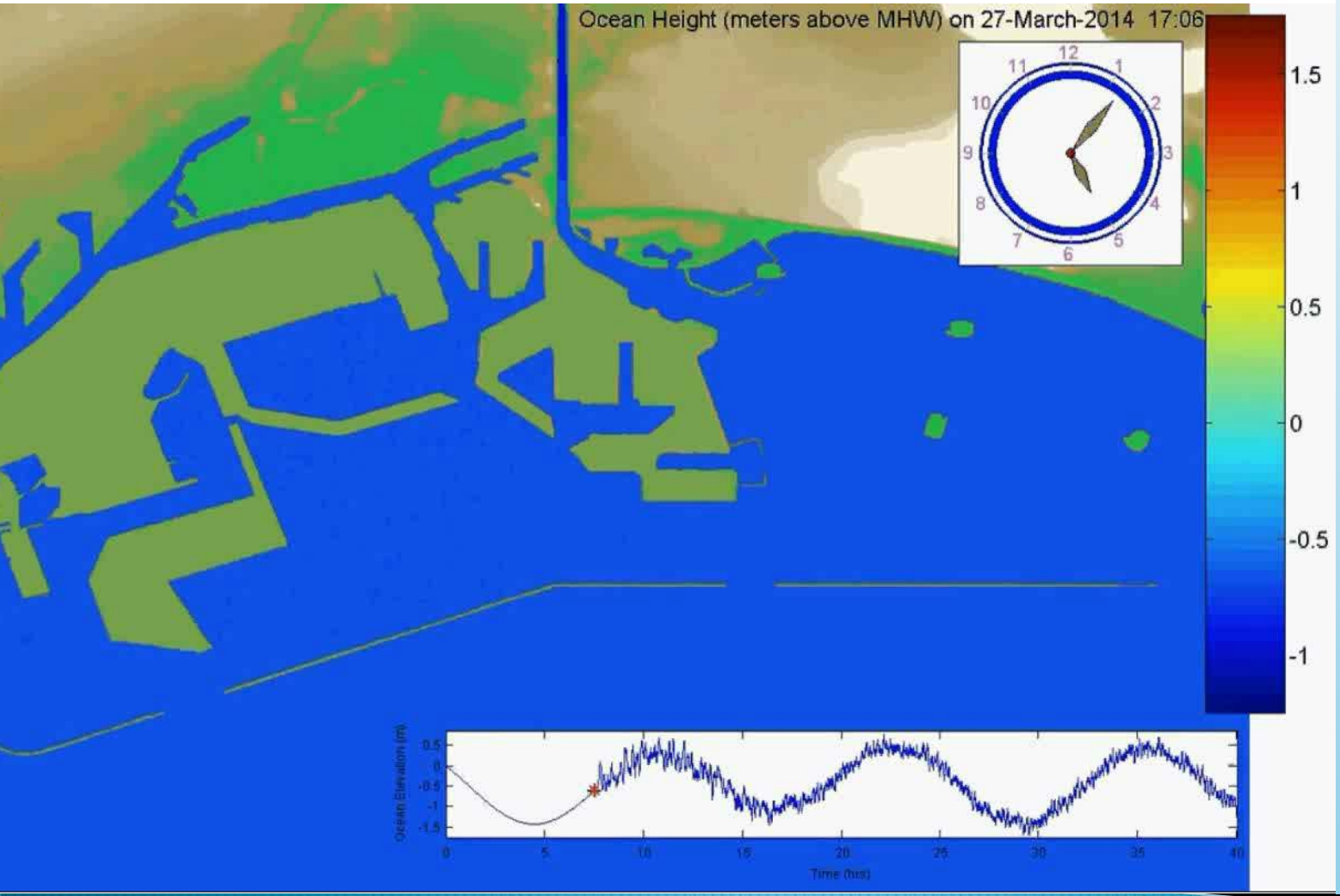
Maritime Tsunami Hazard Assessment in California



Patrick Lynett, University of Southern California

Jose Borrero, eCoast and University of Southern California

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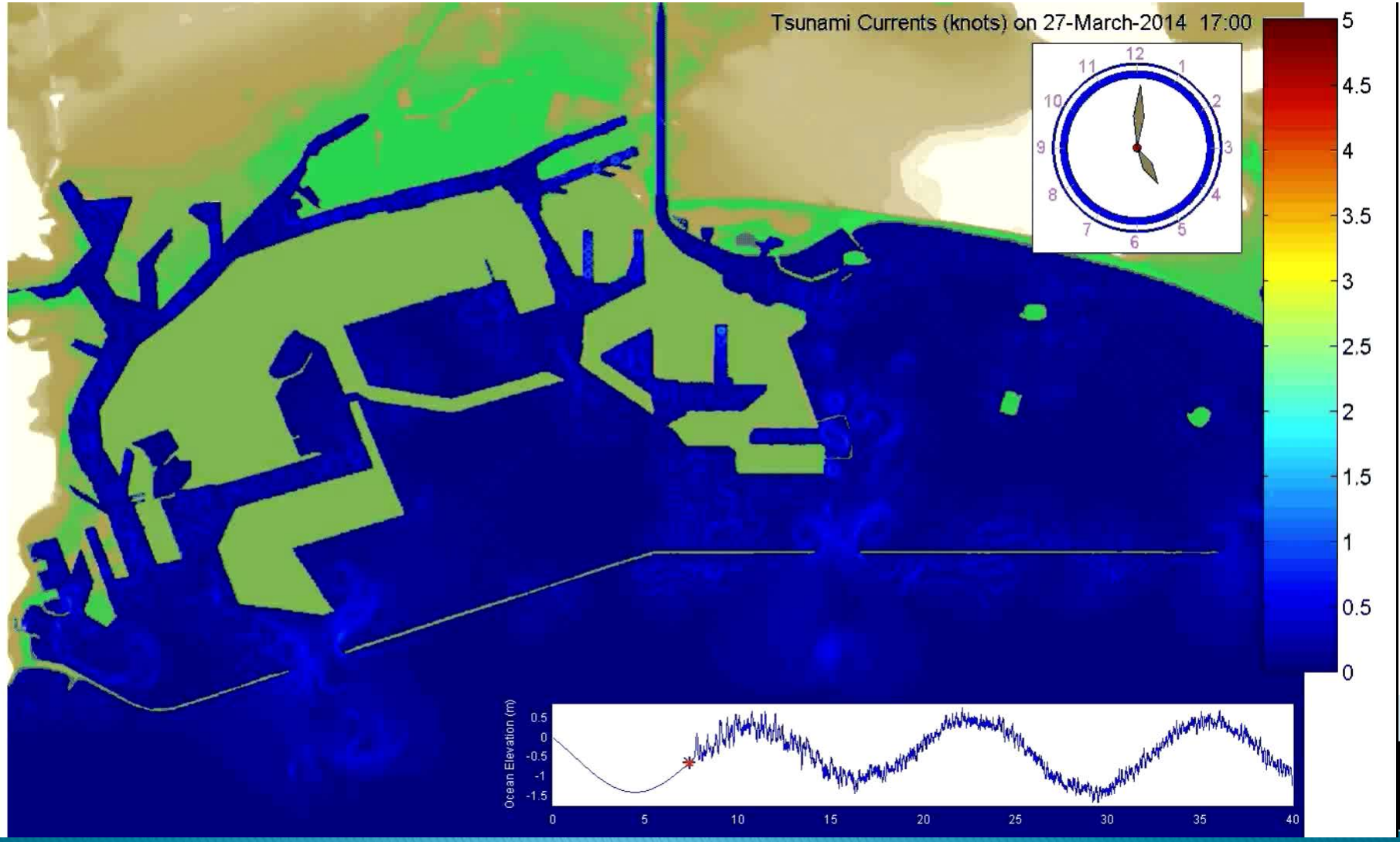
Martin Eskijian, California State Lands Commission

Kevin Miller, California Governor's Office of Emergency Services

Maritime Tsunami Hazard Assessment in California



Tsunami Current Hazard Assessment Approach and Products

Focus on the currents generated by a range of different tsunami sources (scenario-based)

Develop "playbooks" for guidance on tsunami effects in harbors

California Maritime Tsunami Response Playbook And Mitigation Guidance

Port of Los Angeles – Los Angeles County

Maritime Tsunami Response Playbook (MTRP) No. 2014-LA-01

DURING AN EMERGENCY, USE THE "QUICK REFERENCE" SHEET ON THE BACK PAGE (PAGE 22).

(For the expanded Playbook format, use directions on page 7)

California Maritime Tsunami Response Playbook No. 2014-LA-01

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

FEMA

Table of Contents – Tsunami Response Plan Playbooks

DURING AN EMERGENCY, USE THE "QUICK REFERENCE" ON PAGE 2

GATHERING INFORMATION FOR RESPONSE ACTIVITIES.

PURPOSE: This Maritime Tsunami Response Playbook Guidance document will help m maritime community prepare, plan, and respond to strong currents and damage from tsunamis. It has been developed with assistance from the Port by the California Tsunar and principle funding from FEMA. **It is essential that harbor staff become familiar wit Playbook guidance document before use.** The information within the Playbook can al harbor develop and implement tsunami mitigation strategies through their Local Haza Plan, and receive potential mitigation funding if needed.

USE: This Playbook is primarily designed to help the Port with tsunami response activi providing detailed information about potential tsunami scenarios which can be used d event.

First, it requires that the harbor develop response plans for each of the scenarios in t this should be done when the Playbook is first received. The California Tsunami Progra with the Port to assist in develop these plans if requested.

When a tsunami is occurring, follow the steps outlined in either the Quick Reference the last page (Page 22) if the user is not as familiar with the Playbooks, or the Expand guideline on Page 7 if the user wants more detailed information. The harbor master o response manager should fill out information about the source earthquake and tsuna information can be obtained from multiple sources, including the tsunami alert messa National Tsunami Warning Center (NTWC) in Alaska, the city or county emergency mar the National Weather Service, Regional Weather Forecast Office. Keep in mind that thi can change during the first hour or two after the earthquake occurs.

Finally, compare the tsunami forecast amplitude (wave height) to the maximum tsun amplitude on the scenario table on Page 7 or 22. Choose the scenario (Pages 8-17) w matches the forecast information. Follow the instructions on the page for that scenari scenario Playbook may be accompanied by a digital file indicating the response and ev plans; this can be shared during an emergency with emergency responders in the field

APPENDIX
Quick Reference Page for Determining Real-Time Maritime Tsunami Response Activities

Step 1: Obtain basic information about the earthquake and tsunami from National Tsunami Warning Center in Alaska, regional National Weather Service office, and/or county emergency manager. **NOTE: Tsunami Alert Level may change in first couple hours after the earthquake; WATCH may be upgraded to ADVISORY or WARNING.**

Earthquake location _____

Earthquake magnitude _____

Tsunami Alert level (circle one) WATCH ADVISORY WARNING

Closest forecasted tsunami amplitude/wave height _____

Forecasted tsunami arrival time _____

Step 2: Tsunami evacuation and response will depend on the amount of time before the tsunami arrival. Four (4) hours is considered the threshold time needed for evacuation. As a quick reference, we offer the following guidance:

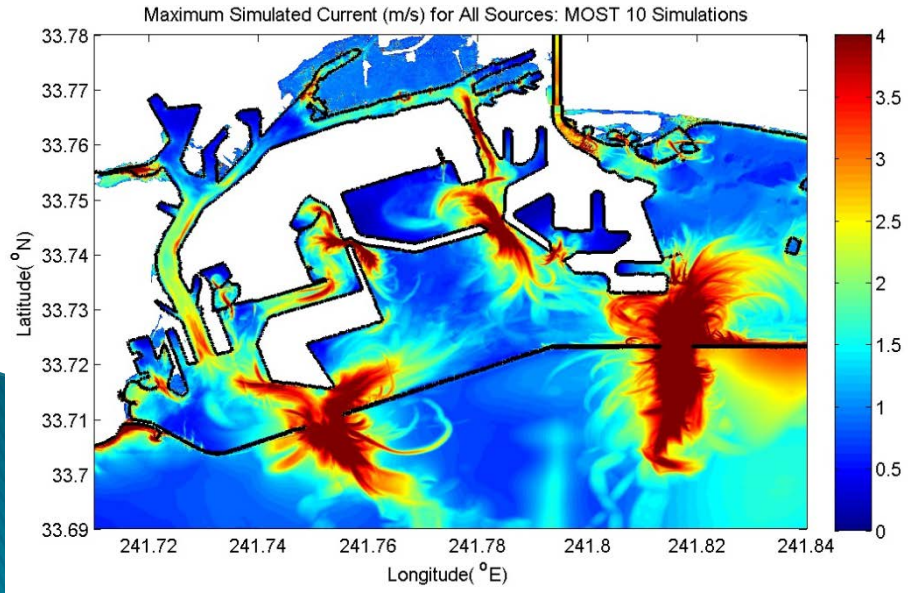
1) **If less than four hours before tsunami arrival, we recommend the following:**
   - ADVISORY – evacuate beaches, harbor docks, and piers
   - WARNING – evacuate entire maximum on-land evacuation zone, or follow guidance provided by local emergency manager

2) **If greater than four hours before tsunami arrival,** and your harbor has fully developed its tsunami response Playbook plans, the harbor can utilize the FORECAST AMPLITUDE from Step 1 on the table on the right to identify the appropriate response plan to use.

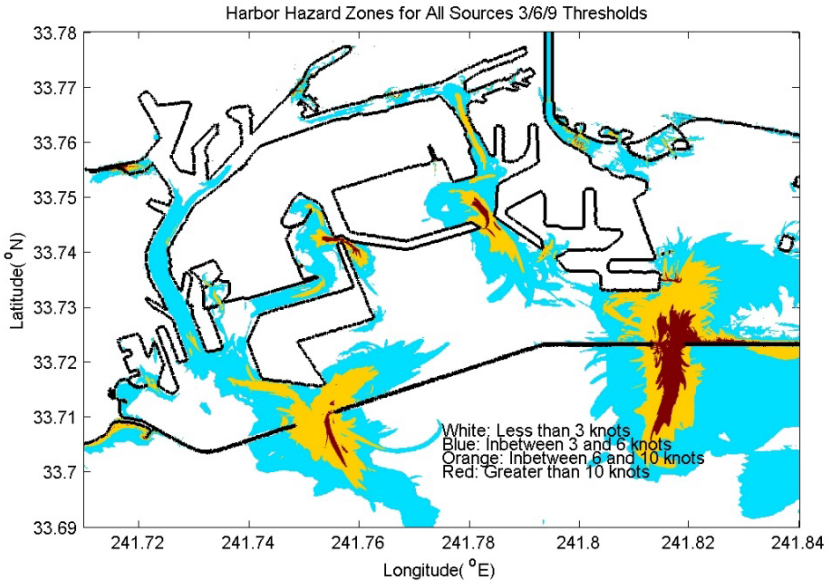
Reference Pages for Details in Maritime Playbook	Scenario Playbook Plan Letter	Peak Amplitude/ wave height (in meters)
	(No action)	0.2
Page 8-9	A	0.5
Page 10-11	B	0.6
Page 12-13	C	0.8
Page 14-15	D	1.0
Page 16-17	E	1.2

Tsunami Current Hazard Maps: Map Generation

- **Maritime Modeling Status:**
  - **Performed 10-m MOST simulations at ~35 port/harbor/marina areas**
  - **5-6 Source scenarios for each location**
  - **Includes 2010 and 2011 events for all harbors**
  - **This hindcast allows us to match the modeled velocity at the exact (to within a grid point) location of the observed damage**
  - **Extract the maximum simulated current at the damage location, assume that current is the cause of the damage**
    - ***-> Connect potential infrastructure damage to current***
    - **Expect that maps of "damage / hazard potential" for a given scenario are more useful than maps of maximum current**



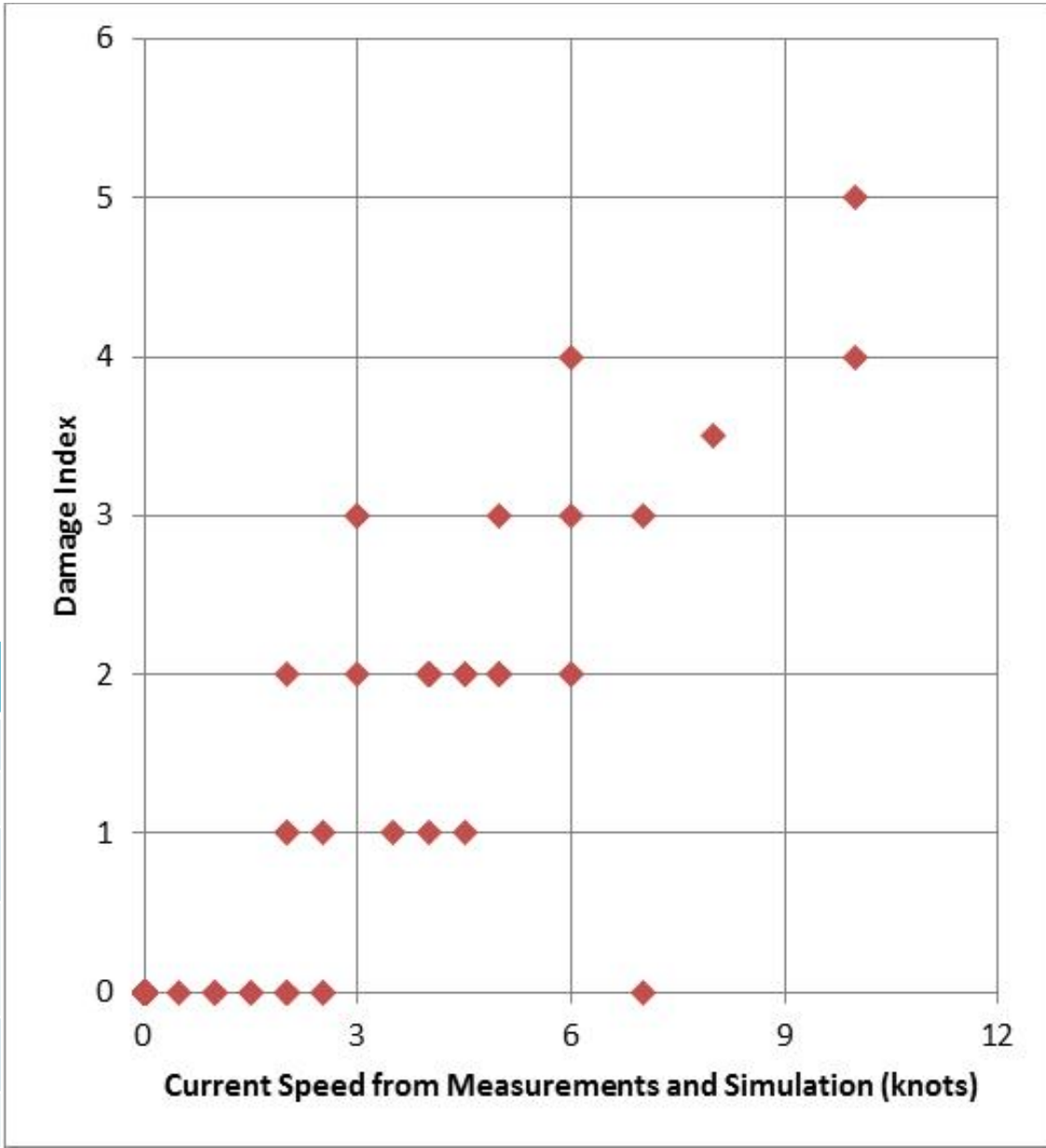
vs



Tsunami Current Hazard Maps
Map Generation

- **Can we filter this information, create areas where certain levels of damage might be expected?**
- **<u>Need to develop current–damage relationships</u>**
  - **Based on previous observations of damage, and numerical hindcast & direct speed measurements at the damage location**

Damage Index:	Damage Type:
0	no damage
1	small buoys moved
2	1-2 docks/small boats damaged, large buoys moved
3	Moderate dock/boat damage, mid-sized vessels off moorings
4	Major dock/boat damage, large vessels off moorings
5	Complete destruction



Tsunami Current Hazard Maps

From Lynett and others (2013)

- **Can we filter this information, create areas where certain levels of damage might be expected?**
- **Need to develop relationship between tsunami currents and damage**
  - **Based on previous observations of damage, and numerical hindcast & direct speed measurements at the damage location**

Damage Index:	Damage Type:
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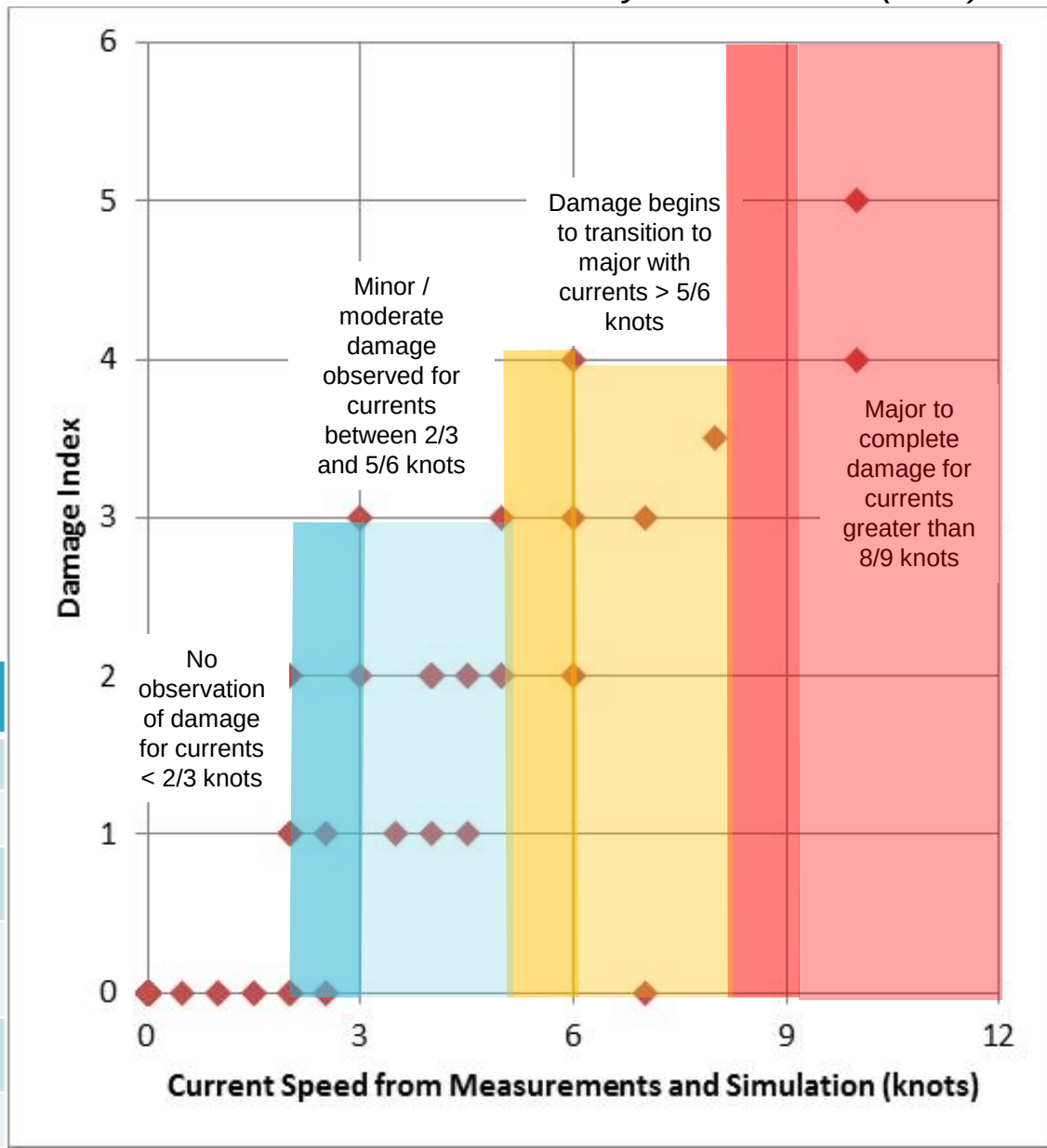

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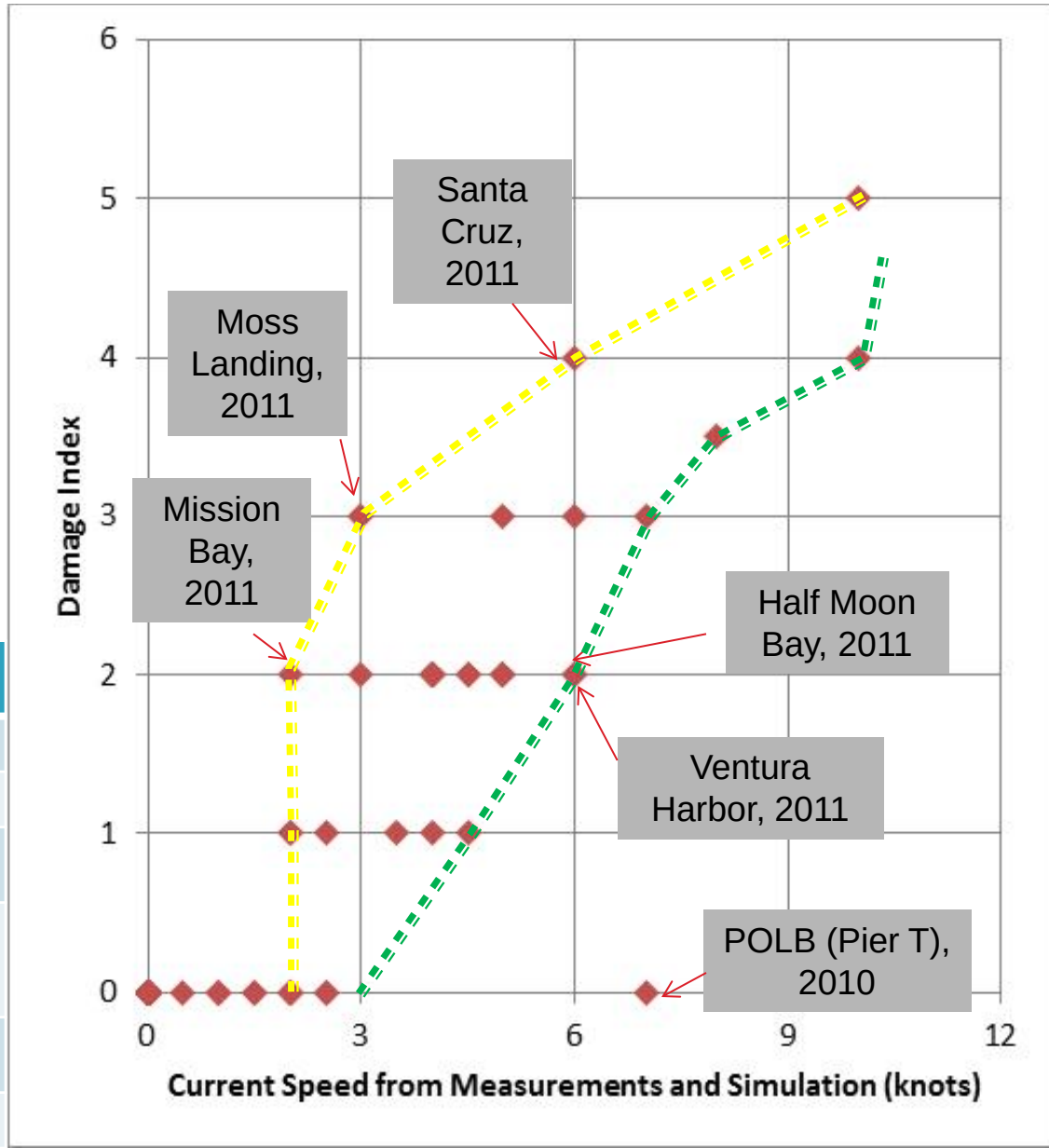
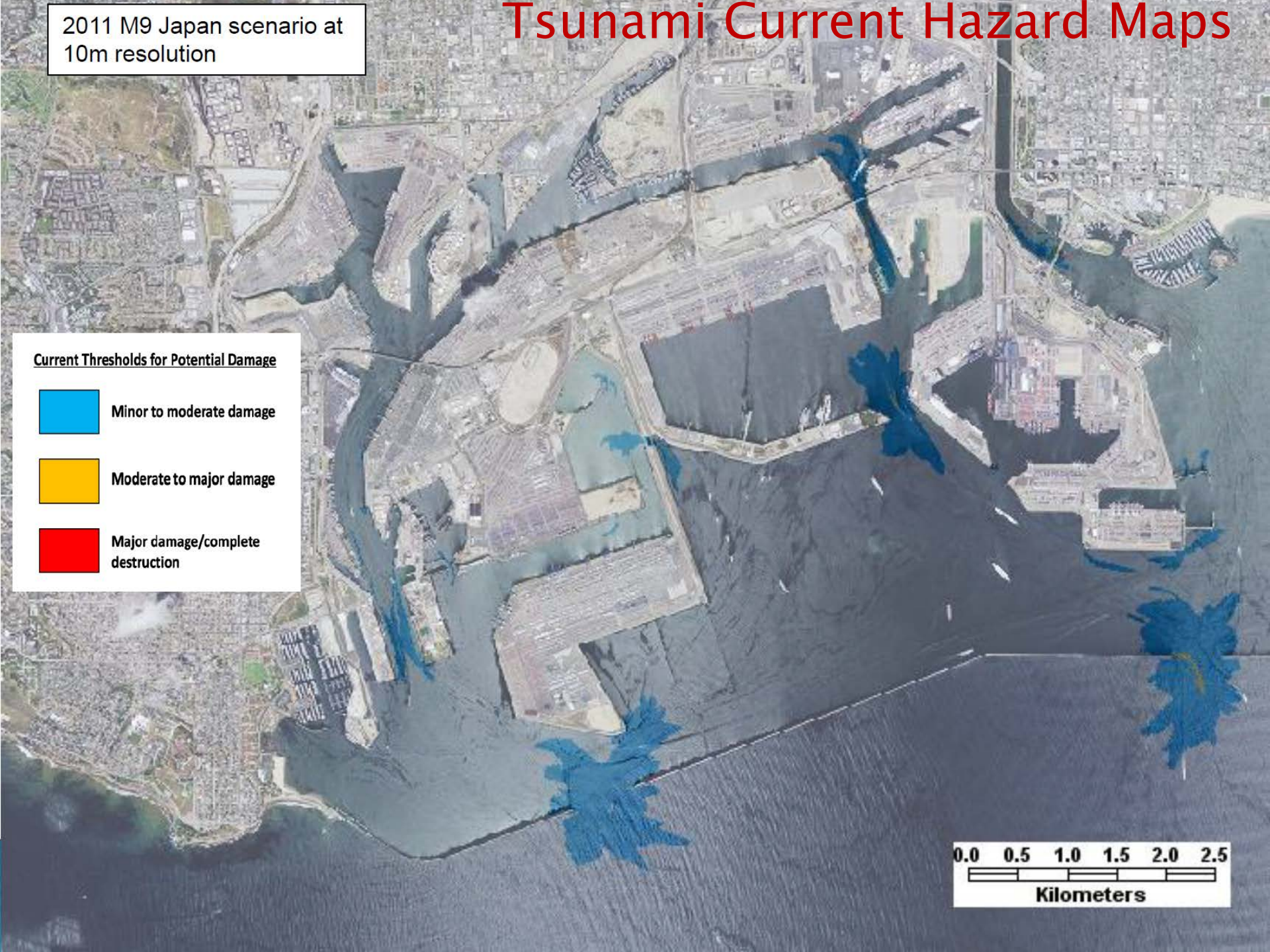


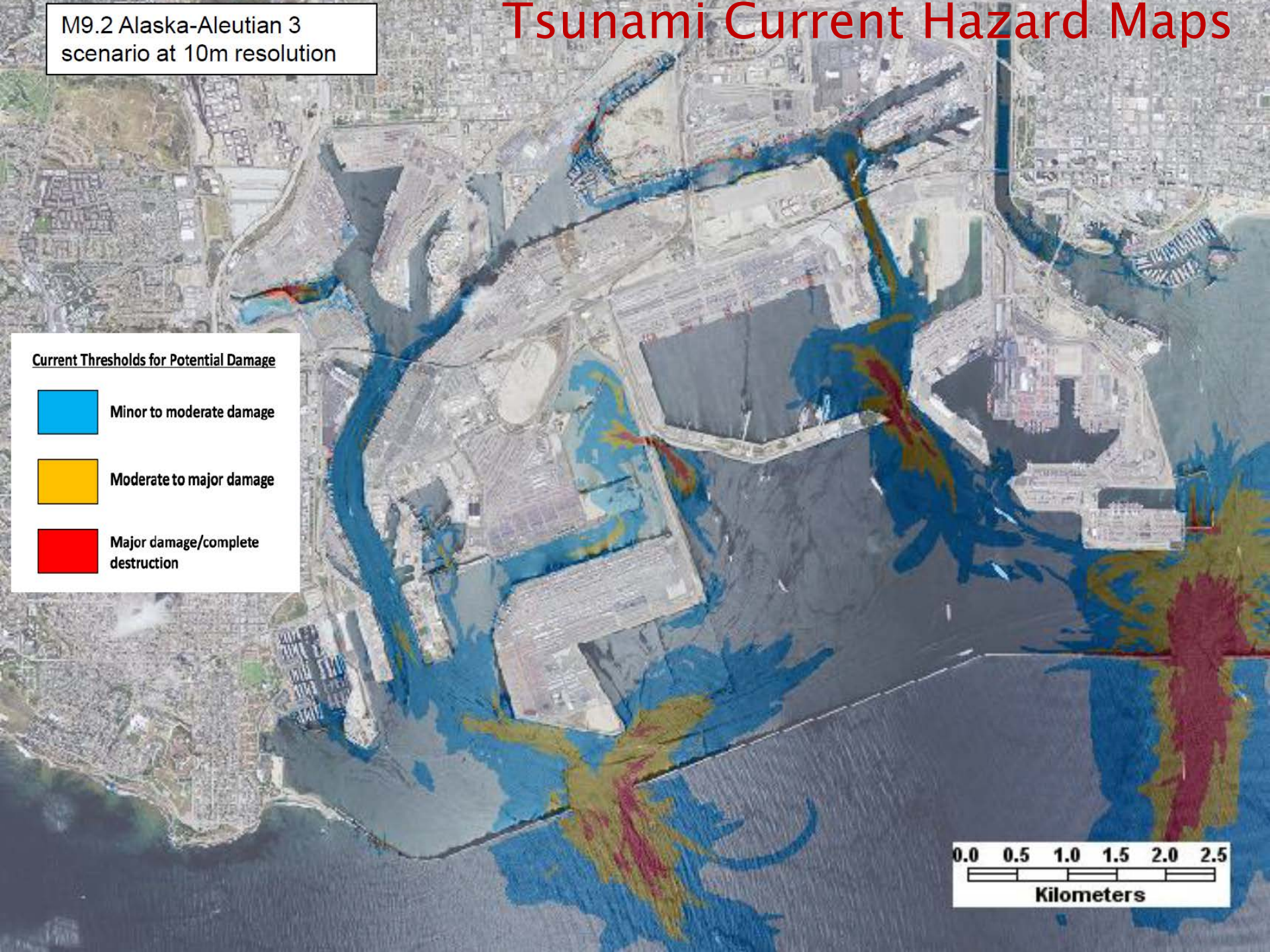
Tsunami Current Hazard Maps

2011 M9 Japan scenario at 10m resolution



Tsunami Current Hazard Maps

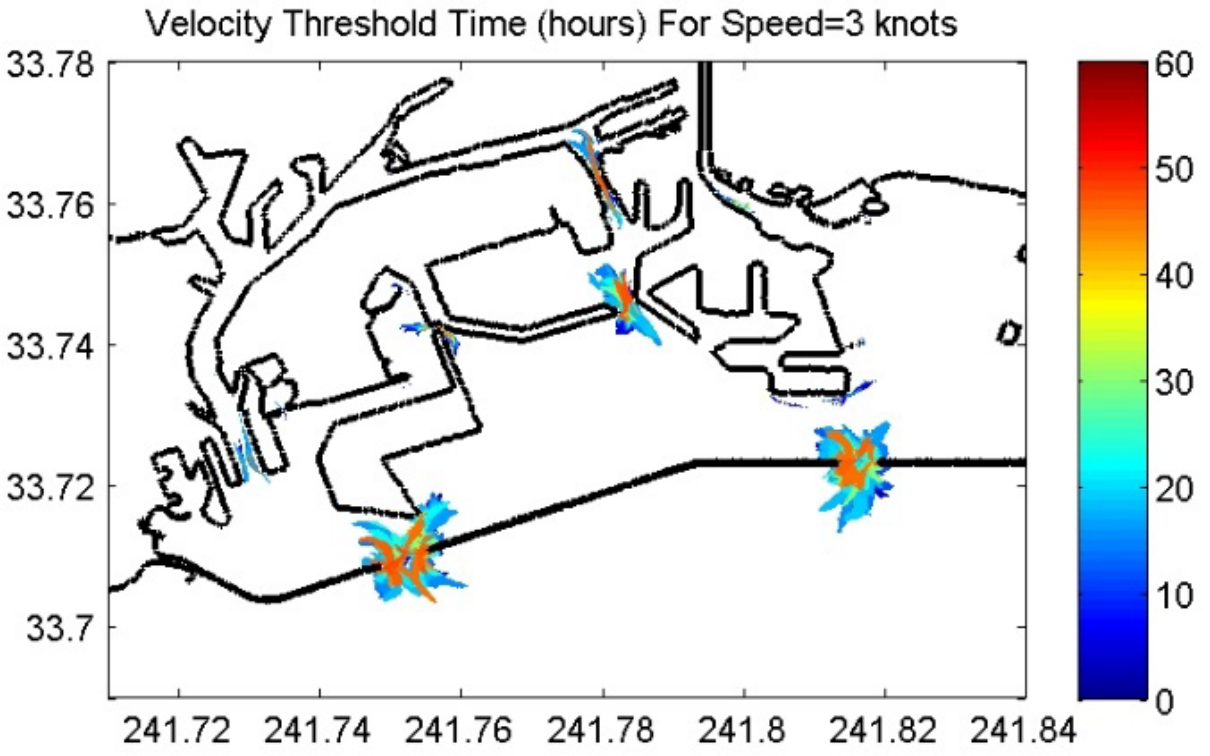
M9.2 Alaska-Aleutian 3 scenario at 10m resolution



Tsunami Current Hazard Maps
Map Generation

- **Time-Threshold Map**
  - **Time-threshold = time interval between arrival of initial wave to a later time after which current does not exceed a given value (threshold)**
- **Allow for an estimation of <u>how long</u> event will last**
- **Useful for showing <u>maximum possible duration of damaging tsunami effects</u>**
- **A more difficult piece of information to convey**

Japan 2011



Tsunami Current Hazard Maps – Example Playbook Page

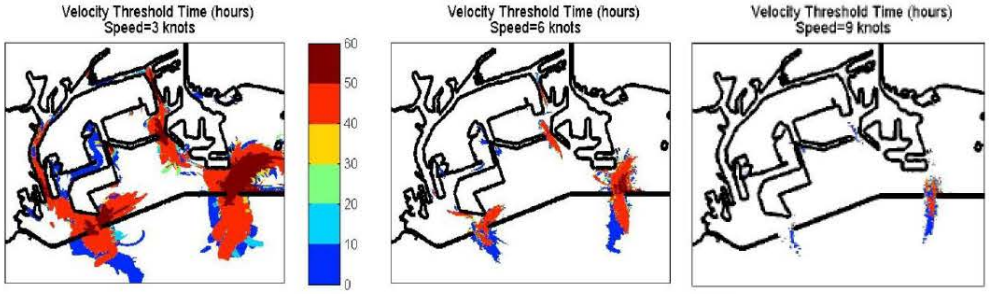
M9.2 Eastern Aleutian-Alaska Scenario

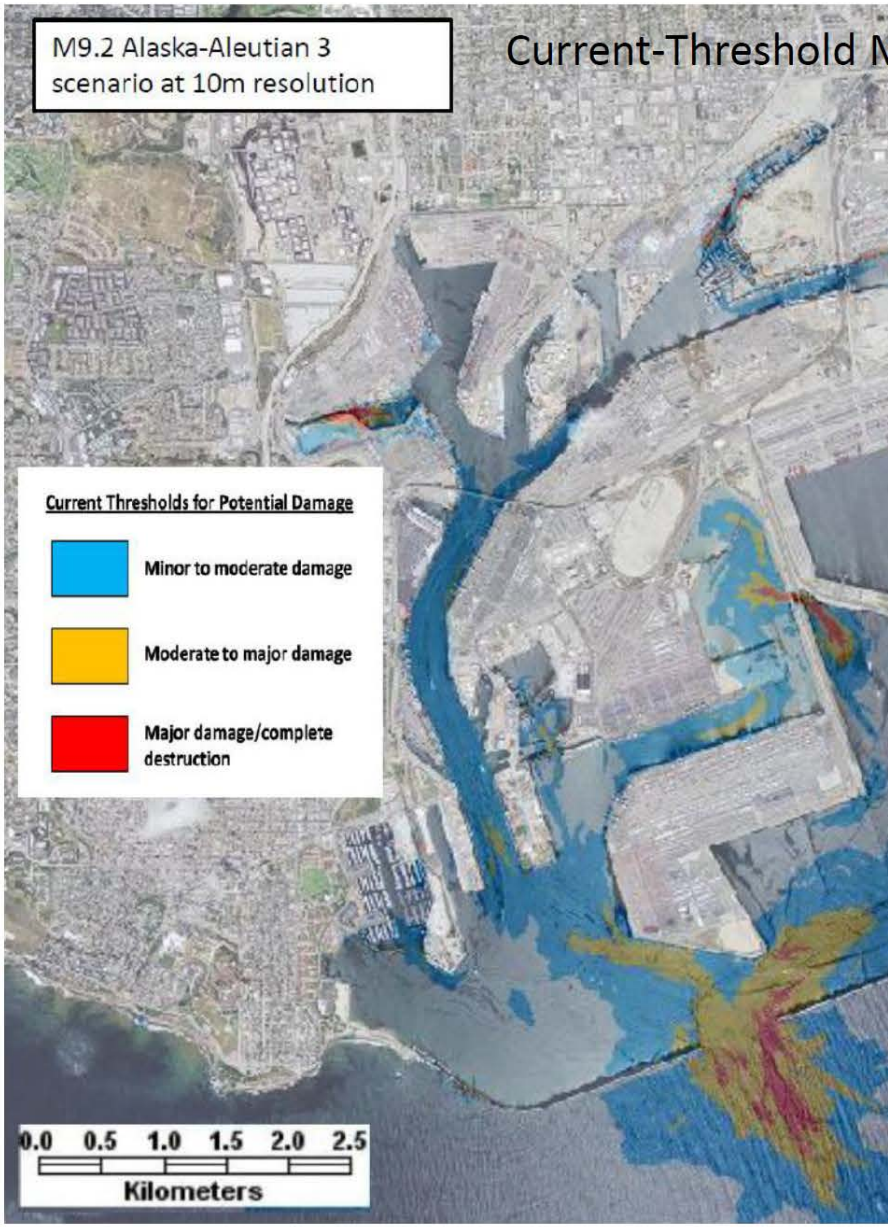
Background Information:
Alert level = Warning
Peak Amplitude = 2+ meters (modeled)
Peak Velocity = 12+ knots
Projected duration of strong currents (see location maps below):
3-6 knots = 60+ hrs; 6-9 knots = 40 hrs; >9 knots = 10 hrs

Specific Instructions:

- Follow general guidance for Warning-level tsunamis (Page 5)
- Strong currents and potential scour are expected in areas identified in blue –yellow-red on the map to the right. Consider relocating vessels located within 100 meters (300 feet) of these areas.
- Specific areas where vessels should be relocated from and docks secured:
  - Vessels can be moved to non-blue areas of the port.
  - (completed with maritime community input)

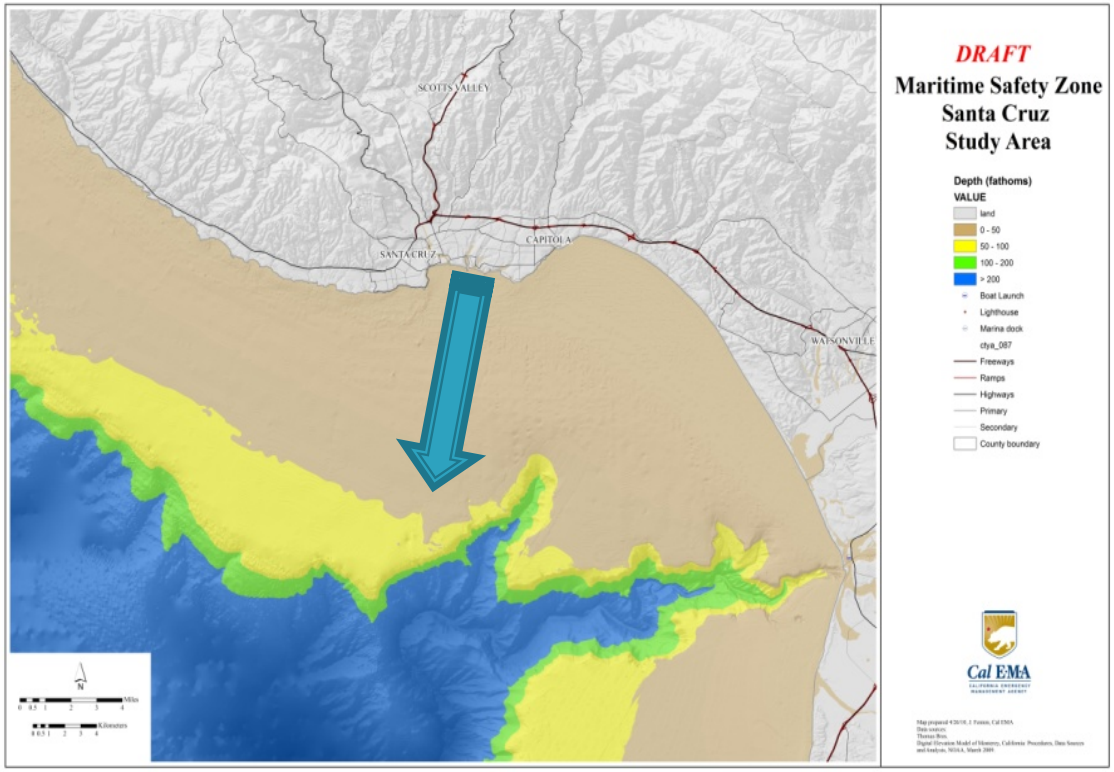
Safe areas for repositioning vessels within POLA:
(completed with maritime community input)





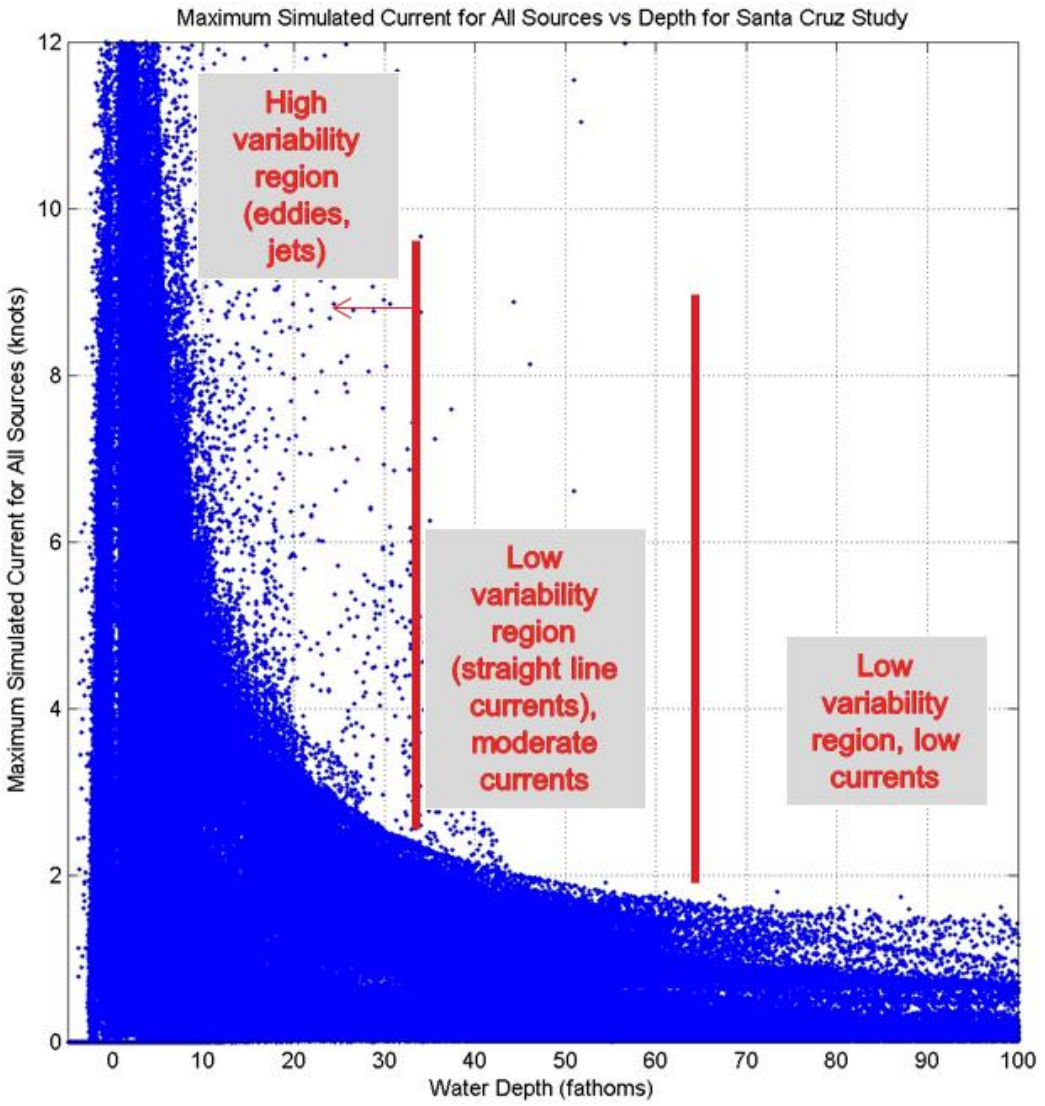
Offshore Safety Zones

- **“Rule of thumb” for safety is 100 fathoms**
- **This is likely to be highly conservative in general**
- **Offshore safe zone should be controlled by expected offshore currents**
  - **What is a acceptable offshore tsunami current?**
- **Zones will be harbor/boat specific and included in navigational charts**
- **Statewide Guidance for Advisory and Warning events**



Offshore Safety Zones

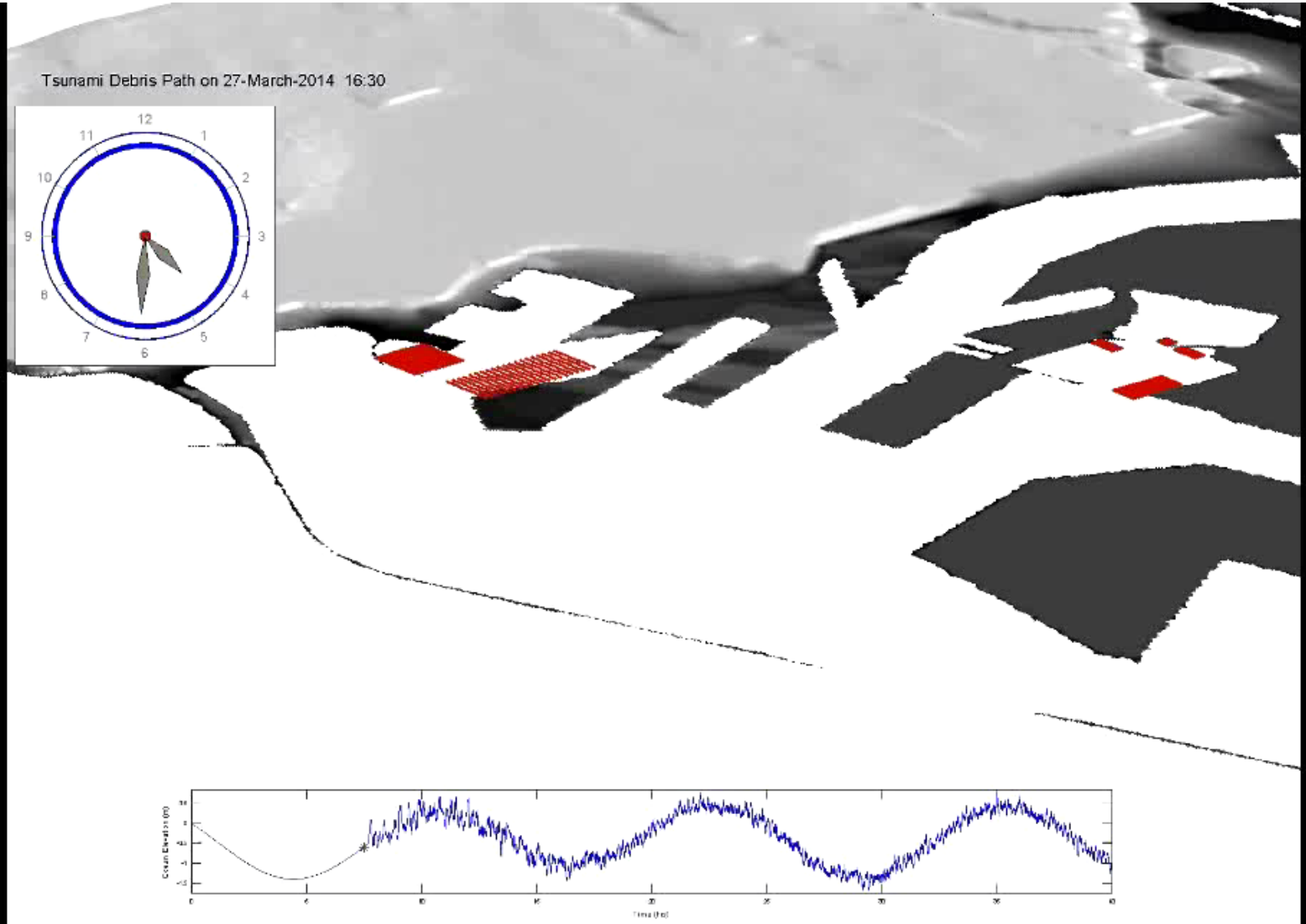
- **Example application – Santa Cruz**
- **Run simulations for a range for different sources**
- **Create a maximum current map for each source**
- **Plot the (max current, depth) pairs for each source, as a scatter plot**
- **Determine current variability at all depths**
- **Set an acceptable current & depth threshold**



1 fathom = 1.8 meters = 6 feet

Future Work

- **Debris and sediment predictions**



Future Work

- **Scenario-Based Failure Probability**

Conclusions

- **Tsunami-Current-based hazard maps**
  - **Damage expectations**
  - **Duration of “strong” currents**
  - **Determination of a defensible retreat depth**
  - **Incorporated in “tsunami playbooks” currently under development for many harbors statewide**
    - **Contact me if interested in obtaining draft versions, pLynett@usc.edu**
- **Looking next to develop:**
  - **Scenario-based sediment scour and deposition maps**
  - **Infrastructure vulnerability assessment methods**