



2016

Authored by National Tsunami
Hazard Mitigation Program
Coordinating Committee Members
January 2017

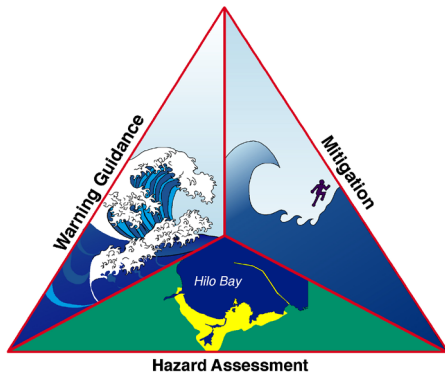


Image: Integrated tsunami vertical evacuation structure, Ocosta Elementary School, Westport, Washington (Credit: Pete Eckert, Eckert & Eckert Photography)

Accomplishments of the National Tsunami Hazard Mitigation Program: An Annual Report

Table of Contents

National Tsunami Hazard Mitigation Program (NTHMP) 2016 General Updates	3
Mapping and Modeling Subcommittee (MMS) 2016 Accomplishments.....	5
Mitigation and Education Subcommittee (MES) 2016 Accomplishments	6
Warning Coordination Subcommittee (WCS) 2016 Accomplishments.....	7
Alaska 2016 Accomplishments.....	8
American Samoa 2016 Accomplishments.....	9
California 2016 Accomplishments	10
Commonwealth of the Northern Mariana Islands	11
East Coast 2016 Accomplishments	12
Guam 2016 Accomplishments	13
Gulf of Mexico 2016 Accomplishments	14
Hawaii 2016 Accomplishments	15
Oregon 2016 Accomplishments	16
Puerto Rico 2016 Accomplishments	17
U.S. Virgin Islands 2016 Accomplishments	18
Washington 2016 Accomplishments.....	19

The National Tsunami Hazard Mitigation Program (NTHMP) works to protect lives and reduce economic losses from tsunamis at the community level. The NTHMP includes the National Oceanic and Atmospheric Administration (NOAA), the Federal Emergency Management Agency (FEMA), the U.S. Geological Survey (USGS), and 28 U.S. states and territories. Through collaboration, coordination, and support to partner states and territories, the NTHMP focuses on three key functions: hazard assessment, warning guidance, and mitigation.

Calendar year 2016 was a busy and active year for the NTHMP. This annual report was informally produced to highlight some of the NTHMP’s 2016 activities. It is a compilation of submissions from the NTHMP’s three subcommittees and partner states and territories.

Summaries provided by the following state and territorial agencies and institutions:

- Alaska Division of Homeland Security and Emergency Management/University of Alaska Fairbanks
Alaska Earthquake Center/Alaska Division of Geological and Geophysical Surveys
- American Samoa Territorial Emergency Management Coordination
- California Governor’s Office of Emergency Services/California Geological Survey
- Commonwealth of the Northern Mariana Islands Homeland Security and Emergency Management
- Guam Homeland Security
- Hawaii Emergency Management Agency/University of Hawaii
- Oregon Office of Emergency Management/Oregon Department of Geology and Mineral Industries
- Puerto Rico Emergency Management Agency/University of Puerto Rico Puerto Rico Seismic Network
- Texas A&M University at Galveston (Gulf Coast)
- University of Delaware/University of Rhode Island (East Coast)
- U.S. Virgin Islands Territorial Emergency Management Agency
- Washington Emergency Management Division/Washington State Department of Natural Resources

<http://nws.weather.gov/nthmp/>

National Tsunami Hazard Mitigation Program (NTHMP) 2016 General Updates

NTHMP Meetings

In addition to the two in-person meetings noted below, the NTHMP Coordinating Committee and subcommittees also met by teleconference throughout the year.

Annual Meeting

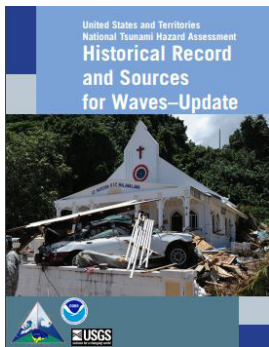
The NTHMP Annual Meeting, a preceding NTHMP-USGS collaboration workshop, and subcommittee meetings were held in Boulder, Colorado, February 1–5. Eighty-four people participated in these meetings throughout the week. <http://nws.weather.gov/nthmp/2016annualmeeting/index.html>



NTHMP Summer Subcommittee Meeting

The NTHMP Mitigation and Education Subcommittee met July 26–28 in Lynwood, Washington, with 31 attendees. The Mapping and Modeling Subcommittee did not meet in person during summer of 2016 due to insufficient travel funding. <http://nws.weather.gov/nthmp/2016messummer/index.html>

NTHMP Publications and Resources



United States and Territories National Tsunami Hazard Assessment Historical Record and Sources for Waves (February 2016)—Update, authored by NOAA and the USGS <http://nws.weather.gov/nthmp/ushazard.html>

U.S. Tsunami Hazard (May 2016)—Two-page fact sheet and web page summarizes the Nation’s tsunami hazard based on the first U.S. hazard assessment and the 2016 update (see above) <http://nws.weather.gov/nthmp/ushazard.html>

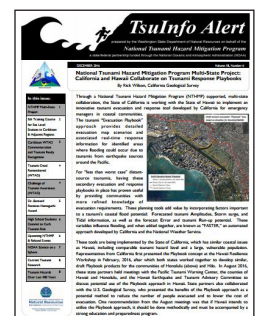
Tsunami Maps (May 2016)—Web page provides “one-stop-shop” for links to tsunami inundation and evacuation maps produced by NTHMP partners <http://nws.weather.gov/nthmp/maps.html>

Tsunami Modeling and Mapping: Guidelines and Best Practices Series (September 2016)—Existing modeling and mapping guidelines reformatted and compiled into a series, minor updates made <http://nws.weather.gov/nthmp/publications.html>

Historical Tsunami Calendar (September 2016)—Two-pager lists tsunamis (reported) that affected U.S. states and territories and caused at least one death (direct or indirect) or \$1 million in damage (2016 dollars) in the United States and other significant tsunamis <http://nws.weather.gov/nthmp/documents/tsunamicalendar.pdf>

TsuInfo Alert (six issues)—Bimonthly newsletter that describes current work by NTHMP partners, showcases interesting reports and information, and provides links to current tsunami research <http://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/tsunamis/tsuinfo-alert>

World Tsunami Awareness Day Social Media (September 2016)—Messages developed for partners to use as foundation for their World Tsunami Awareness Day social media



Grants

For the FY16 grant cycle (September 1, 2016–August 31, 2018), NOAA's National Weather Service (NWS) awarded \$5,750,515: \$5,394,515 directly to 12 NTHMP partners, and \$356,000 was transferred within NOAA (to the Pacific Marine Environmental Lab and the National Centers for Environmental Information) on behalf of two states (Washington and Alaska) to meet critical capabilities and within the scope of the NTHMP Strategic Plan. More information on the FY16 grant-funded projects is available at <http://nws.weather.gov/nthmp/grants/2016grants/index.html>.

Administration

The Coordinating Committee welcomed replacement state and territorial members of the NTHMP Coordinating Committee:

- Gerald Guerrero, Emergency Management, Commonwealth of the Northern Mariana Islands
- Maximilian Dixon, Emergency Management, State of Washington Emergency Management Division

The Coordinating Committee welcomed newly elected subcommittee co-chairs:

- Marie Eblé, Oceanographer with NOAA's Pacific Marine Environmental Laboratory, NOAA Co-Chair of the Mapping and Modeling Subcommittee, replacing Kara Gately who ably served for two years
- Gala Gulacsik, Regional Earthquake Program Manager for FEMA Region X, FEMA Co-Chair of the Mitigation and Education Subcommittee, replacing Tamra Biasco who ably served for eight years

The NTHMP was led by Chair Dr. Grant Cooper, NWS Western Region Director, and supported by NTHMP Administrator Dr. Rocky Lopes, Tsunami Program at NWS Headquarters.

Other Major Actions

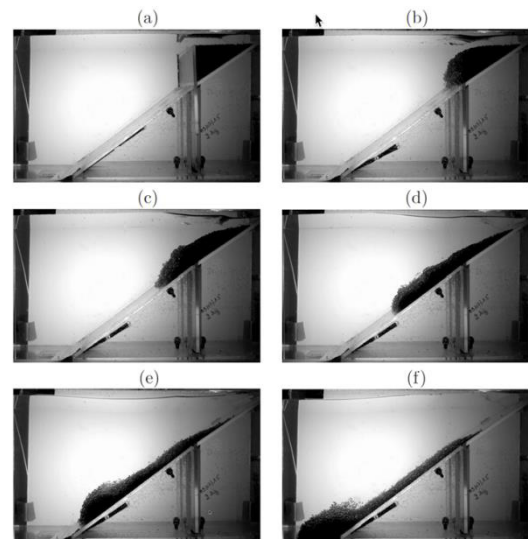
- The Coordinating Committee authorized the formation of an Island Caucus. This provides for an informal method for people who live and work on islands to meet and discuss issues common to island environments. NTHMP partners involved include Alaska, American Samoa, Commonwealth of the Northern Mariana Islands, Guam, Hawaii, Puerto Rico, and U.S. Virgin Islands. The first meeting of the Island Caucus will occur in 2017 at the NTHMP Annual Meeting.
- NTHMP partner FEMA Region X provided support for an online collaborative resource called Basecamp for use by the Mitigation and Education Subcommittee. This online resource allows for shared document editing, task assignments and reminders, and provides a method for subcommittee members to collaborate on an ongoing basis.
- NTHMP subcommittee co-chairs will no longer be asked to review semi-annual NTHMP grant narratives and recommend acceptance or rejection since that responsibility rests with the grant program officer (and his delegees) at NWS Headquarters. However, for awareness and tracking of accomplishments, the co-chairs will be provided all of these narrative reports. They just will not be asked to formally recommend acceptance or rejection of reports on tight deadlines.
- The Coordinating Committee decided not to recognize a single week in 2017 as National Tsunami Preparedness Week. The NTHMP recognizes the importance of tsunami preparedness campaigns and will continue to support partners in their efforts to promote tsunami preparedness at times during the year that make the most sense for their coasts. <http://nws.weather.gov/nthmp/tpw/tsunami-preparedness-week.html>



Mapping and Modeling Subcommittee (MMS) 2016 Accomplishments

Organized a Tsunamigenic Landslide Model Benchmarking Workshop

MMS members recognized that non-seismic sources of tsunamis are important for many NTHMP partners. In order to represent this source in mitigation and education products, a landslide tsunami model validation workshop was organized for January 9–11, 2017, in Galveston, Texas. The accuracy/adequacy of approximately ten numerical models in simulating landslide generation of tsunamis and propagation will be determined to ensure that consistent hazard reduction products are developed for use by NOAA and NTHMP partners.



Established Recommendations for Maritime Products

Maritime products to address the needs of the maritime community were a direct outcome of a tsunami currents benchmarking workshop led by University of Southern California. MMS members gained a better awareness of their ability to accurately capture the physics of tsunami currents and, therefore, a better understanding of how to use these simulation tools for hazard assessment to develop products that support mitigation and education. In collaboration with one another and with federal, state, and territorial entities, concise general recommendations for recreational and commercial boaters were developed, and offshore safe depths for maritime vessel evacuation prior to tsunami arrival were established. These guidelines are available at: <http://nws.weather.gov/nthmp/documents/NTHMPUSCGoffshoreguidance.pdf>.

Streamlined and Consolidated Modeling Guidance and Best Practice Documents

MMS and MES members collaboratively updated guidelines and best practices for the development of tsunami inundation maps, evacuation maps, and approaches to determine potential inundation for non-modeled areas. MMS model benchmarking criteria and model acceptance process for models intended for NTHMP use were also developed.

Prioritized Digital Elevation Model Development by NOAA's National Centers For Environmental Information

Digital elevation models (DEMs) are the cornerstone of all tsunami modeling activities. In their absence, development of accurate tsunami hazard assessment products would be significantly impeded. In 2016, MMS set DEM development priorities as Key Largo and Destin, Florida, and False Pass, Port Lions, and Larsen Bay, Alaska. For 2017, the list of DEM priorities was established as Bristol Bay, Alaska; Bellingham Bay, Washington; and Miramar Beach to Laguna Beach, Florida. An additional location is pending.

Updated the MMS Website

- DRAFT NTHMP and U.S. Coast Guard Maritime Vessel Evacuation—Minimum Offshore Depths
- MMS Benchmarking Criteria

Mitigation and Education Subcommittee (MES)

2016 Accomplishments

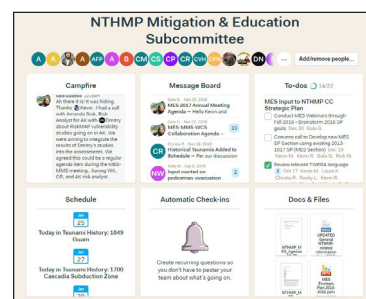
MES Products

- Tsunami Modeling and Mapping: Guidelines and Best Practices Series (MES/MMS reviewed, streamlined, and updated)
 - Part I: Tsunami Inundation Modeling
 - Part II: Tsunami Inundation Maps
 - Part III: Tsunami Inundation Determination for Non-Modeled Regions
 - Part IV: Tsunami Evacuation Maps
 - Checklist for Tsunami Modeling and Mapping Reports and/or Metadata
- Historical Tsunami Calendar
- Social Media Messages for World Tsunami Awareness Day



MES Business Conducted/Completed

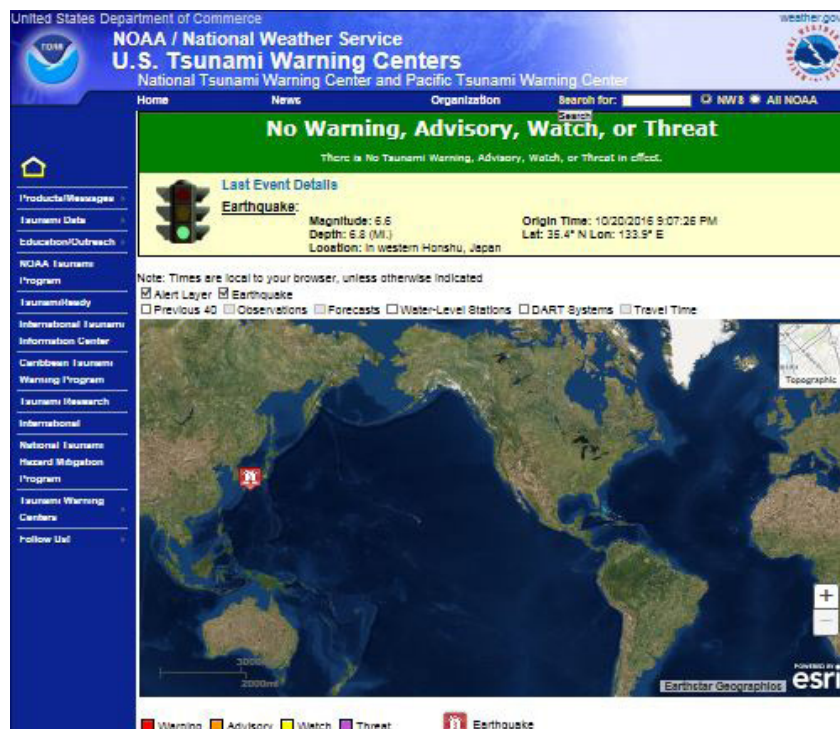
- Reviewed grant report/applications for partner states and territories:
 - FY14, FY15 progress reports (April, November)
 - FY16 applications (February, March)
- Convened Annual Meeting. Agenda included:
 - Discussion of MES priorities for 2013 and 2018 strategic plans and consistent U.S. preparedness message, strategy, and approach
 - Reports on MES evacuation guidance, MES maritime guidance, Tsunami Awareness Safety Fact Sheet, and evacuation/inundation maps online
 - Votes on Co-Chair and Terms of Reference
- Conducted May 11 Business Meeting. Topics included:
 - Evacuation approaches resources and studies
 - Online map compilation and hazard assessment summary
 - Updates on tsunami mitigation in Oregon
 - HAZUS tsunami module update
 - Maritime guidelines course of action—form working group
 - Summer meeting agenda development
- Convened MES Summer Meeting. Highlights included:
 - Workshops on maritime guidance document development, TsunamiReady, and evacuation approaches, vulnerability assessment, and studies
 - Discussion about upcoming strategic planning and using an online collaboration platform (Basecamp)
 - Reports on state and territorial preparedness campaigns
 - Outcomes from meeting captured in the “Task List” on Basecamp
- Conducted bimonthly MES business meetings (August, October, December). Topics included:
 - MES contribution to NTHMP Strategic Plan
 - MES/MMS guideline documents series
 - Post-Tsunami Protocol—Clearinghouse, Tsunami Observer Program
 - Evacuation modeling—inform the socialization of evacuation modeling on the NTHMP website
 - MES input to maritime guidance (Part 2: Preparedness, Part 3: Mitigation/Recovery to follow)
 - Review and approve 2017 Annual Meeting agendas



Basecamp screenshot

Warning Coordination Subcommittee (WCS) 2016 Accomplishments

- Tsunami Warning Center product improvements:
 - The Tsunami Warning Centers are working toward combining their websites and integrating them with tsunami.gov so that there is only one NWS operational tsunami warning website (see figure below).
 - Tsunami Warning Center EQI*** and TIB*** products combined to reduce number of different products issued by centers.
 - National Tsunami Warning Center messages now issued in upper and lower case and include special characters such as a colon.
- Auto EAS activation software installed and activated for faster transmission of tsunami warning on EAS at NWS Weather Forecast Offices (WFOs) throughout the NWS Western Region.
- Tsunami forecast private web viewer to be released in 2017 (called TView). The private site will allow emergency management to view forecast inundation and other forecast graphics.
- Wireless Emergency Alert activation zones (polygons) have been defined for Southern California to help limit the automatic cell phone activation. The process has been advanced through the NWS Capabilities and Requirements Decision Support system for implementation.
- Conducted several national tsunami exercises: Pacifex, Lantex, and Caribe Wave. Many constituents participated in the drills.
- Conducted several end-to-end communication tests that exercised the NOAA Weather Radio, EAS, and other local tsunami alert devices.
- Supported state partner efforts related to tsunami warning exercises, drills, communication tests, and tsunami alert reception and local dissemination.

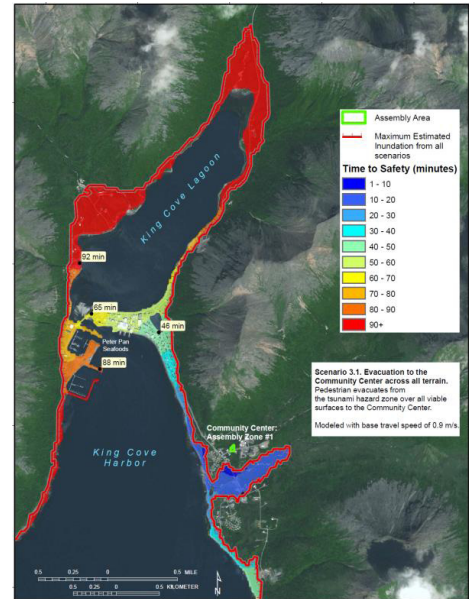


Alaska 2016 Accomplishments

Alaska experienced numerous devastating tsunamis in its history, and widespread damage by the 1964 tsunami is still visibly seen in many communities. The next tsunami is only a matter of time, and a high frequency of earthquakes in Alaska makes a recurrence interval dangerously short. To mitigate this risk, Alaskans need to assess the tsunami hazard for the coastal communities. This goal is best achieved through scenario planning, mitigation tools, and broad education in support of the TsunamiReady program.

Scenario Planning and Tsunami Hazard Assessment

- Modeling of potential tsunamis is completed for Kodiak (an update of previously published tsunami inundation maps for the Kodiak area) and Juneau (a new map).
- Publication and presentation of the tsunami inundation maps are done for Yakutat, King Cove, Cold Bay, Nikolski, Chignik Bay and Chignik Lagoon. A tsunami hazard assessment report for Sand Point is expected to be published by the end of 2016.
- Assessment of potential tsunami currents due to local and distant earthquakes and development of the maritime guidance are accomplished for the cities of Unalaska, Kodiak, and Sitka.
- Development of an approximation to the potential inundation zones is completed for communities in Southcentral and Southeast Alaska: Port Graham, Nanwalek, Anchor Point, Craig, Port Alexander, and Ketchikan. Maps for Adak, False Pass, Akhiok, Chiniak, Karluk, Larsen Bay, Old Harbor, Ouzinkie, and Port Lions were presented to the communities and are now in the publication stage.



Travel-time map of pedestrian evacuation to assembly area at King Cove Community Center across all terrain

Mitigation and Education

- Presentation of the Pedestrian Travel Time to Safety maps was conducted in communities of Homer, Unalaska, Chignik Bay, and King Cove. At many communities, the presentation of maps was accomplished by a public lecture "The Threat of Tsunamis" and outreach to school students.
- Tsunami siren warning system was installed in Cordova.



- We presented a Tsunami Maritime Guidance for Ports during the annual Alaska Association of Harbormaster and Ports Authority Conference in Dutch Harbor. There was major support in creating Alaska-specific goals and directives for actions during tsunami events both local and distant source.
- We completed a tour with the quake simulator of Southeast Alaska. We reached 15 communities and had an estimated participation of 10,000 during the month with our outreach campaign.

TsunamiReady

- Work with the NTHMP and NWS WFOs in Alaska in promoting the TsunamiReady program.
- Kodiak Coast Guard Station is working toward recognition as TsunamiReady.

American Samoa 2016 Accomplishments

Two Samoa Annual Meeting (May 23–24)

American Samoa and Samoa continue efforts to improve public awareness of weather and tsunami terminologies. In addition, a tsunami-focused two Samoa annual meeting is being discussed.



New Outdoor and Indoor Siren Installation (Completed August 8)

The installation of 25 indoor and 8 outdoor notification systems/sirens was completed in August. The indoor sirens were placed inside government buildings, schools, and other public facilities that are located in tsunami hazard areas. The outdoor sirens were placed strategically around the territory to cover coastal villages that had difficulty hearing tones from existing sirens. All sirens are tested by the American Samoa Department of Homeland Security on a monthly basis.

Tsunami Preparedness Week (September 21, 24–30)

The American Samoa (AS) NTHMP and NWS Weather Service Office (WSO) remain active in tsunami awareness and preparedness outreach to the people of American Samoa during Tsunami Preparedness Week. Such collaboration was evident during Tsunami Preparedness Week, which coincided with the week of the devastating 2009 Samoa tsunami. The following is a summary of events:

- National Disaster Preparedness Center Tsunami Awareness training—35 participants from distinct American Samoa government departments were certified (September 21)
- The partnership with American Samoa High-School Athletic Association enabled a successful kick-off of ASNTHMP and WSO Pago Pago's Tsunami Preparedness Week at the local stadium during high school football games. Spectators and players participated in “the wave” during half time, and many visited our outreach booth (September 24)
- Sunday service island-wide (September 25)
- Evacuation drills, public and private schools (September 26–28, 30)
- Media campaign (September 29)

Erection of New & Update Tsunami Signs for Manu'a (October 31–November 4)

Workshop and Outreach (December 6–8)

A three-day workshop including government employees, non-government employees, local media, and village mayors (Pulenu'u) was an opportunity for the ASNTHMP and WSO Pago Pago to provide tsunami educational materials and to set a tentative planning schedule for tsunami outreach/drills, etc. for the current fiscal year.



Tsunami Evacuation Drills (Ongoing)

Efforts to conduct tsunami evacuation drills are ongoing. Part of these drills is to also revisit existing evacuation plans and ensure the leaders/decision makers are aware of the tsunami alert levels defined by the Pacific Tsunami Warning Center for American Samoa.

Maritime Hazardous Products: Meeting with Seaport Police Chief

As part of the ongoing discussion with the maritime community, a meeting was held with the Department of Port Administration to discuss Maritime Hazardous Products on mapping and modeling of offshore and in-harbor safe zones, current speed, surge elevation, and drawdown ranges of tsunami amplitude of Pago Pago.

California 2016 Accomplishments

Tsunami Preparedness Week (March 20-26)

Preparedness activities occur year round, Tsunami Preparedness Week-specific activities coordinated among local, state, and federal partners included:

- Tsunami Warning Communications Test (Eureka NWS WFO area of responsibility): test siren activation, TV messaging, coastal notification overflights
- Required Monthly Test (Monterey, Oxnard, and San Diego NWS WFO areas of responsibility)
- Statewide communications drill to test FASTER/playbook information exchange during response
- Governor's proclamation and numerous local government proclamations
- State support of local activities, including:
 - Seaside Tsunami Walk public evacuation drills with elected officials
 - Promotion and registration of activities on the TsunamiZone website
 - Crescent City "Tsunami Days" week-long public events
 - Stinson Beach workshop
 - Marin County social media/"Next Door" campaign
 - Santa Cruz County WebEOC tabletop exercise
- Poster describing 2011 Japan tsunami impacts, response, mitigation, and recovery in Japan and California



California Tsunami Evacuation Playbooks

- Completed FASTER Program and user video and documentation with California Geological Survey and NWS Monterey.
- Held numerous county workshops and exercises for playbooks/FASTER approach information.
- Completed draft playbooks for Marin, San Luis Obispo, and Santa Cruz Counties.
- Co-authored USGS paper on evacuation/cost benefits of playbooks.
- Began playbook collaboration with State of Hawaii and Pacific Tsunami Warning Center.

Maritime Tsunami Response Playbooks and Mitigation Planning

- Held maritime workshops and planning meetings with various harbors and harbor master/harbor patrol organizations.
- Continued to support and expand analysis work with University of Southern California partners.



Probabilistic Tsunami Hazard Analysis (PTHA) Maps (co-partnered with FEMA)

- Conducted fieldwork and review to finalize maps in San Diego, Orange, Los Angeles, Ventura, Humboldt, and Del Norte Counties.
- Draft second PTHA report completed with AECOM.

Pedestrian Evacuation Modeling

- Collaborated with USGS on report (and press release) analyzing evacuation in city of Alameda.
- Met with and briefed city fire and administrative officials in Alameda and Oakland.

Policy, Land-Use, and Recovery Work Groups

Continued work on the California Tsunami Policy Working Group's recommended actions under three major goals of our tsunami risk reduction framework: building a solid foundation for tsunami mitigation and recovery, practice risk-based land-use and construction, and enhance emergency management and response.

Commonwealth of the Northern Mariana Islands

2016 Accomplishments

- Earthquake and tsunami seminars by NWS Guam WFO (GWFO) during annual two-day Tropical Cyclone, Disaster Preparedness, and Climate Workshop on Saipan (May) and on Tinian (November).
- Saipan successfully met the requirements for its three-year TsunamiReady assessment. Saipan worked closely with the NWS GWFO Guam to restructure requirements to meet the updated TsunamiReady Guidelines. Saipan was one of the first locations to use the new format.
- Saipan worked diligently with the University of Hawaii Sea Level Center to replace the tide gauge destroyed by Typhoon Soudelor in 2015.
- The Commonwealth of the Northern Mariana Islands (CNMI) Homeland Security and Emergency Management (HSEM) submitted input for the completion of the Boaters Tsunami Guide Book.
- NWS GWFO researched and assessed that Saipan had up-to-date digital elevation maps and did not need to be placed on the list for updates.
- In April, HSEM visited Guam to coordinate issues with GWFO; including TsunamiReady and notification and dissemination of impending hazards/threat information; to tour the FEMA Warehouse; and to coordinate common tsunami issues with Guam Homeland Security.
- In April, the CNMI made initial contact with the Hawaii Emergency Management Agency to further discuss and develop an early warning system (EWS) to be implemented in the CNMI. The first priority is to establish EWSs throughout Saipan, with an eventual build out to Tinian. Rota is currently exploring opportunities that will assist them in revitalizing their EWS.
- In October, the governor appointed Gerald Deleon Guerrero of HSEM as the NTHMP Coordinating Committee Emergency Management Representative and Brien S. Nicholas, Jr. of HSEM as his alternate. He also designated Charles Guard of GWFO to act as the CNMI's Science Representative on the Coordinating Committee.



One of the more popular outreach materials produced by CNMI HSEM, this Tsunami Wheel provides residents with information about evacuation routes and assembly areas



CNMI HSEM staff do quarterly island-wide assessments of tsunami signs to ensure signs have not been tampered with or altered. If necessary, signs are removed for cleaning and then reinstalled

- After a long delay, CNMI HSEM applied for and was awarded \$185,000 in FY16 NTHMP funding to implement four priorities identified in the FY16 NTHMP grant application. Moving forward, HSEM is excited to complete the priorities and forge a stronger future for the CNMI and its people.

East Coast 2016 Accomplishments

Modeling Tsunami Inundation and Hazard for the U. S. East Coast

- Continued developing draft inundation maps for portions of U.S. East Coast from Georgia to Massachusetts. Draft reports and maps are available for inspection and comment at http://www.udel.edu/kirby/nthmp_protect.html (Figure 1).
- Completed identifying and preparing benchmark cases for the NTHMP landslide tsunami model validation workshop to be held January 9–11, 2017, in Galveston, Texas. Tests will consist primarily of laboratory data sets on solid and granular slides, in both subaerial and submarine slide configurations (e.g., Figure 2). This work is also tied closely to ongoing National Science Foundation-supported work on model development and enhancement aimed at improving the physical realism and numerical efficiency of slide and tsunami simulation.
- Started using new models to simulate tsunami generation by deforming slides in order to quantify the effect of slide rheology on tsunami coastal hazard along the U.S. East Coast. Figures 3a,b compare maximum surface elevation for the tsunami generated by a rigid slump or three deforming slides of varying rheology in the Hudson River Canyon. Figure 3c shows the maximum tsunami elevation at the five-meter isobaths (yellow line in Figures 3a,b) for the different simulations. Results show that the rigid slump hypothesis used in earlier inundation work to date is conservative as far as maximum inundation and runup. Details can be found in Grilli et al. (2016).

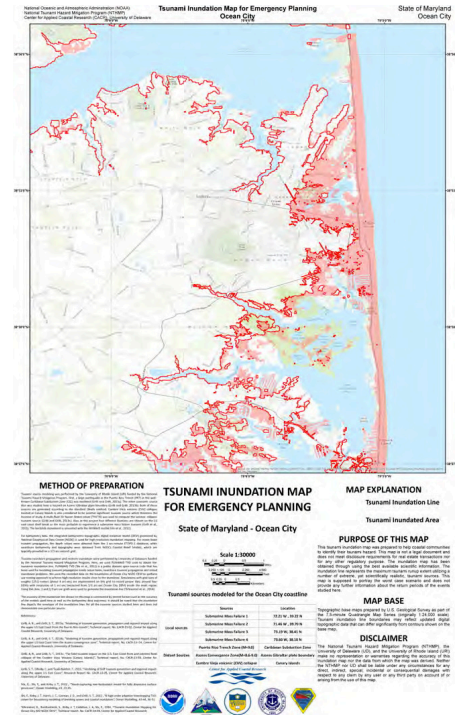


Figure 1. Draft inundation map for Ocean City, Maryland

Figure 2 (below). Comparison of model simulations of deforming slide tsunami generation and glass bead experiments (see Grilli et al., 2016). This was selected as Benchmark #4 of workshop

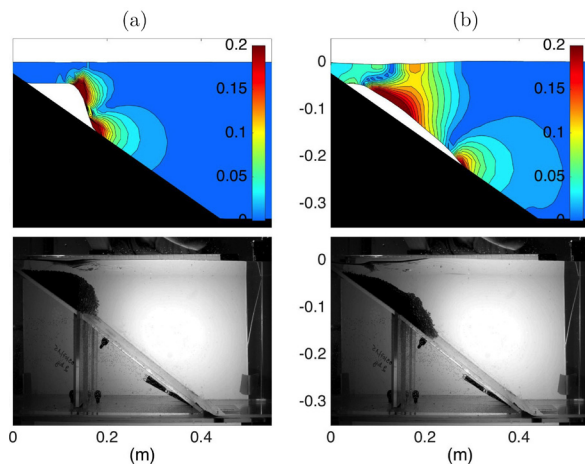
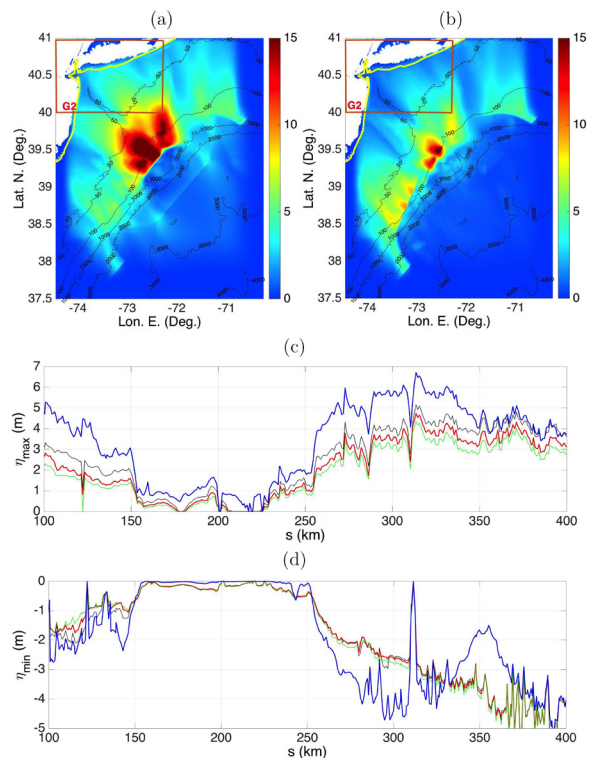


Figure 3 (right). Tsunami generation by a submarine mass failure in the Hudson River Canyon; maximum surface elevation assuming a rigid slump (a) or a deforming slide (b); maximum tsunami elevation at the five-meter isobaths (yellow line in Figs. 3a,b) for the rigid slump (blue) and deforming slides of varying rheology (green, red, black)



Guam 2016 Accomplishments

Tsunami Awareness through Community Outreach and Public Education Campaign

- Completed no less than 60 outreach events with an estimated 4,000+ people reached.
- Regularly conducted Disaster Preparedness and Tsunami-Earthquake Puppet Shows in schools.
- Supported various preparedness outreach events, such as: Martin Luther King, Jr. Day of Service and Remembrance (January 18); Tsunami Preparedness Week (March 27–April 2), National Preparedness Month's Grand Finale (September 17), Military Headquarters Marianas National Preparedness Event (September 24), Guam Hotel and Restaurant Association Safety and Security Fair (October 21), Church of Jesus Christ and Latter-Day Saints Preparedness Fair (October 22).
- NWS Guam WFO (GWFO) worked with NTHMP MES members to conduct outreach.



Workshops and Training

- Conducted Annual Tropical Cyclone, Disaster Preparedness, and Climate Workshop (May 3–4).
- Conducted Hazard and Risk Awareness, Service Learning, and Youth Preparedness Coalition Workshop (April 9).
- Supported various workshops/trainings, such as: Western Pacific Islands Typhoon Readiness and Planning Workshop (June 13–14), Guam Department of Education Professional Development Training Series for Teachers (August 8–11), Guam Volunteers Youth Preparedness and Leadership Summit (September 3).
- NWS GWFO conducted tsunami and earthquake seminars and workshops in Guam, Saipan, Tinian, Yap, Chuuk, and Pohnpei.
- NWS GWFO conducted considerable behind-the-scenes coordination and assistance to Guam and Commonwealth of the Northern Mariana Islands.



Printing and Distribution of Tsunami Outreach Materials

- Printed and distributed updated tsunami evacuation maps to accommodate growing population of local, military, and visitors. Also printed updated TsunamiReady Cards (in various languages), Tsunami Evacuation Wheels, and Tsunami Media Tool Kit.



Boating Handbook

- NWS GWFO coordinated tsunami safe boating requirements and submitted them to the subcommittee for Boating Handbook. Provided critical reviews of handbook.

TsunamiReady

- Enhanced tsunami awareness through continued Be Tsunami Ready! campaign with broadcast media, movie theaters, and outdoor billboards.
- NWS GWFO conducted TsunamiReady reassessment for Military Headquarters Marianas. Educated customers on the changes to TsunamiReady program.

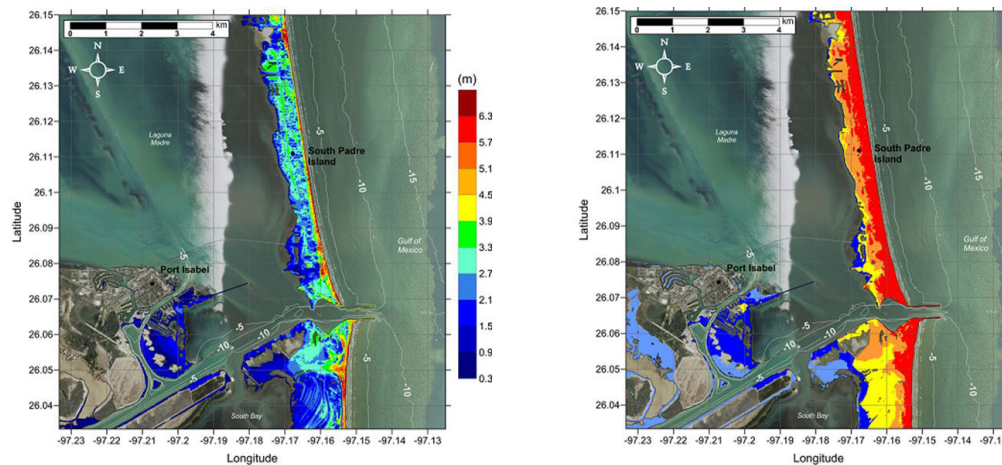


Gulf of Mexico 2016 Accomplishments

Since FY08, the NTHMP has provided grants to the Gulf of Mexico (GOM) states (through Texas A&M University at Galveston) to identify the tsunami hazard to the Gulf Coast and mitigate its impact. Based on evidence of massive ancient landslides and continued emptying of sediments into the GOM mainly from the Mississippi River, a massive underwater landslide in the GOM is considered a potential hazard, although the probability of such an event is quite low.

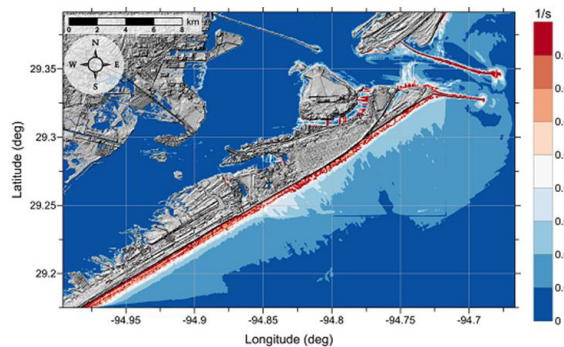
During the calendar year of 2016, the GOM group has the following accomplishments:

- Development and implementation of a temporal-low-order study based on existing hurricane storm surge flooding results for tsunami hazard areas (community) where inundation studies have not yet been assigned/executed or where little bathymetric and elevation data exists. The study has been done in five locations (South Padre Island, Texas; Galveston, Texas; Mobile, Alabama; Panama City, Florida; and Tampa, Florida) where we have a good detail of the tsunami impact from several tsunami sources, allowing us to withdraw meaningful conclusion as we compare these results with products based on hurricane categories.



Maximum of maximum (left) and hurricane category (right) tsunami inundation depth (in meters) in South Padre Island, Texas

- Pilot study in Galveston Bay to include maritime products (currents, vorticity, etc.) in current tsunami inundation map projects. We produced the velocity field, velocity magnitude, and vorticity magnitude maps for all the landslide scenarios. Based on these velocity maps, location of strong currents and their damaging levels are identified. We hope these results will help the maritime communities, port managers, and other interested parties.



Maximum of maximum vorticity magnitude contour plot in Galveston West Bay and Bay Entrance (Texas)



- On September 27, Santa Rosa County, Florida, received the sign-offs for their TsunamiReady application, making the county the first TsunamiReady Community along the Gulf Coast.

NWS Warning Coordination Meteorologist from NWS Mobile WFO (left) and Florida Division of Emergency Management Region 1 Coordinator (right) review the TsunamiReady Guidelines during Santa Rosa County Emergency Management site visit

Hawaii 2016 Accomplishments

Tsunami Harbor Modeling

With the recent completion of tsunami inundation maps, we redirect the modeling and mapping effort to support maritime emergency response and infrastructure planning. The ongoing work develops tsunami safety products for Honolulu Harbor.

TsunamiReady/Hawaii Hazards Awareness and Resilience Program

Hawaii Emergency Management Agency (HIEMA) is proud to be a part of building resilient communities in Hawaii. With the overwhelming support from the Hawaii National Guard, we recognized or renewed three communities as TsunamiReady: Kailua, Joint Base Pearl Harbor/Hickam, and Aina Haina.



Tsunami Schools



Tsunami educational material and support for public schools, children, and parents located within the tsunami evacuation zone, which will include the development of a comprehensive evacuation plan, distribution of a standardized evacuation plan template, pre-scripted messaging for parents, and an evacuation kit.

Foreign Language Radio

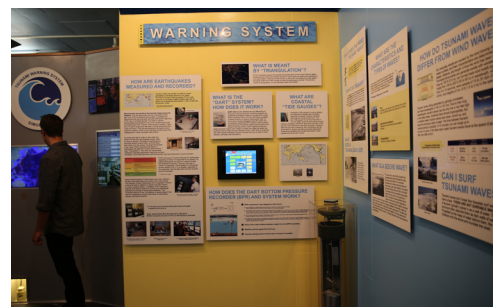
Partnership with local radio stations that broadcast our messages in 16 languages.

Tsunami Observer Program

We continue to align both the Tsunami Observers Program and the Post-Tsunami Protocol under the leadership of Dr. Laura Kong.

Pacific Tsunami Museum

The Pacific Tsunami Museum, located on Hawaii Island, unveiled its brand new Tsunami Science exhibit in April with the assistance and support of the NTHMP and HIEMA. In addition to illustrating the latest science and technology related to monitoring, interpreting, and alerting, an interactive seismic/tsunami-generating display was created that is very popular.



Building a Resilient Hawaii Workshop (February 17-18)

Playbooks

Hawaii has worked closely with the State of California to develop secondary evacuation zones in cooperation with local jurisdictions. These playbooks enhance planning evacuation for less-than-worst-case tsunamis. To date, playbooks for the communities of Honolulu and Hilo have been completed.

Tsunami Awareness Month

April 1 marked the 70th anniversary of a massive tsunami generated by an earthquake in the Aleutian Islands. It caused widespread deaths, damage, and devastation to the entire state, but Hilo Harbor on Hawaii Island was especially vulnerable. Our 2016 objective was to encourage the public to take tsunami safety into their own hands by preparing their homes and families during Tsunami Awareness Month.

Oregon 2016 Accomplishments

Tsunami Comic Book

In a partnership with DarkHorse Comics, the Oregon Office of Emergency Management released the second of its popular preparedness comics, *Without Warning: Tsunami*.

Tsunami Evacuation Wayfinding Project

The Blue Line Project brought an innovative approach to tsunami evacuation route wayfinding to Oregon. Four communities installed blue lines and a sign on the pavement of critical routes where the route leaves the evacuation zone. Other communities have asked to join this highly popular project.



Tsunami Safe: Hospitality Begins with Safety

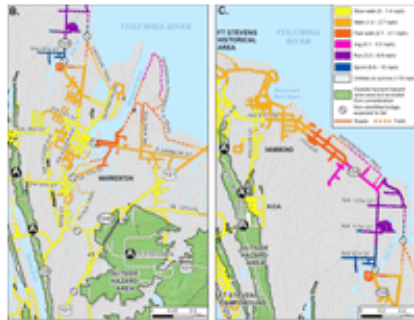
To date, the Tsunami Safe program has reached 109 management members of the hospitality industry along the Oregon Coast (~75 participating facilities). In addition, over 130 hotel employees have completed the online education module since its inception.

“Entering and Leaving Tsunami Hazard Zone” Signs

The Oregon Department of Geology and Mineral Industries (DOGAMI) and the Oregon Department of Transportation (ODOT) are partnering to install 100 “Entering and Leaving Tsunami Hazard Zone” signs on Highway 101 and several secondary highways in the tsunami inundation zone. To date, 34 signs have been installed in Astoria and Warrenton on the northern Oregon coast. ODOT expects to have the remaining 66 signs installed by spring 2017. A preliminary meeting has been held with ODOT staff in District 4 (central Oregon coast) to discuss installation of 72 signs in Lincoln County.



Beat the Wave Modeling



DOGAMI released new “Beat the Wave” modeling and evacuation route analysis for Warrenton and Hammond (<http://www.oregongeology.org/pubs/ofr/p-O-16-08.htm>). Map plates depict minimum pedestrian evacuation speeds needed to stay ahead of the wave for two levels of increasing evacuation difficulty: 1) all bridges intact, 10-minute delay from start of earthquake before starting evacuation and 2) only retrofitted bridges intact, 10-minute delay. The maps are important for evaluating mitigation options such as evacuation route improvement, establishment of wayfinding signage, land use planning actions, and helping to guide establishment of vertical evacuation structures. Similar work is underway at Rockaway Beach in Tillamook County and is expected to be completed early in 2017.

Maritime Guidance

DOGAMI is currently working on port-specific maritime response guidance for distant-source tsunami events for the Ports of Gold Beach and Port Orford on the southern Oregon coast.

Tsunami Conference

At the first Oregon Tsunami Conference, over 25 speakers presented on tsunami topics ranging from effective public education techniques to new evacuation modeling techniques. The diverse group of participants (~140) included representatives from federal, state, and local agencies; private industry; and the hospitality industry as well as emergency response volunteers.



Puerto Rico 2016 Accomplishments

With the support of the NTHMP, the Puerto Rico component of the National Tsunami Hazard Mitigation Program ensures that all the tsunami exposed communities improve their preparedness and consequently reduce the vulnerability of our population to tsunami hazards. In the past year, the accomplishments can be summarized as below.

TsunamiReady

- Two new non-coastal, but exposed, communities were recognized.
- All Puerto Rico was recognized.
- Ten individuals were recognized as TsunamiReady Champions.
- Twelve communities renewed their TsunamiReady recognition.
- Six TsunamiReady Supporters were recognized.
- Two hundred forty-five tsunami signs were replaced or installed, including 12 poster-size signs.
- Twenty NOAA weather radios were replaced.
- Twelve EMWIN system were updated or upgraded.



Puerto Rico TsunamiReady Champions

Workshops and Training

- An island-wide workshop for emergency managers and tsunami warning focal points personnel to train them on Tsunami Warning Center messages and products was held.
- A workshop to present the Tsunami Media Kit was held for communication school students.
- More than 332,000 participants were registered to participate in the regional Caribe Wave exercise through the TsunamiZone website; more than 140,000 were from Puerto Rico.
- Six workshops were held as part of the TsunamiReady Supporter program.

Maps and Modeling

- Pedestrian evacuation modeling reports were generated and presented for three communities.
- Two ports were studied as part of the tsunami currents analysis.
- The Tsunami Decision Support Tool was upgraded to a JavaScript platform.

Education and Outreach

- More than 13,000 residents were reached directly through conferences, meetings, workshops, and trainings.
- More than 80 news interviews and more than 130 educational activities were held.
- Thousands of tsunami-related materials were distributed, including flyers, brochures, and booklets (39,000), safety rules card, media kits, and pencils (3,479).
- Six thousand tsunami evacuation maps were distributed to exposed communities.
- In a partnership with the Puerto Rico Broadcaster Association, four 30-second daily radio spots were aired on all the participating radio stations (78).
- A tsunami meeting with emergency state personnel was held as part of World Tsunami Awareness Day.



Puerto Rico participation in World Tsunami Awareness Day

U.S. Virgin Islands 2016 Accomplishments

In March, the U.S. Virgin Islands participated in the Caribe Wave exercise with evacuation drills for more than 1,000 students territory-wide along with government agencies, the Virgin Islands legislature, local businesses and hotels, and non-governmental organizations. As part of the exercise, the Virgin Islands Territorial Emergency Management Agency's (VITEMA) 911 Emergency Communications Center activated the tsunami siren system territory-wide. VITEMA aired 153 spots on five radio stations to raise awareness about the exercise and about tsunamis in general.

This year, to enhance the tsunami siren system, VITEMA installed two repeaters and two SAFE Keys and upgraded the server on the island of St. Thomas. Two repeaters and two SAFE Keys were also purchased for the island of St. Croix, and installation is in progress. Repairs and maintenance were conducted on the Phase I sirens. Additionally, the agency also completed the process to procure and install 16 additional warning sirens throughout the territory—five for the island of St. Croix, five for St. Thomas, four for St. John, and two for Water Island.

During 2016, VITEMA produced its first children's tsunami book titled *Oh No! A Tsunami!* for primary school students. The book was written by Virgin Islands author Dr. Denise Bennerson and illustrated by local artist Wayne Petersen. Among the editors is Roy Watlington, local tsunami expert. In 2017, the book will be distributed to first-graders territory-wide.

VITEMA also created the first edition of the Virgin Islands Tsunami Awareness Guide, which provides general information and history of tsunamis.



VITEMA's highlights for 2016 also include:

- Procuring 75 NOAA Weather Radios (WR120) for critical facilities in the inundation zone.
- Holding three Maritime Tsunami Preparedness Taskforce meetings. The taskforce identified 17 harbor locations as potential sites for the tsunami modeling project and developed outreach activities for the maritime community.
- Holding a tsunami tabletop exercise (July 13).
- Conducting 11 tsunami preparedness outreach events to schools, businesses, churches, and preparedness expos.



Washington 2016 Accomplishments

- On behalf of the NTHMP, the *TsuInfo Alert* newsletter was published and distributed throughout the year.
- A new map was released in the tsunami hazard series Tsunami Hazard Maps of the San Juan Islands, WA—Model Results from a Cascadia Subduction Zone Earthquake Scenario.
- New inundation modeling was completed for the communities of Taholah, Queets, Kalaloch, La Push, Neah Bay, Port Angeles, and Port Townsend. Modeling for Taholah was in collaboration with the Quinault Indian Nation as part of planning to move the village out of the tsunami hazard zone.
- Current modeling was completed for the Ports of Seattle and Tacoma.
- The Washington Ferry System, Puget Sound Harbor Safety Committee, and the U.S. Coast Guard were briefed on tsunami current hazards in Puget Sound and the Strait of Juan de Fuca.
- Tsunami risk and preparedness outreach to Spanish speaking communities was done in Pacific and Grays Harbor Counties.
- Tsunami risk and preparedness outreach was done for the Ports of Seattle and Tacoma.
- Tsunami risk and preparedness outreach (including yellow brick road tsunami evacuation drills) was done for the following tribal nations: Muckleshoot, Shoalwater Bay, and Quinault.
- Pedestrian evacuation drills were held in conjunction with the ShakeOut Drill (October 20).
- TsunamiReady renewals were completed for the following communities and tribal nations: Westport, Raymond, South Bend, Shoalwater Bay, Quinault, and Lower Elwha Klallam.
- Five All Hazard Alert Broadcast (AHAB) sirens were ordered and are being installed in Whatcom, Grays Harbor, and Pacific Counties.
- Updated communication capabilities for existing AHAB sirens to provide more robust activation options.
- Installed Spanish and English tsunami evacuation/hazard zone signs in Grays Harbor County and Jefferson County.



- Completed a new Project Safe Haven report with updated vertical evacuation tower cost and height estimates based upon the new L1 tsunami modeling.