California Maritime Community Preparedness Initiatives

Disaster Planning Cycle

- Hazard Assessment
- Preparedness
- Mitigation
- Response
- Recovery

March 2011: Post tsunami; Boats sunk; recovery efforts in Crescent City Harbor

Rick Wilson, California Geological Survey

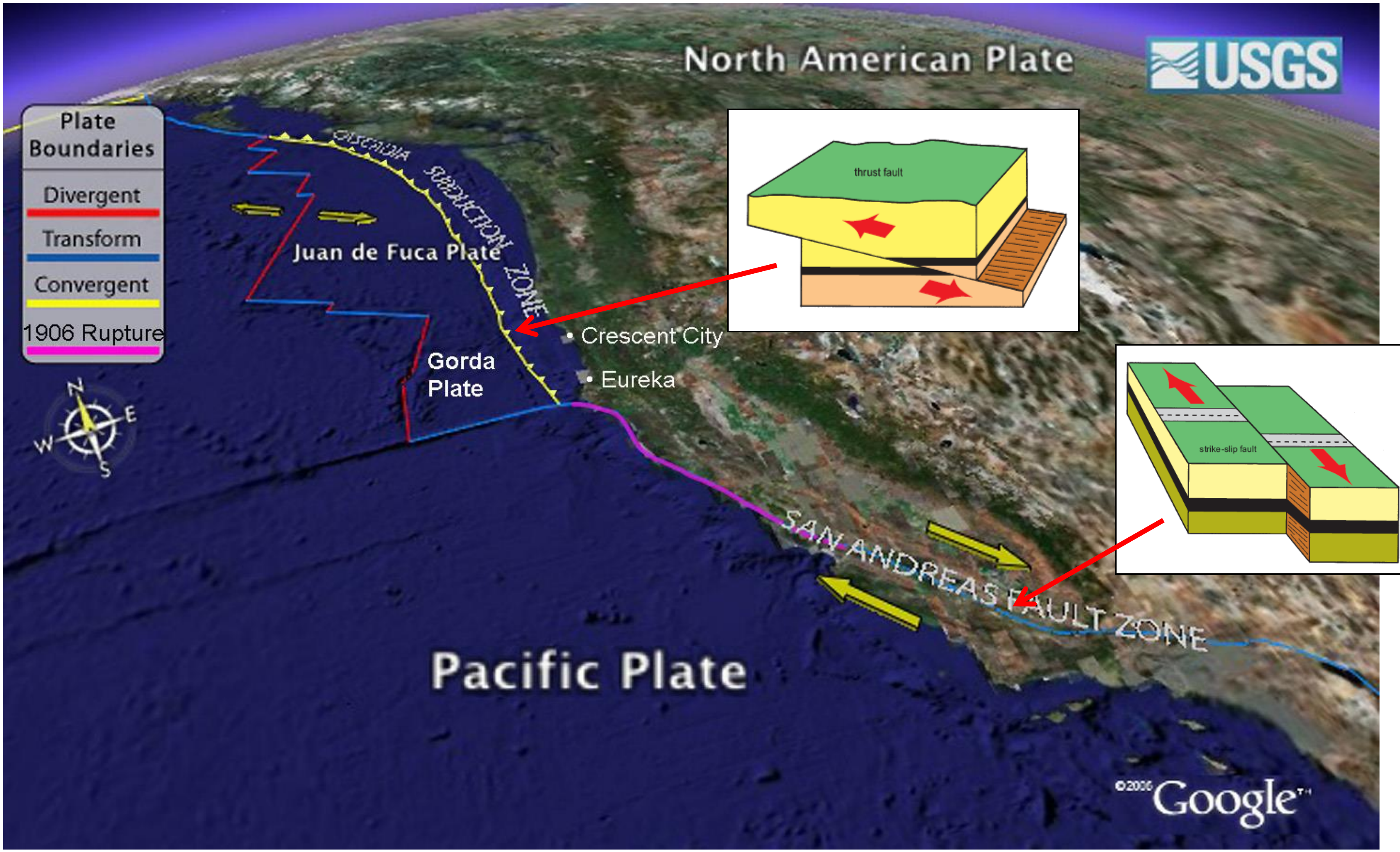
Patrick Lynett, Aykut Ayca, and Adam Keen, University of Southern California

Martin Eskijian, California State Lands Commission

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

Partners = CGS California Geological Survey, Cal OES Governor's Office of Emergency Services, USC University of Southern California, Humboldt State University, California State Lands Commission, California Coastal Commission, AECOM, U.S. Department of Homeland Security, FEMA, NOAA, USGS science for a changing world

California has its faults!



2011 Tohoku Tsunami in Japan

- 20-30 minutes between earthquake and tsunami arrival
- Vessels which tried to evacuate (Miyako Harbor)
    - Most were damaged or sunk
    - Became part of debris field and did more damage on land
- Crews which got off vessels and docks, and evacuated on land by foot, typically survived (Noda Harbor)

March 11, 2011 Tohoku Tsunami in Miyako Harbor, Japan

Search “2011 Tsunami EERI Rick Wilson”

2011 Tohoku Tsunami in California

- Strong currents/debris in harbor
- 27 harbors damaged in California
- Some vessels were taken offshore before tsunami's arrival
  - Commercial fishing fleet in Crescent City = stayed offshore; traveled to safe ports
  - Recreational boater elsewhere = returned too early; caused injuries to harbor staff
- Recovery – took 5 years in some harbors
  - Issues = dock/pile replacement, contamination clean-up, sediment removal
  - Crescent City = half fishing fleet went elsewhere and did not return

March 11, 2011 Tohoku Tsunami in California; video from Coast Guard helicopter above Crescent City Harbor

Search "CGS 2011 tsunami in California"

Needs and Lessons Learned from Recent Tsunamis

March 2011: During tsunami in Santa Cruz Harbor

March 2011: Tsunami damage to boats and docks in Brookings Harbor, Oregon

- Inconsistent response activities, including If-When-Where to reposition vessels?
- Where and what harbor structures and infrastructures are at risk to damage? What areas should be safe?
- Educating boat owners about tsunami hazards to help them make better decisions, for example:
  - Not taking boats offshore, unless prepared
  - Not bringing boats into harbor during tsunami
- Ongoing hazard reduction and recovery issues: What can be done to improve tsunami resistance and resiliency in harbors?

Tsunami Hazards for Harbors and Ports

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

- Sudden **water-level fluctuations** where docks and boats:
  - Hit bottom (grounded) as water level drops
  - Could overtop piles as water level rises
- **Strong and unpredictable currents**, especially where there are narrow entrances, narrow openings, and other narrow parts of harbor
- **Tsunami bores and amplified waves** resulting in swamping of boats and damage to docks
- **Eddies/whirlpools** causing boats to lose control
- **Drag** on deep draught boats causing damaging forces to the docks they are moored to
- **Debris in the water;** collision with boats, docks, and harbor buildings
- **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 **contamination and environmental hazards**

Maritime Tsunami Response and Mitigation Playbooks

33 Playbooks Covering 70+ Harbors/Ports at Risk

Maps are FEMA RiskMAP Products

DRAFT 3/22/2017

California Maritime Tsunami Response Playbook
[Combined, Excerpted version]

City and County of San Francisco
North and East

2015-SF-01
2015-SF-02

DURING AN EMERGENCY, USE THE "QUICK REFERENCE" SHEET ON PAGES 32–33.

For the expanded Playbook format, use directions on pages 7–8.

Source: California Maritime Tsunami Response Playbook No. 2015-SF-01
California Maritime Tsunami Response Playbook No. 2015-SF-02

California Geological Survey
California Governor's Office of Emergency Services
University of Southern California
Humboldt State University
National Oceanic and Atmospheric Administration

Funded by the Federal Emergency Management Agency and the National Tsunami Hazard Mitigation Program

Quick Reference Page for Determining Maritime Tsunami Response Activities for *CCSF-North*

Step 1: Obtain basic information about the earthquake and tsunami from National Tsunami Warning Center (NTWC), National Weather Service-Monterey office, or San Francisco Department of Emergency Management (SFDEM).

Earthquake location: ______________________

Earthquake magnitude: ______________________

Tsunami Alert level (circle one): WATCH ADVISORY WARNING

Closest forecasted tsunami amplitude/wave height: ______________

Forecasted tsunami arrival time: ______________

NOTE: Tsunami Alert Level may change in first couple hours after the earthquake. A WATCH may be upgraded to an ADVISORY or a WARNING.

Step 2 North: Tsunami evacuation and response depend on the amount of time before tsunami arrival. Four hours is considered the threshold time needed for an officially-conducted evacuation. As a quick reference, the State offers the following guidance:

If less than four hours before tsunami arrival:
- ADVISORY - Evacuate beaches, harbor docks, and piers.
- WARNING - Evacuate maximum on-land evacuation zone, or follow guidance provided by SFDEM.

If more than four hours before tsunami arrival, use the State/NWS recommended Playbook Plan, based on the Forecast Amplitude from Step 1, as "Peak Amplitude" in the table to the right to identify the response plan to use.

PEAK AMPLITUDE IN BAY (in meters, above existing conditions)	SCENARIO PLAYBOOK PLAN LETTER	PLAYBOOK REFERENCE PAGES
< 0.2	No action	
0.5	A	Pages 9–10
0.7	B	Pages 13–14
1.0	C	Pages 17–18
1.2	D	Pages 21–22
2.5 +	E	Pages 25–26

32

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Guidance for Safe Minimum Offshore Depth for Vessel Movement

Work between NTHMP States/Territories and U.S. Coast Guard

General Recommendations for Recreational and Commercial Boaters:

*** In general, it is NOT recommended that boaters try to take vessels offshore before or during a tsunami. And, if they are offshore, they should not try to re-enter the harbor until the harbor master or port captain indicates it is safe to do so.***

LARGE LOCAL-SOURCE TSUNAMI – Tsunami may arrive in 10-15 minutes

- If you are on land or tied up at the dock: Do not attempt to take your vessel offshore. Leave your boat and go to high ground on foot as soon as possible. You do not have time to save your boat in this situation and put your life at risk if you try to do so.
- If you are in deep water or very close to deep water: Take your vessel further offshore beyond the "minimum offshore safe depth" outlined in the Table 1 for your U.S. state/territory/commonwealth or region. Typically, this depth is 50 to 100 fathoms (300 to 600 foot) depth, then you are safe from tsunamis.
- If you are on the water but very near shore: Use your best judgement to decide between the two options: safely beach/dock the vessel and evacuate to high ground or get to the minimum offshore safe depth. Attempting to beach the vessel could be challenging and dangerous, being dependent on wave conditions, water levels, and the presence of bars. It is easy for a boat to run aground or capsize before reaching the shore only to then be swept away by the coming tsunami. However, if you can safely beach or dock your boat and get to high ground before the tsunami, then this is your best chance. If that is not possible, head to deep water as quickly as possible.

LARGE DISTANT-SOURCE TSUNAMI – Tsunami arrival at least two-hours away

- It is NOT recommended that boaters try to take their vessels offshore before or during a tsunami. It is safer to keep your boat docked during a tsunami because most tsunamis are relatively small, and your personal safety is more important than saving your property/boat.
- On the rare occasion when a larger tsunami is expected (Warning level), the boat owner may consider taking their boat offshore considering the following criteria:
    - The SIZE of the tsunami.
    - How much TIME you have before the tsunami arrives.
    - The PREPAREDNESS of the boat and EXPERIENCE of its captain to stay offshore for extended period of time (12-24 hours), or travel to safe, undamaged harbors.
    - The WEATHER at sea could be as dangerous as the tsunami itself.
- Do not go offshore unless you are very sure that you can get beyond the recommended minimum offshore safe depth at least 30 minutes before the estimated tsunami arrival time for your coastline. Please refer to the Table 1 for the recommended minimum safe depth for your U.S. state/territory/commonwealth or region.

Guidance for Safe Minimum Offshore Depth for Vessel Movement

Work between NTHMP States/Territories and U.S. Coast Guard

TABLE 1: Specific guidance for minimum offshore safe depths for maritime vessel evacuation prior to the arrival of tsunami.

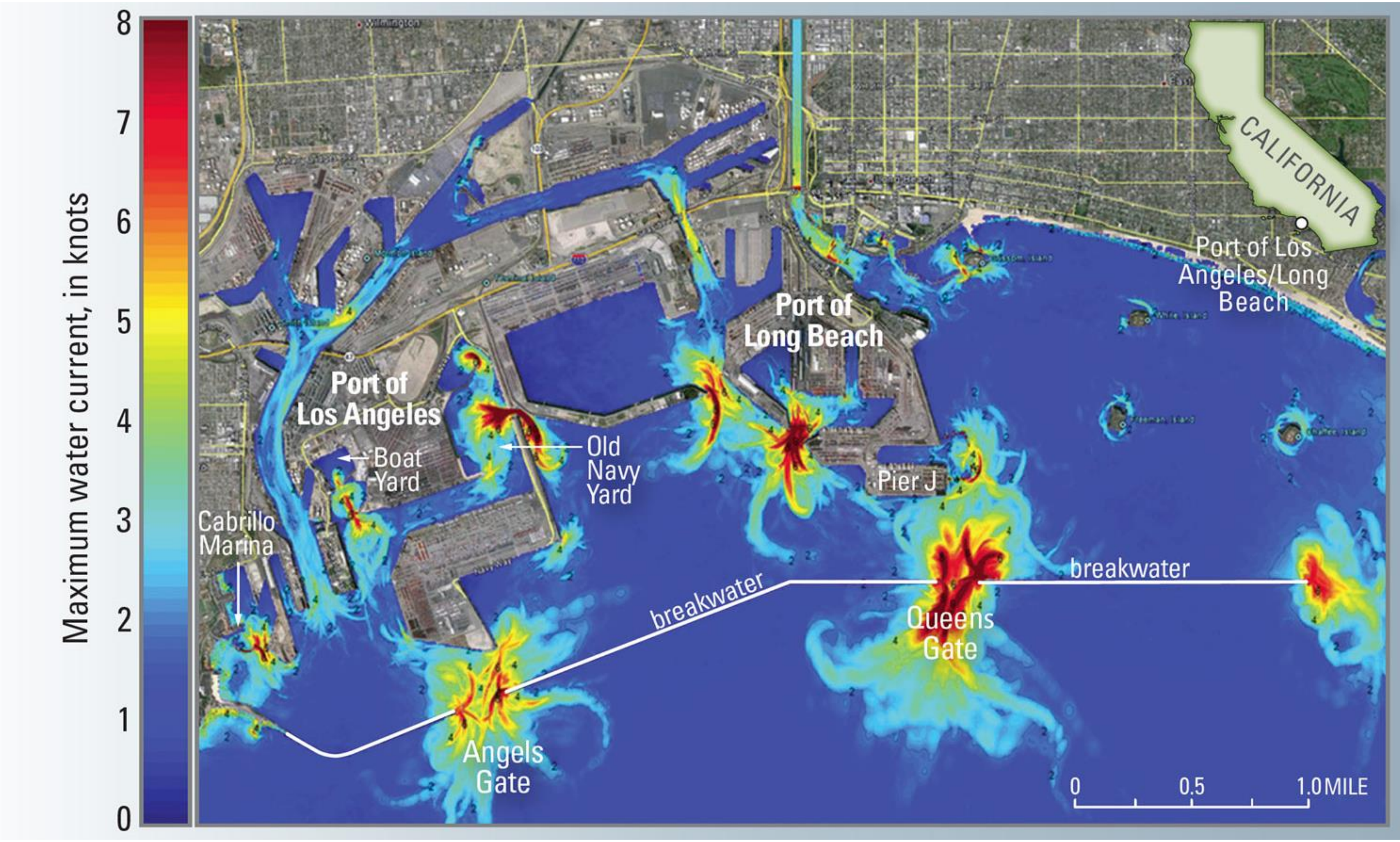
State/Territory	Distant Source (ships in harbor)*	Local Source (ships at sea)*	Notes
California	30 fathoms	100 fathoms	Evaluated; may add potential safe areas within large bays and ports
Oregon	30 fathoms	100 fathoms	Evaluated, but is re-evaluating based on new data; also evaluating Columbia River
Alaska	30 fathoms	100 fathoms	Evaluated; ships should be at least 1/2 mile from shore for all scenarios
Washington	30 fathoms	100 fathoms	Evaluated; special conditions exist inside Puget Sound
Hawaii	50 fathoms	50 fathoms	Evaluated; implemented in Coast Guard plan in some locations
American Samoa	50 fathoms	50 fathoms	Evaluating, guidance from others
Puerto Rico	50 fathoms	100 fathoms	Evaluated
USVI	50 fathoms	100 fathoms	Evaluating; possibly follow PR
Guam	50 fathoms	100 fathoms	Coordinated with USCG Guam Sector
CNMI	50 fathoms	100 fathoms	Coordinated with USCG Guam Sector
Gulf Coast		100 fathoms	Evaluating; issues with long, shallow shelf complicate getting beyond safe depth offshore
East Coast		100 fathoms	Evaluating; issues with long, shallow shelf complicate getting beyond safe depth offshore

* Ships also recommended to be a minimum of ½ mile from shore or fringing reef

Page 3 of Maritime Tsunami Response and Mitigation Playbooks

Mitigation Measures for Reducing Impacts in Maritime Communities

Real-time response ("soft") mitigation measures	**Permanent ("hard") mitigation measures**
Reposition ships within harbor	Increase size and stability of dock piles
Move boats and ships out of harbors	Fortify and armor breakwaters
Remove small boats/assets from water	Replace flotation portions of docks and dock cleats
Shut down infrastructure before tsunami arrives	Increase flexibility of interconnected docks
Evacuate public/vehicles from water-front areas	Improve movement along dock/pile connections
Restrict boats from moving during tsunami	Increase height of piles to prevent overtopping
Prevent boats from entering harbor during event	Deepen/Dredge channels near high hazard zones
Secure boat/ship moorings	Move docks/assets away from high hazard zones
Personal flotation devices/vests for harbor staff	Widen size of harbor entrance to prevent jetting
Remove hazardous materials away from water	Reduce exposure of petroleum/chemical facilities
Remove buoyant assets away from water	Strengthen boat/ship moorings
Stage emergency equipment outside affected area	Construct flood gates
Activate Mutual Aid System as necessary	Prevent uplift of wharfs by stabilizing platform
Activate of Incident Command at evacuation sites	Install debris deflection booms to protect docks
Alert key first responders at local level	Ensure harbor structures are tsunami resistant
Restrict traffic entering harbor; aid traffic evacuating	Construct breakwaters further away from harbor
Identify/Assign rescue, survey, and salvage personnel	Install Tsunami Warning Signs
Identify boat owners/live-aboards; establish phone tree, or other notification process	Identify equipment/assets (patrol/tug/fire boats, cranes, etc.) to assist response activities

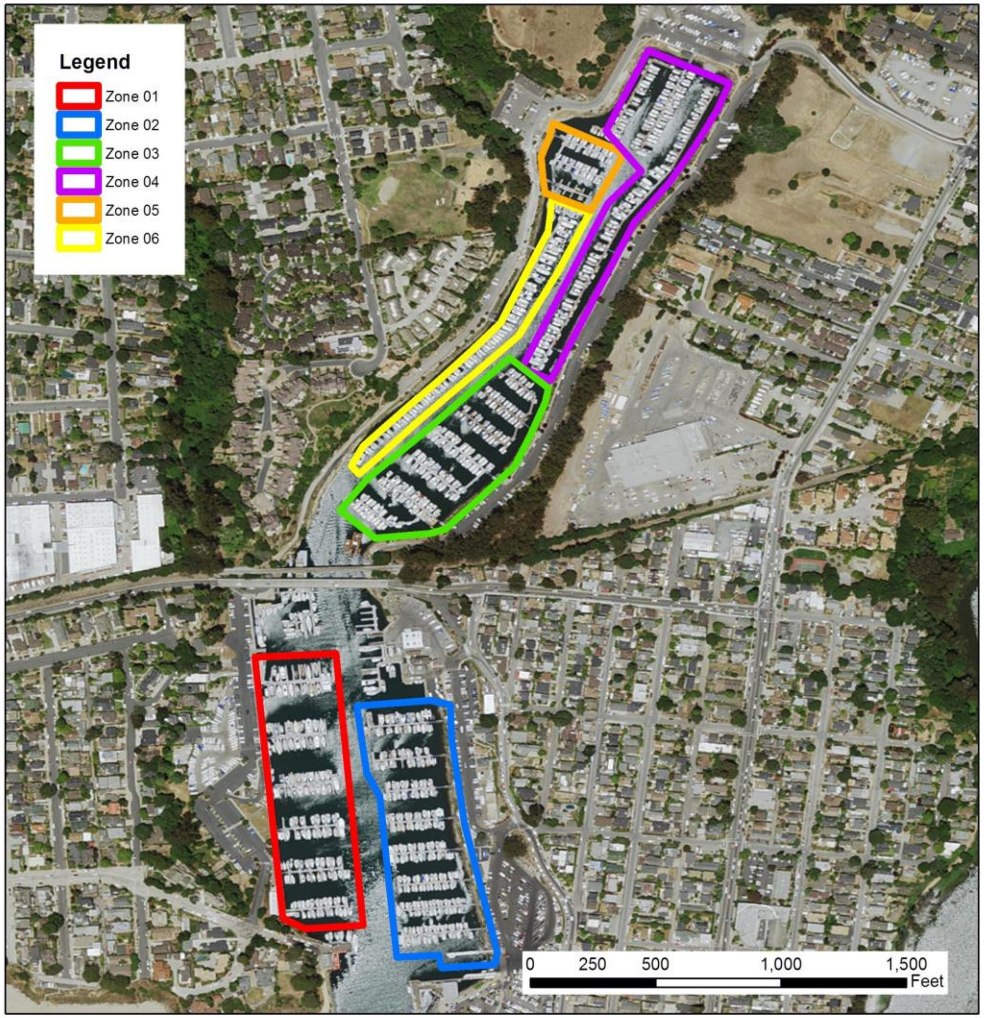


These modeling results describe the hazard level, but what about the *vulnerability*?

For this we move towards an engineering analysis, attempting to quantify the potential damage to various components at different hazard levels

Harbor Improvement Reports

Tsunami Damage Assessments



Map of Santa Cruz Harbor identifying failure potential study zones.

Cleat Damage Estimate

Tsunami Event	Zone					
	1	2	3	4	5	6
2010 Magnitude 8.8 Chile Event (Historical)	Low	Low	Low	Low	Low	Moderate
Magnitude 9.0 Cascadia Scenario	Moderate	Moderate	Low	Moderate	Low	High
2011 Magnitude 9.0 Japan Event (Historical)	Low	Low	Moderate	Moderate	Low	Moderate
Magnitude 9.4 Chile North Scenario	Low	Moderate	Moderate	Moderate	Low	Moderate
Magnitude 9.2 Eastern Aleutian-Alaska Scenario	Moderate	Moderate	Moderate	Moderate	Moderate	High

Pile Guide Damage Estimate

Tsunami Event	Zone					
	1	2	3	4	5	6
2010 Magnitude 8.8 Chile Event (Historical)	Low	Low	Low	Low	Low	Moderate
Magnitude 9.0 Cascadia Scenario	Moderate	Moderate	Moderate	Moderate	Low	High
2011 Magnitude 9.0 Japan Event (Historical)	Moderate	Low	High	Moderate	Low	Moderate
Magnitude 9.4 Chile North Scenario	Moderate	Moderate	High	Moderate	Moderate	Moderate
Magnitude 9.2 Eastern Aleutian-Alaska Scenario	High	Moderate	Moderate	Moderate	Moderate	High

Keen, Adam S., et al. "Monte Carlo–Based Approach to Estimating Fragility Curves of Floating Docks for Small Craft Marinas." Journal of Waterway, Port, Coastal, and Ocean Engineering (2017): 04017004.

Harbor Improvement Reports

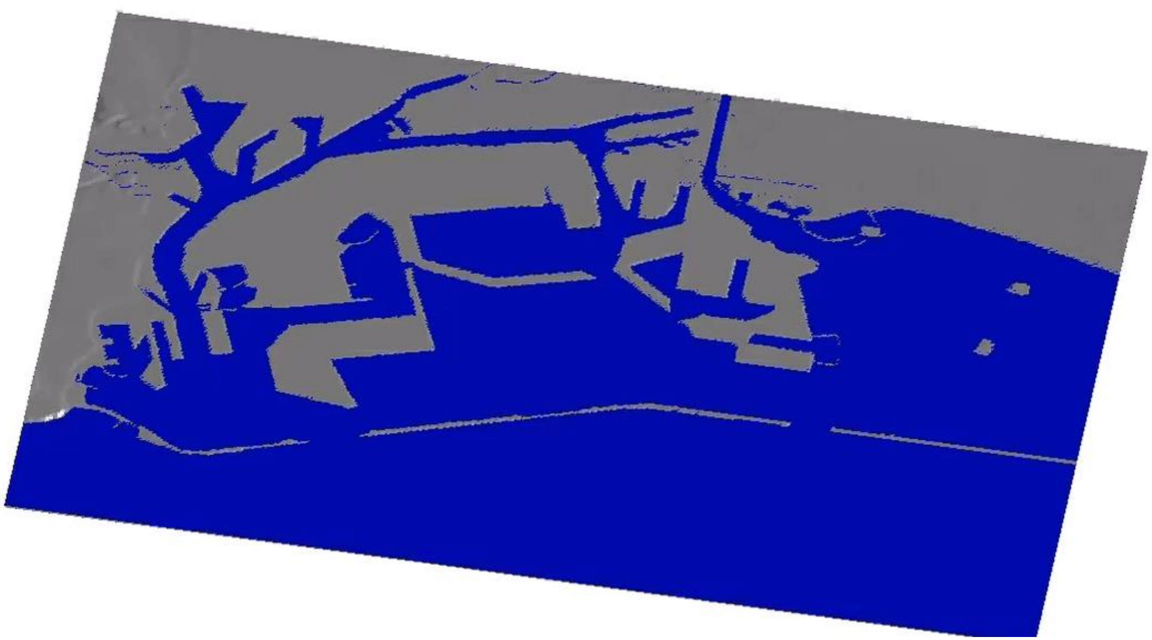
Sediment Movement Analysis

Model the sediment erosion, transport, and deposition during a tsunami

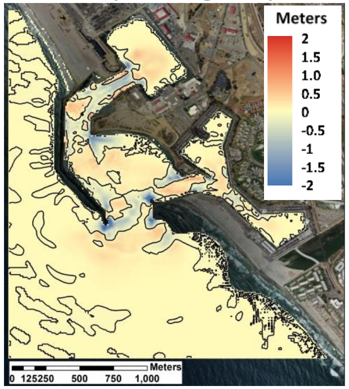
HIRs and possibly Playbooks will include maps of seafloor elevation change for a set of scenarios

Identify likely areas of high scour and areas of high deposition, where vessel clearance and long-term recovery issues post-tsunami may arise

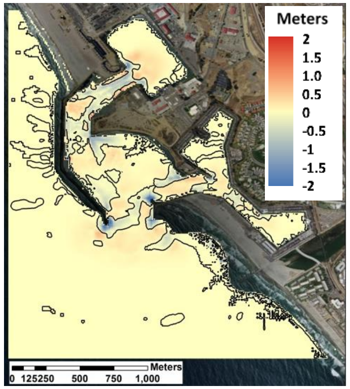
Sediment Conc. at Time = 5.6381 (hr) since EQ



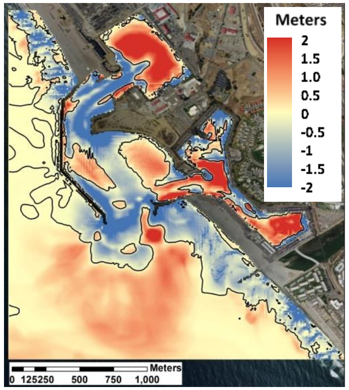
2011 Japan – Change in Depth



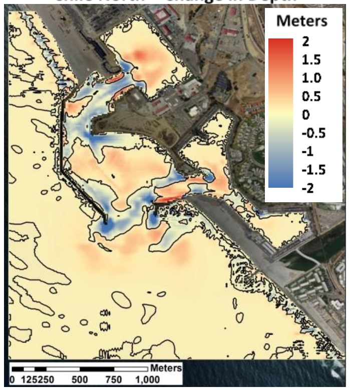
2010 Chile – Change in Depth



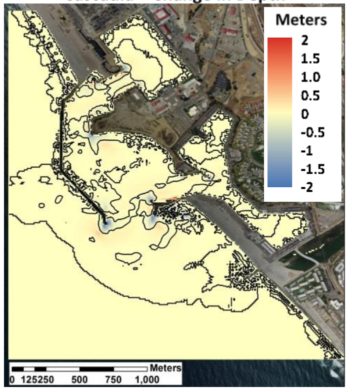
Alaska – Change in Depth



Chile North – Change in Depth



Cascadia – Change in Depth

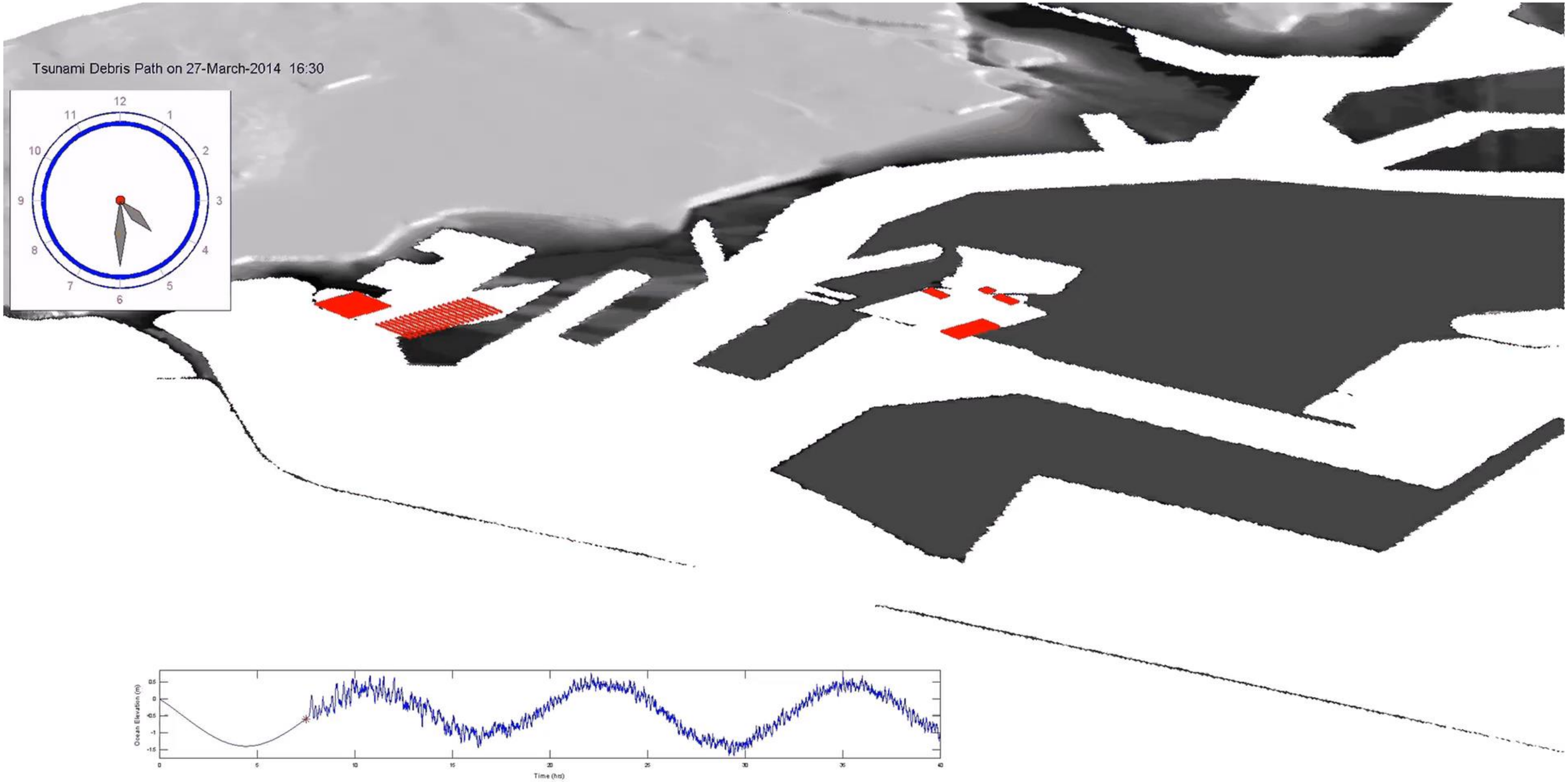


Harbor Improvement Reports

Debris Movement Assessments

Using engineering analysis, we know approximately when to expect damage to initiate in ports and marinas

Potential debris mapping provides an estimate of the likely location of debris during and immediately after a tsunami



Status of Harbor Improvement Reports (HIRs)

- Field work/meetings with harbors
- New damage potential analysis techniques: dock cleats/pile guides, and sediment/debris movements
- Report sections
    1. Purpose
    2. Tsunami Impact Report
    3. Recommended Actions (multiple hazards)
    4. **Local Hazard Mitigation Plan Section (mitigation measures for direct input)**
- Working draft(s) completed/shared with 6 harbors: Oceanside, Crescent City, Santa Cruz, Richmond Marina Bay, Noyo River, and Pillar Point harbors
- Active 2017 Hazard Mitigation Grant Program funding opportunity available in CA (winter storms)
    - Contacted dozen harbors
    - Most using HIR to apply for mitigation grants
- Introduce HIRs to NTHMP for feedback; could lead to National guidance development

Harbor Improvement Report

Maritime Tsunami and Coastal Hazard Mitigation Guidance
For Harbor Engineers and Emergency Managers

Noyo Harbor – Mendocino County
Harbor Improvement Report (HIR) No. 2017-Mendo-01

DRAFT

Draft Completed June/2017

By California Geological Survey
University of Southern California
California State Lands Commission
California Governor's Office of Emergency Services

Funded through a Cooperative Technical Partnership with the Federal Emergency Management Agency

FEMA

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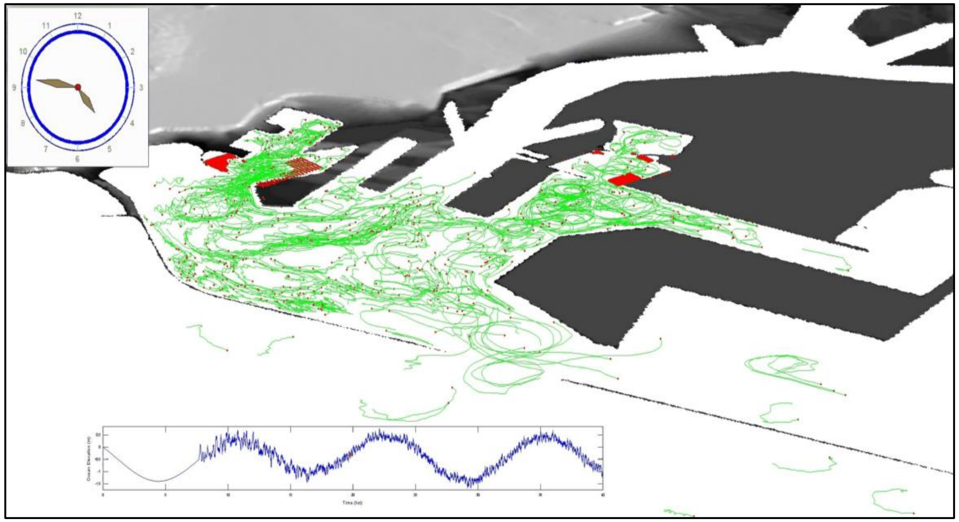
Model Run	Dock								
	A	B	C	D	E	F	G	H	I
Magnitude 9.2 Eastern Aleutian-Alaska Scenario	Moderate	High	High	High	High	Moderate	Moderate	Moderate	Low
Magnitude 9.0 Cascadia Scenario	Moderate	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low
2010 Magnitude 8.8 Chile Event (Historical)	Low	Moderate	Low	Low	Low	Low	Low	Low	Low
Magnitude 9.4 Chile North Scenario	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Low
2011 Magnitude 9.0 Japan Event (Historical)	Low	Moderate	Mode	Moderate	Moderate	Moderate	Low	Low	Low

Description of Mitigation Activity	Prioritization (High, Medium, Low) and Timeframe	Hazards Addressed	esponsible Agency	(B/C) Benefits-Costs (TF) Technical Feasibility
Develop and share educational materials with boating community (recreational and commercial) that identify the hazards and provide sensible response actions for extreme events like tsunamis.	High Short term - Ongoing	All coastal hazards		B/C: Sustained mitigation outreach program has minimal cost, especially with the educational resources (brochures, guidance, Playbooks) provided by the State and the National Weather Service (NWS). TF: This low cost activity can be combined with recurring outreach opportunities at meetings where hazard specific information can be presented in small increments.
Develop a harbor response plan, using tsunami response Playbooks or other format, which outlines specific response activities for extreme events of different sizes like tsunamis. Close coordination with community emergency managers will be required.	High Short term	All coastal hazards		B/C: Developing or updating harbor response plans has a minimal cost, especially with the resources, like the Playbooks, provided by the State and the NWS. TF: This relatively low cost activity can be completed with the help of the local community emergency manager as well as the State and NWS.
Reinforce fuel dock and dock with the pump-out station. Delays in recovery efforts may occur if there is infrastructure damage and spills occur.	High Short term	Tsunamis		B/C: The cost of reinforcement is minimal compared to that of long-term recovery. If this infrastructure becomes damaged and environmental spills occur, the harbor could be closed while water and sediment decontamination and removal takes place. TF: Dock reinforcement and infrastructure hardening would take an engineering analysis but there are mitigation measures available.
Reduce the exposure of or remove liquid and solid chemical containers from waterfront areas.	High Long term	All hazards		B/C: Removing or relocating environmental hazards away from the water will reduce the potential for contamination during extreme events. Removal and monitoring of chemicals is an inexpensive endeavor with large benefit.

Parts of new Harbor Improvement Report. Analysis of damage potential for cleats and pile guides in Noyo River Harbor. Table identifies direct Mitigation Activities for integration into LHMP (based on FEMA "Local Mitigation Planning Handbook")

Maritime Tsunami Recovery Guidance



Model of potential debris movement in Port of Los Angeles during large Alaska tsunami; can use this information to determine where debris will accumulate

March 2014: Rebuild in "tsunami resistant" Crescent City Harbor

Guidance for harbors, communities, and state to produce recovery plans for large local- (Cascadia) and distant-source events.

Direct Impacts (Damage):

- Vessels, docks, and harbor infrastructure damage
- Permanent land change in large local source EQ
- Debris in water and on land
- Sedimentation and scour
- Contaminants in water and sediment

Indirect Impacts (Time):

- Commercial fishing and shipping disruption
- Waterfront business disruption
- Regulatory redundancy and delays
- Limited resources and funding for recovery
- Loss of business and workforce over time

Tsunami Hazard Mitigation and Response

Questions?

Thank you

Rick Wilson, California Geological Survey

Rick.Wilson@conservation.ca.gov

www.tsunami.ca.gov