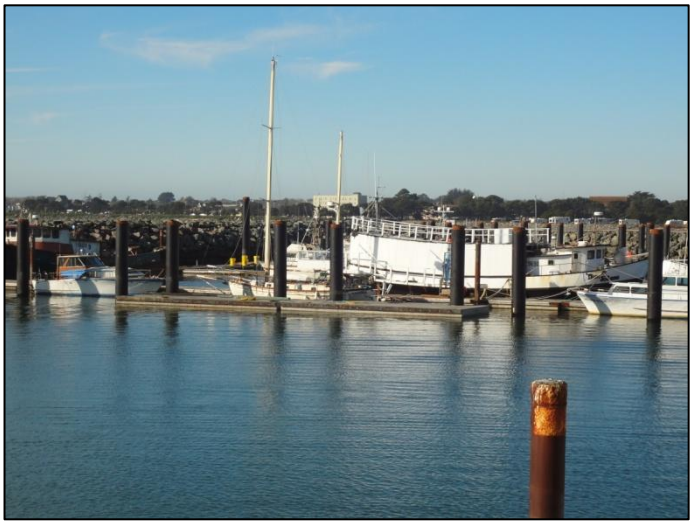
Tsunami Hazard Mitigation Activities in California Maritime Communities

Tsunami hazard mitigation activities are the focus of the California Tsunami Program, comprised of the California Geological Survey (CGS) and the California Emergency Management Agency (CalEMA), its modeling, engineering, and academic partners at the University of Southern California (USC) and Humboldt State University (HSU), and its Cooperative Technical Partners at FEMA. Nowhere is the need more apparent for initiating tsunami hazard mitigation measures than within the state's 70+ coastal maritime communities. Relatively small to moderate teletsunami events in 2006, 2010, and 2011 caused over $100M in total damage within at least two dozen of these maritime communities. According to the USGS-led Science Application for Risk Reduction Project (SAFRR; in progress), larger tsunami events have the potential of causing tens of billions of dollars in damages and a large number of casualties in California.

With the assistance of the California Tsunami Program and state/federal funding, these maritime communities have begun implementing a number of life-safety and damage-reduction mitigation measures for tsunami hazards. These measures include non-structural mitigation efforts that include real-time (pre-tsunami) ship movement and infrastructure strengthening, and permanent mitigation measures that include wave-jetty fortification, pile reinforcement, and dock improvements. A number of other mitigation measures that may be implemented in the future include improved harbor emergency response and planning activities, repositioned/improved docks and infrastructure, increased harbor dredging, entrance channel widening, and removal of exposed petroleum/chemical facilities.

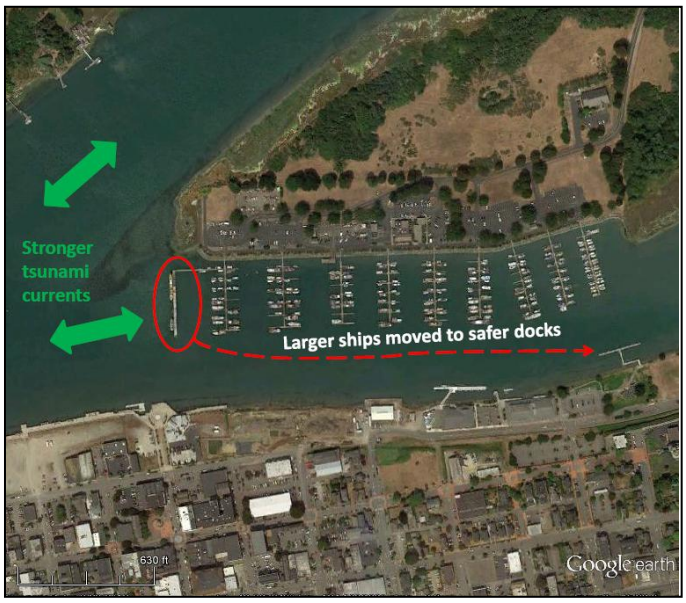
The following information offers a few examples of tsunami hazard mitigation activities, both structural and non-structural, that have been implemented in California:



Crescent City Harbor – The 2006 and 2011 teletsunamis caused $50M in damages in Crescent City Harbor. In 2011, destruction of most docks and deposition of 150,000 cubic meters of sediment in the small boat basin caused nine months to a year of delays in initiating recovery of the commercial fishing industry in Crescent City, which is vital to the community's survival. The harbor has proactively initiated several mitigation measures to reduce the direct impact of future tsunamis. Before the 2011 tsunami, harbor officials and the commercial fishing community worked with the Redwood Coast Tsunami Work Group to initiate a plan to evacuate the fishing fleet from the harbor once a tsunami warning was issued. During the 2011 tsunami, 90 percent of the sea-worthy fleet was able to evacuate the harbor, greatly reducing the potential for more

vessels sinking and additional tens of millions of dollars in physical and environmental damage and recovery costs. After the 2011 tsunami, the harbor implemented a harbor improvement plan which included fortifying the harbor breakwater and installing more massive dock piles (30-inches wide) to better resist strong tsunami currents and reduce the potential for replacing piles in the future (photo above). Between these non-structural and structural mitigation measures, Crescent City Harbor will not only reduce future losses but also recover more quickly after a tsunami.

Humboldt Bay maritime – Humboldt Bay is a large, narrow-mouth bay with several harbors and marinas as well as port moorings for large ships. Members of the maritime communities in Humboldt Bay have formed a harbor safety committee that addresses tsunami issues, including emergency response planning and potential tsunami mitigation measures. Part of their real-time response plan is to move the large ships on the western end of Woodley Island Marina, where they are docked perpendicular to tsunami currents, to other areas within the Bay where currents are not that significant. This mitigation procedure, which was implemented during the 2011 tsunami, greatly reduced the potential for damage to both these ships and their primary dock, and other nearby docks which would have experienced a cascading failure if the first dock failed (map right). Because these docks survived, they provided a safe haven for part of the Crescent City Harbor fishing fleet while that harbor recovered.



Santa Cruz Harbor – During the 2011 tsunami, Santa Cruz Harbor sustained at least $28M in damages from strong currents, large waves (3-4 feet high), and sedimentation in the back portion of the harbor. Upon initial evaluation, the tsunami appeared to damage only about one-quarter of the docks and several dozen boats. However, closer analysis of the undercarriage of the docks indicated that all docks had been damaged during the event. The primary source of the damage was cracked cement linings on the foam-core floats under the docks. As of January 2013, the harbor is still in the process of replacing all the docks, using hardened, torque- and puncture-resistant dock floats that should help reduce damage during future similar tsunamis (photo right).

Ports of Los Angeles and Long Beach – The Ports of Los Angeles and Long Beach are a vital international trading hub where over one-billion dollars of trade is completed on a daily basis. Although there was only minor damage during the 2010 and 2011 tsunamis in the Ports, other historical tsunamis in 1960 and 1964 caused more significant damage to Port facilities. The California Tsunami Program has partnered with the USGS-led Science Application for Risk Reduction (SAFRR) Project to evaluate the impacts of a large, teletsunami scenario on these two Ports. Potential at-risk facilities and large ship docks were identified by the SAFRR Project, and the Ports are in the process of improving their tsunami response planning to mitigate most of the exposed assets, such as large cargo ships and petroleum/chemical tankers. Further analysis of tsunami hazards within the Ports may also lead to permanent mitigation measures, such as moving docks for large ships away from narrow harbor entrances.

Current Mitigation Planning Efforts: The California Tsunami Program, FEMA, and its partners are developing tsunami hazard planning tools to help all California maritime communities mitigate damages and loss of life from future tsunamis. These tools include: 1) detailed maps identifying in-harbor tsunami hazards (strong currents and eddies, peak amplitude surges, large tidal fluctuations, etc.), 2) offshore safety zones where ships can evacuate to and gather during a tsunami, and 3) preparedness, mitigation, and recovery/continuity plans to help maritime communities be more resilient to tsunami hazards. Mitigation plans will be used by these maritime communities to determine where infrastructure enhancements should be initiated, and provide a mechanism for pre-disaster hazard mitigation funding through additions to their Local Hazard Mitigation Plans (see the list of potential mitigation measures below). Although these products, plans, and related mitigation efforts will not eliminate all casualties and damages from future tsunamis, they will provide a basis for greatly reducing future tsunami impacts on life-safety, infrastructure, and recovery in California maritime communities.

Mitigation Measures for Reducing Impacts of Tsunami Hazards in Maritime Communities

Real-time response mitigation measures

- Moving boats and ships out of harbors
- Repositioning ships within harbor
- Remove small boats/assets from water
- Shut down infrastructure before tsunami arrives
- Evacuate public/vehicles from water-front areas
- Restrict boats from moving during tsunami
- Prevent boats from entering harbor during event
- Secure boat/ship moorings
- Harbor staff donning personal flotation devices/vests
- Remove hazardous materials away from water
- Remove buoyant assets away from water
- Stage emergency equipment outside affected area
- Activate Mutual Aid System as necessary
- Activate of Incident Command at evacuation sites
- Alert key first responders at local level
- Restrict traffic entering port; aid traffic evacuating
- Provide personnel to assist rescue, survey and salvage
- Identify boat owners/live-aboards; establish phone tree, 'reverse-911,' or other notification process

Permanent mitigation measures

- Fortify and armor breakwaters
- Increase size and stability of dock piles
- Improve floatation portions of docks
- Increase flexibility of interconnected docks
- Improve movement along dock/pile connections
- Increase height of piles to prevent overtopping
- Deepen/Dredge channels near high hazard zones
- Move docks/assets away from high hazard zones
- Widen size of harbor entrance to prevent jetting
- Reduce exposure of petroleum/chemical facilities
- Strengthen boat/ship moorings
- Construct flood gates
- Prevent uplift of wharfs by stabilizing platform
- Debris deflection booms to protect docks
- Harbor control structures should be tsunami resistant
- Construct breakwaters further away from harbor
- Install Tsunami Warning Signs
- Purchase equipment/assets (patrol boats, tug boats, fire boats, cranes, etc.) to assist in response activities