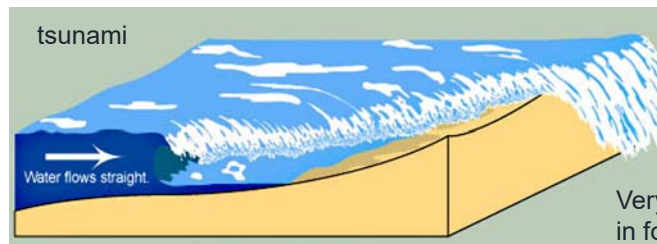
City of Alameda
Marinas and Coast Guard Island

Photo credit: marinas.com

What is a tsunami?



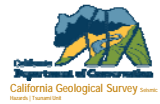
Curling, breaking waves, water flows in for less than a minute



Very long surges, water flows in for tens of minutes

California Department of Conservation | conservation.ca.gov

Other tsunami facts....



- A tsunami always has many waves/surges
- This first wave is almost never the largest
- The danger period can last 24 hours or more! (like the March 11, 2011 Japan tsunami in California)



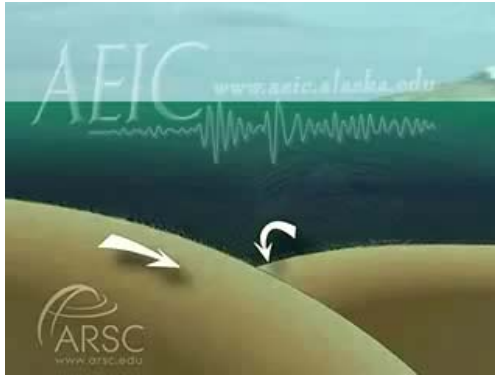
California Department of Conservation | conservation.ca.gov

Third surge arriving at Ko Phi Thailand, December 26 2004

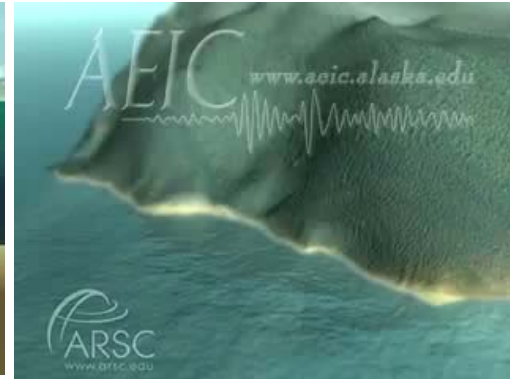
What causes a tsunami?



Submarine faults



Submarine/Subaerial landslides



California Department of Conservation | conservation.ca.gov

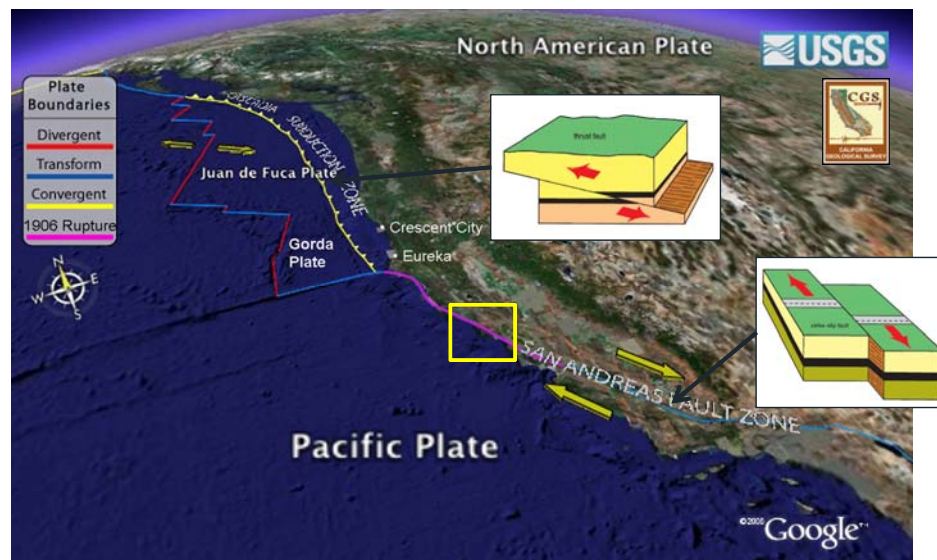
March 11, 2011 Tohoku-oki tsunami
Location: Sendai Plain, Japan - Tsunami arrives one hour after
M9.0 earthquake



California Department of Conservation | conservation.ca.gov

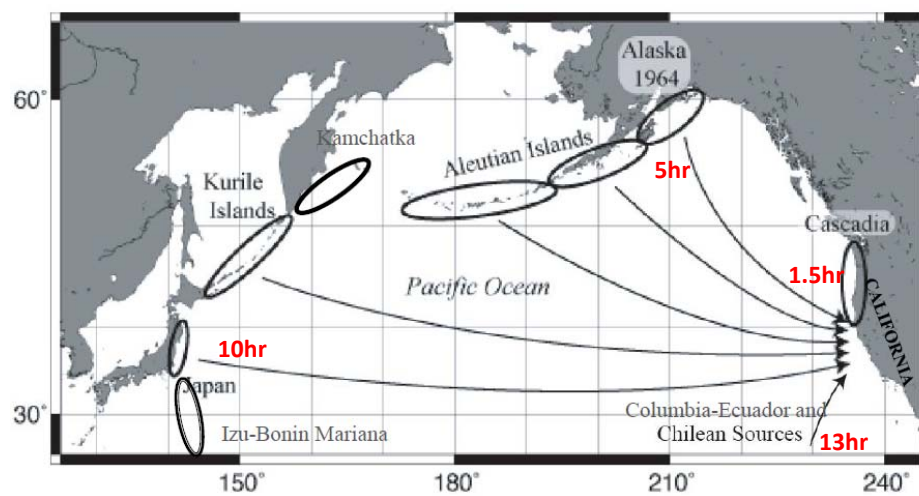
Search "EERI Rick Wilson
 observation Japan tsunami"

California has its faults!



California Department of Conservation | conservation.ca.gov

Potential Distant/Regional Tsunami Threats for California

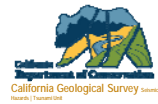


**Tsunami travel time
To City of Alameda**

California Department of Conservation | conservation.ca.gov

10

Significant Historical Tsunamis in California



- Eight significant trans-Pacific tsunamis (1946, 1952, 1957, 1960, 1964, 2006, 2010, and 2011) over past 70 years.
- Each of these events caused damage in California, with 1946, 1960, and 1964 causing inundation.
- Local tsunami events are less common but the most significant one was 1700 Cascadia (no written US record).



1946 – Half Moon Bay



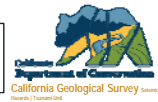
1960 – Crescent City



1964 – Crescent City

California Department of Conservation | conservation.ca.gov

Notable Historical Tsunamis in the San Francisco Bay Area



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

OBS = observed tsunami
activity

NR = No damage or severe
conditions reported

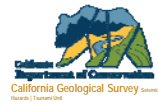
- Distant Source -
Tsunamis without felt
earthquakes

- Local Source -
Earthquake and tsunami
together

Date	Magnitude-Source area	Tsunami location	Run-Up/Amp	Remarks
2/15/1856	M5.5 - SF Bay (possible submarine landslide)	San Francisco	3 ft	"...water in the bay is exceedingly thick...by throwing up of mud and sand at bottom of bay..."
8/13/1868	M8.5 - Chile	SF-Fort Point	1 ft	NR
10/21/1868	M6.8 - Hayward Fault (possible submarine/subaerial landslide)	SF-Cliff House	OBS	"...decided commotion in the ocean...wave sent inland..."
3/31/1898	M6.2 - Hayward-Rodgers Creek Fault crossing Suisun Bay	Oakland	1 ft	"churned" water may be from storm activity, not tsunami
4/1/1946	M8.8 - Aleutian Islands	SF-Presidio	1 ft	NR
11/4/1952	M9.0 - Kamchatka	San Francisco	2 ft	NR
		Alameda	1 ft	NR
3/9/1957	M8.6 - Aleutian Islands	San Francisco	1 ft	NR
5/22/1960	M9.5 - Chile	San Francisco	2 ft	San Francisco ferry service disrupted by a current "running like the Mississippi River"
		Alameda	1 ft	NR
3/28/1964	M9.2 - Alaska	San Francisco	4 ft	NR
		Alameda	2 ft	NR
		Oakland	4 ft	NR
		San Rafael	4 ft	Multiple docks damaged; boats sunk and damaged
		Sausalito	6 ft	Docks/boats damaged; minor inundation on dry land
2/27/2010	M8.8 - Chile	San Francisco	1 ft	NR
3/11/2011	M9.0 - Japan	San Francisco	2 ft	Two piles broken; boats heeled over
		Alameda	2 ft	4-6 knot currents but no damage reported
		Berkeley	2 ft	\$80K in damages to docks and piles
		Richmond	1 ft	5-6 knot currents with buoys displaced
		Sausalito	4 ft	Minor damage to house boats and marinas

California Department of Conservation | conservation.ca.gov

Tsunami Source Scenario Model Results for the San Francisco Bay Area

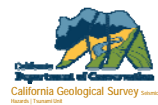


Near shore tsunami heights (flow depths) for both local and distant source scenarios, in FEET above Mean Sea Level. NOTE: The projections do not include any adjustments for ambient conditions, such as storm surge and tidal fluctuations, and model error (it is very important to note this difference, as those numbers can increase the projected water height during an event).

	TSUNAMI SOURCES	Approximate Travel Time	Pacifica	Ocean Beach	Black Point-Aquatic Park	Candlestick Park	Alcatraz Island	Treasure Island	Yerba Buena Island	Redwood City	Alameda	Richmond	Mare Island	Sausalito	Bollinas
Local Sources	M7.3 Point Reyes Thrust Fault	10-15min	7	6	4	3	4	3	3	4	4	4	3	6	8
	M6.6 Rodgers Creek-Hayward Fault	10-15min	2	2	2	2	2	2	2		3	3	3	3	
	M7.1 San Gregorio Fault	10-15min	4	4	3	3	3	3	3		4	3	3	3	
Distant Sources	M9 Cascadia-full rupture	1hr	4	5	3	3	3	4	3		4	3	3	4	4
	M9.2 Alaska 1964 EQ	5hr	13	12	7	4	6	5	6		9	7	3	8	10
	M9.3 Alaska-East Aleutians	5hr	26	26	13	6	12	10	8	5	15	11	4	13	24
	M8.9 Central Aleutians I	5hr	9	11	6	4	6	5	4	4	9	7	3	7	7
	M8.9 Central Aleutians II	5hr	5	6	5	3	5	4	4		5	4	3	5	7
	M9.2 Central Aleutians III	5hr	18	22	11	6	10	8	7	5	16	10	4	10	19
	M8.8 Kuril Islands II	9hr	3	3	3	3	3	3	2		5	3	3	4	3
	M8.8 Kuril Islands III	9hr	4	4	3	3	3	3	3		4	3	3	4	5
	M8.8 Kuril Islands IV	9hr	5	5	3	3	3	3	3		4	3	3	4	5
	M8.8 Japan II	10hr	5	5	4	3	3	3	3		6	3	3	3	4
	M8.6 Marianas Trench	11hr	3	3	3	3	3	3	3	4	3	3	3	6	3
	M9.5 Chile 1960 EQ	13hr	5	6	3	3	3	3	3		5	4	3	5	5
	M9.4 Chile North	13hr	4	5	4	3	4	4	4		6	3	3	4	5
Maximum Runup - Local Source			8	6	3	3	4	4	4	4	5	4	3	7	9
Maximum Runup - Distant Source			20	24	12	6	12	10	9	6	18	10	4	11	22
UPDATED Maximum Runup - Distant Source			31	32	14	6	13	11	9	6	18	11	4	14	27

2019 Updated Source Information

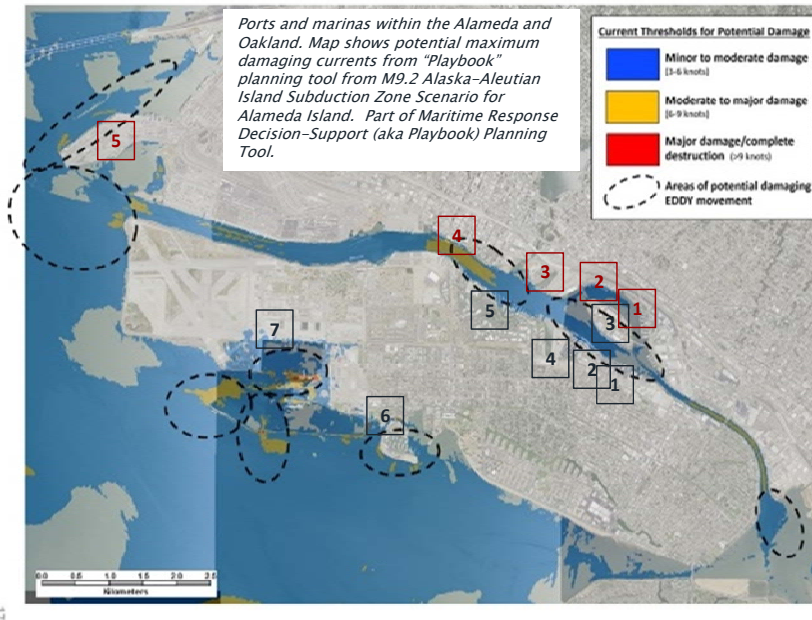
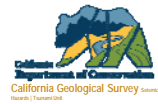
Tsunami Hazards for Harbors and Ports



There are a number of **TSUNAMI HAZARDS** that could directly affect harbors and boaters:

- **Strong and unpredictable currents**, especially where there are narrow entrances, narrow openings, and other narrow or shallow parts of harbor
- **Eddies/whirlpools** causing boats to lose control
- Sudden **water-level fluctuations** where docks and boats:
 - Hit bottom (grounded) as water level drops
 - Could overtop piles as water level rises
- **Tsunami bores and amplified waves** resulting in swamping of boats and damage to docks
- **Drag** on deep draught boats causing damaging forces to the docks they are moored to
- **Collision** with other boats, docks, and debris in the water
- **Scour and sedimentation** can affect harbor protection measures and shipping channels, respectively
- **Dangerous tsunami conditions can last tens of hours** after first wave arrival, causing problems for inexperienced and unprepared boaters who take their boats offshore
- Recovery delays because of **environmental hazards**

California Tsunami Maritime Safety Planning



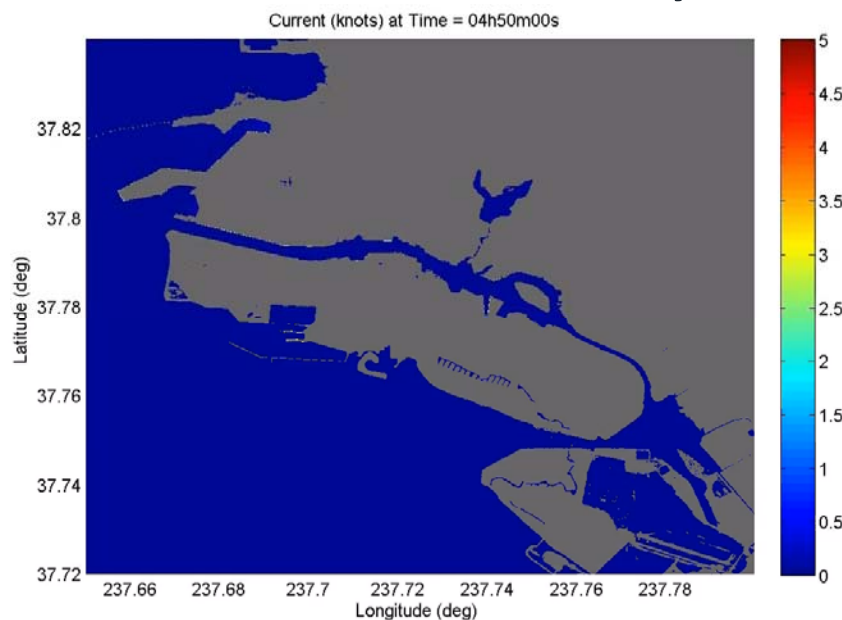
Alameda Marinas and Ports

1. Alameda Marina
2. Grand Marina
3. Coast Guard Island
4. Fortman Marina
5. Marina Village Yacht Harbor
6. Ballena Isle Marina
7. Alameda Naval Air Station

Oakland Marinas and Ports

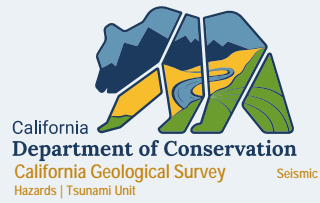
1. Oakland Marinas
2. Estuary Cove Marina
3. Fifth Avenue Marina
4. Jack London Square Marina and Oakland Marina Fuel Docks
5. Port of Oakland

California Tsunami Maritime Safety Planning



Simulation of currents from USGS SAFRR Alaska Scenario for Alameda Island

California



THANK YOU

Rick Wilson
Rick.Wilson@conservation.ca.gov