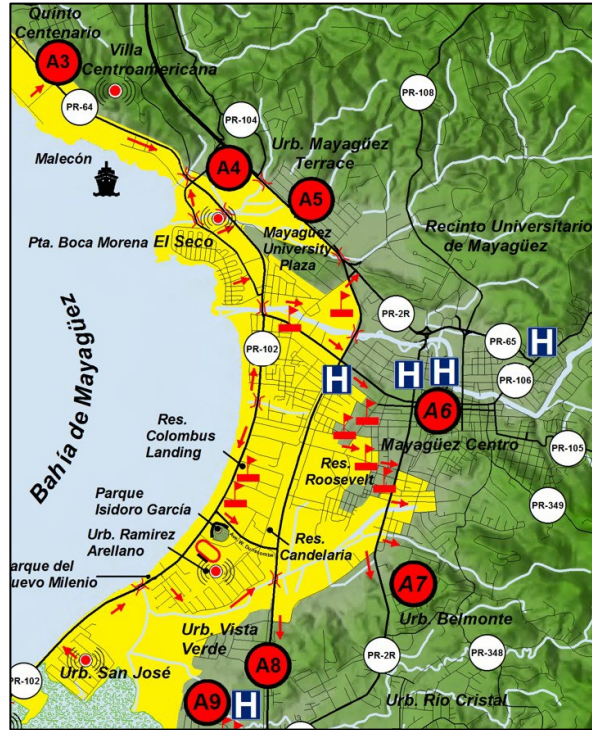




United States National Tsunami Hazard Mitigation Program Strategic Plan for 2024 - 2029



Message from the Chair

It is my pleasure to share with you the National Tsunami Hazard Mitigation Program’s (NTHMP) 2024–2029 strategic plan.

Tasked with reducing the impact of tsunamis on the nation, the NTHMP is a unique and effective partnership between the National Oceanic and Atmospheric Administration (NOAA), Federal Emergency Management Agency, U.S. Geological Survey, and 28 U.S. coastal states and territories. One of the greatest strengths of the NTHMP is the extraordinary commitment each member brings to the program and the high level of cooperation between federal, state, and territory emergency management and scientific partners. This collaboration enhances cost effectiveness and improves the program’s ability to implement consistent national policies and projects at the local level.



This plan builds upon accomplishments of the NTHMP to prepare U.S. coastal communities to respond to tsunamis and provides a strategic framework to guide future activities informed by the Tsunami Warning, Education, and Research Act of 2017, the NTHMP 2018-2023 Strategic Plan, and 2021 recommendations from the NOAA Tsunami Science and Technology Advisory Panel. Cross-cutting initiatives across four strategic themes include encouraging national consistency of products; leveraging continuing research and emerging technology; recognizing the potential impacts of climate change on tsunami hazards; promoting economic development; and leveraging social science in developing products that equitably meet the needs of all at-risk individuals in tsunami hazard zones.

I would like to acknowledge the contributions of the NTHMP Strategic Plan Work Group (Appendix A) in developing this document and to express my appreciation to the NTHMP administrator for coordinating the work group’s efforts and ensuring all partners had a voice in the process.

Raymond Tanabe
Chair, National Tsunami Hazard Mitigation Program
Director, Pacific Region, NOAA/National Weather Service

Cover Captions:

1. *Tsunami inundation map for Ocean Shores, Washington*
2. *Tsunami evacuation map for Mayagüez, Puerto Rico*
3. *Tsunami evacuation route sign from Cannon Beach, Oregon*
4. *The National Tsunami Warning Center in Palmer, Alaska*
5. *The nation’s first tsunami vertical evacuation tower, built by the Shoalwater Bay Indian Tribe and located in Tokeland, Washington*
6. *A sign used for the NWS TsunamiReady® Program*
7. *A tsunami-evacuation painting on the road to direct people to safety in Puerto Rico*
8. *Tsunami outreach by Guam Civil Defense*



Executive Summary

The U.S. National Tsunami Hazard Mitigation Program (NTHMP) brings together federal, state, and territory partners to mitigate the impact of tsunamis through public education, community response planning, hazard assessment, and warning coordination. This plan advances the NTHMP's mission and vision through goals and strategies that strengthen tsunami preparedness, mitigation, mapping and modeling, warning coordination, and response and recovery while considering impacts of climate change, equitably meeting the needs of all at-risk individuals in tsunami hazard zones, and protecting our maritime resources.

The NTHMP has four strategic overarching priorities, or themes:

1. Hazard and Risk Assessment
2. Education and Preparedness
3. Mitigation and Recovery
4. Alert, Warning, and Response

The themes are supported by goals and strategies, which the NTHMP will strive to meet through collaboration between partners and stakeholders. There are several cross-cutting initiatives that will be implemented in various ways within the four strategic themes:

- **Encourage national consistency of products** by sharing best practices and guidelines to promote the protection of life, property, and maritime resources;
- **Leverage continuing research and emerging technology** to ensure all NTHMP products are based on the best available science and technology, such as the increasing roles of artificial intelligence and high-performance computing in data analysis;
- **Incorporate evidence-based approaches from social-science research** to ensure that all NTHMP products and practices are easily understood and useable for all stakeholders;
- **Integrate equity into NTHMP efforts** by developing practices and products that meet the needs of America's underserved and vulnerable populations in tsunami-hazard zones;
- **Recognize the potential impacts of climate change** on community readiness and resilience to tsunamis, as part of NOAA's goal of a Climate Ready Nation; and
- **Promote economic development to enhance the New Blue Economy** by improving the resilience of coastal communities and economies to tsunami hazards.

Table 1. Themes, goals, and strategic actions of the 2024-2029 NTHMP Strategic Plan.

Theme	Goals	Strategies
<p>Hazard And Risk Assessment</p>	<p>Tsunami hazard assessments identify areas where risk-reduction planning is needed</p>	<ul style="list-style-type: none"> Identify and address gaps in tsunami source characterization and modeling Complete inundation and evacuation maps for all U.S. coastal communities Identify and address product requirements that support the maritime industry
	<p>Methods to characterize and communicate societal risks to tsunamis are developed and properly applied to support risk-reduction planning</p>	<ul style="list-style-type: none"> Assess population exposure, vulnerability, and evacuation potential to tsunami Support the development and appropriate use of tsunami loss-estimation methods and tools, such as Hazus and the National Risk Index
<p>Tsunami Education and Preparedness</p>	<p>At-risk populations are informed and prepared to respond appropriately to tsunamis</p>	<ul style="list-style-type: none"> Engage public and private schools and institutions of higher learning Develop, update, and disseminate consistent outreach materials Conduct training and outreach events and campaigns Evaluate tsunami outreach and incorporate findings into future efforts
	<p>New TsunamiReady® sites are established and existing sites are maintained</p>	<ul style="list-style-type: none"> Recognize TsunamiReady® Communities Increase number of recognized TsunamiReady® Tier 2 Communities Increase number of designated TsunamiReady® Supporters Determine and promote best practices for tsunami risk-reduction Evaluate TsunamiReady® criteria and re-establish TsunamiReady® boards
	<p>Engage and support local efforts to improve tsunami preparedness</p>	<ul style="list-style-type: none"> Conduct exercises that include tsunami scenarios to improve future response Promote effective planning for tsunami preparedness
<p>Mitigation and Recovery</p>	<p>Mitigation and recovery strategies are developed for long-term community planning</p>	<ul style="list-style-type: none"> Develop guidelines and model practices for mitigation and recovery Develop resources and model practices for mitigation and recovery funding Support improvements to FEMA’s National Risk Index and RiskMAP Help building code developers incorporate best available science Incorporate non-seismic sources and long-term impacts of climate change on coastal communities into tsunami mitigation and recovery planning
	<p>Mitigation and recovery strategies are initiated and incorporated into long-term community planning</p>	<ul style="list-style-type: none"> Implement guidelines and model practices for mitigation and recovery Increase local stakeholder capacity for mitigation and recovery efforts
<p>Alert, Warning, and Response</p>	<p>Tsunami Warning Center products are understandable, effective, and actionable</p>	<ul style="list-style-type: none"> Provide guidance to refine Tsunami Warning Center and state-level products Provide stakeholder requirements through the WCS Improve availability of products for underserved and vulnerable communities Support the National Weather Service Hazard Simplification Project
	<p>Warning forecast dissemination is effective and reliable</p>	<ul style="list-style-type: none"> Coordinate periodic system-wide communication tests and encourage authorities to participate and provide feedback Dedicate outreach and exercise efforts for underrepresented communities Improve local warning reception capabilities Improve local warning dissemination capabilities
	<p>Tsunami response is effective</p>	<ul style="list-style-type: none"> Support and provide tools to enhance community-level response planning Align NTHMP partner alerting and response Collaborate with USGS on testing and consistent messaging of ShakeAlert earthquake messaging and tsunami alerting
	<p>Field data collection and communication efforts are coordinated after a tsunami</p>	<ul style="list-style-type: none"> Support and implement post-tsunami event protocols Exercise field data collection efforts locally, regionally, and nationally

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National Tsunami Hazard Mitigation Program Partners



Background

NTHMP Mission: To mitigate the impact of tsunamis through public education, community response planning, hazard assessment, and warning coordination

NTHMP Vision: Resilient communities that result in reduced loss of life and property when a tsunami strikes any U.S. state or territory

Tsunamis pose a major threat to U.S. coastlines, demonstrated most recently by the 35 fatalities and considerable damage in American Samoa from the 2009 Samoa tsunami disaster and most famously by the 1964 Alaska earthquake and tsunami which resulted in 131 fatalities along the US west coast. Other, even larger disasters elsewhere in the world, such as the 2004 Indian Ocean tsunami (227,899 fatalities across 15 countries and ~\$10 billion in damages), the 2011

Tōhoku tsunami (18,428 fatalities in Japan and ~\$220 billion in damages; 1 fatality and over \$100 million in damages in California), and the 2018 Sulawesi tsunami (4,340 fatalities in Indonesia and \$1.5 billion in damages) demonstrate the need for sustained improvements in tsunami preparedness, alerting, response, mitigation, and recovery planning in U.S. coastal communities.

On September 29, 2009, a magnitude 8.1 earthquake in the southern Pacific Ocean created tsunami waves that caused many fatalities and widespread destruction in American Samoa. (NOAA)



Many areas of the U.S. coastline are threatened by tsunami hazards similar to the 2011 Tōhoku tsunami disaster, i.e., events that could kill thousands of people and cause billions of dollars in damages with only minutes of warning time before the first tsunami waves arrive (Dunbar and Weaver 2015). Tsunamis cannot be prevented, but their impacts on life, property, natural and cultural resources, and the economy can be greatly reduced. Efforts to reduce such impacts are essential where large, locally generated tsunami waves cause catastrophic damage and provide only a few minutes for at-risk individuals to evacuate. Efforts are also important where distant tsunamis could arrive hours after generation and cause significant damage. For example, a U.S. Geological Survey scenario of potential impacts in California from a tsunami originating offshore of Alaska suggests that 80-90 percent of the damage and years of recovery could be prevented with mitigation, response, and recovery planning efforts (Ross et al. 2013). Tsunami education, preparedness, and mitigation planning and actions are ongoing processes, and this strategic plan strives to meet these challenges head on by providing goals and strategies for a variety of federal, state, territory, and tribal partners.

Foundation

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. coastal states and territories. This strong and active partnership connects states and federal agencies to bring together the expertise and experiences necessary to right size community strategies that will protect lives, minimize damages and community disruptions, and promote a prosperous Blue Economy in an ever-changing environment. NTHMP activities directly affect at-risk individuals in tsunami hazard zones and the agencies and organizations tasked with preparing them for future events and managing risks in coastal communities. NTHMP activities also indirectly affect everyone else in the United States due to the significant role that coastal communities play in tourism and in the national economy. Important partners and customers for NTHMP products include coastal residents and visitors, emergency managers, land-use planners, elected officials, educators, government and business organizations, the military, the media, and the tourism and maritime industries.

On March 27, 1964, the largest recorded earthquake in U.S. history struck Alaska's Prince William Sound. The 9.2 magnitude earthquake and subsequent tsunamis ravaged coastal communities throughout the Pacific Ocean basin. (NOAA)



Policy Context

The NTHMP's strategic plan is part of a broader framework to support tsunami resilience. In 1995, recognizing the threat, the U.S. Congress directed NOAA to form and lead a federal/state working group to develop a plan for reducing tsunami risk to U.S. coastal communities. This group—the NTHMP—has become a model for federal/state partnerships.

Following the 2004 Indian Ocean tsunami, Congress passed the Tsunami Warning and Education Act (TWEA, P.L. 109-479, Title VIII) to strengthen the NTHMP's capabilities and "to improve tsunami preparedness of at-risk areas in the United States and its territories." In 2017, Congress passed the Tsunami Warning, Education, and Research Act of 2017 (TWERA, P.L. 115-25, Title V) to update TWEA and continue the federal authority. TWERA calls for action to improve tsunami preparedness in the U.S. with efforts such as: 1) improve research and guidelines for tsunami mapping, modeling, and assessment efforts to support notification, response, outreach, mitigation, and recovery capabilities; 2) improve NOAA's National Weather Service (NWS) TsunamiReady® program to make communities more tsunami resilient through the use of inundation maps and other mitigation practices; and 3) integrate tsunami preparedness, mitigation, and recovery into state-based planning and risk-management activities. These and other TWERA recommendations provide direction to the NTHMP and this strategic plan.

The NTHMP also considered recommendations from recent NOAA and NTHMP reviews during plan development. A 2017 external program review recommended: (1) an increased focus on mitigation and recovery issues; (2) development of internal guidelines; (3) integration of models and maps that include nonseismic tsunami sources; (4) improved methods of distributing tsunami maps and products to tourism and maritime industries and emergency managers in lower-hazard regions, like the U.S. East and Gulf Coasts; and (5) application of social science research and assessments to appraise program work (Goltz et al. 2017). A 2021 report of the NOAA Science Advisory Board's Tsunami Science and Technology Advisory Panel (TSTAP) included recommendations such as (1) improving capabilities of the Tsunami Forecast System; tsunami detection and observation systems; and Tsunami Warning Center forecasts and alert systems, (2) providing more extensive, consistent, and accurate tsunami messages and products, (3) improving consistency in tsunami preparedness, mitigation, and resilience products for communities, while also leveraging climate change strategies, and (4) developing research priorities, such as improving tsunami hydrodynamic modeling.

The widespread devastation from the 2004 Indian Ocean earthquake and tsunami disaster led to the U.S. Tsunami Warning and Education Act, which was focused on improving tsunami preparedness across the United States. (USGS)



NTHMP Structure

NOAA is the lead agency for the NTHMP and is responsible for administering the program. An appointee of the NOAA administrator within the NWS serves as the chair of the NTHMP Coordinating Committee. The NTHMP chair, on behalf of the NOAA administrator, appoints a staff member to serve as the NTHMP administrator. The NTHMP is led by the Coordinating Committee, which includes emergency management and scientific representatives from state, territory, and federal agency partners. The Coordinating Committee guides and governs the work of subcommittees established to address the NTHMP's three key functions—hazard assessment, mitigation and education, and warning guidance—as well as caucuses and work groups formed to help meet program goals.

The primary funding source for the work of the NTHMP is a grant program administered by the NWS (NOAA/NWS Financial Assistance for Tsunami Activities). When funds are appropriated by Congress, the NWS passes them on to NTHMP state and territory partners for projects that support the mission and vision of the NTHMP and its strategic plan. Examples include inundation mapping, providing tsunami public outreach, promoting community networks to improve tsunami resilience, encouraging the adoption of tsunami warning and mitigation measures, and conducting applied tsunami research to support product development. Further information about the structure and organization of the NTHMP as well as the grants program can be found on the NTHMP website.



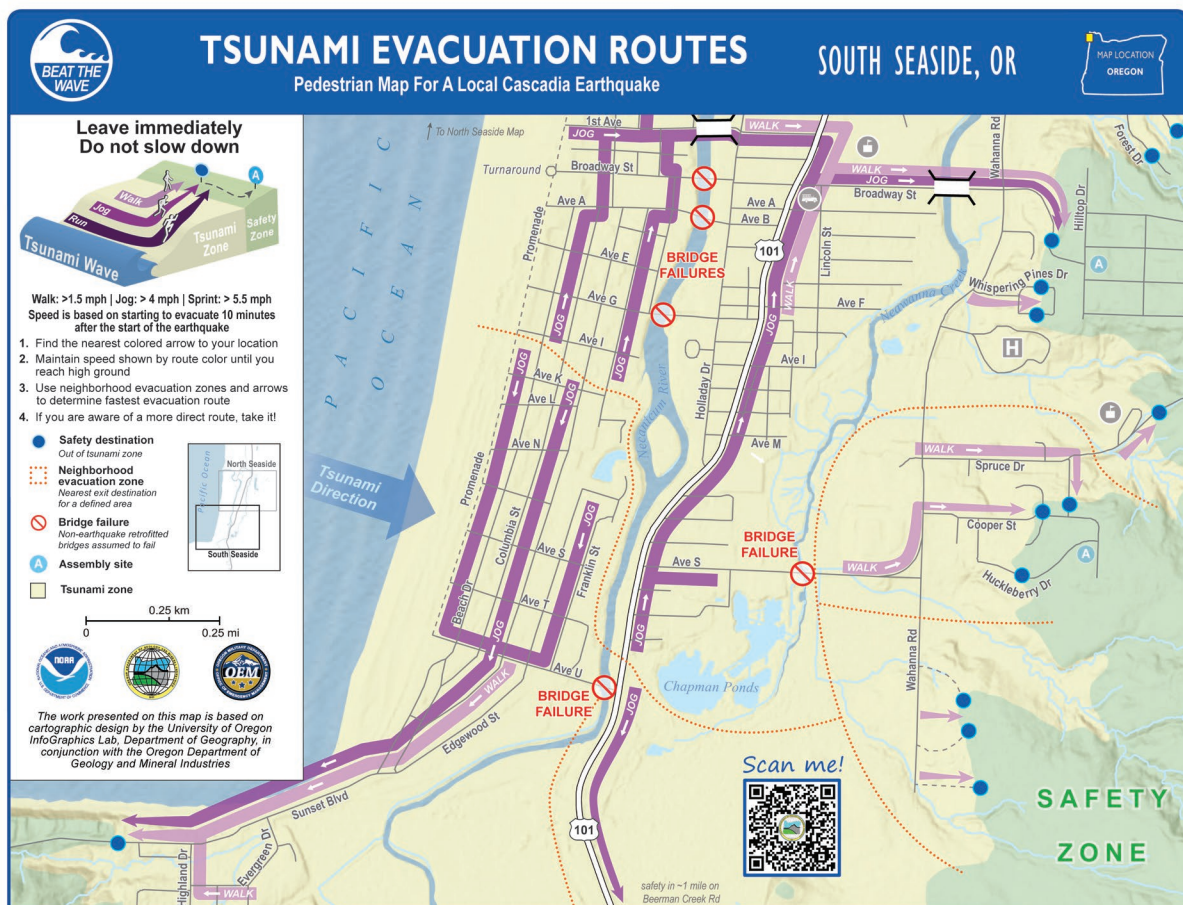
The National Tsunami Hazard Mitigation Program (NTHMP) is led by the NTHMP Coordinating Committee and is comprised of three subcommittees (Mapping and Modeling, Mitigation and Education, and Warning Coordination). There are also working groups and caucuses that self-organize around topics of collaborative interest among NTHMP members.

Theme 1: Hazard and Risk Assessment

Fundamental goals of the NTHMP are to protect life safety during tsunamis and to minimize societal damage after events. This theme of the NTHMP strategic plan supports these overarching goals through the development of accurate, consistent, and cost-effective assessments of how and where tsunamis may form, the effects they may have on coastal landscapes, what damage they may create in coastal communities, differential and inequitable impacts to at-risk individuals, and the range of efforts that could reduce unacceptable risks. Maps and other products that communicate the results of these assessments can support effective and equitable mitigation, preparedness, response, and recovery plans.

Although substantial progress has been made in the development of tsunami hazard and risk assessment guidelines and products, more work remains to be done. The NTHMP will assess, revise, and develop new approaches for characterizing and communicating tsunami hazards and the subsequent societal risks related to these hazards based on lessons learned from recent tsunamis and expanded partner and stakeholder requirements. This work will also leverage research efforts of NTHMP partners and the academic community to ensure products are based on the best available science.

There are many ways to characterize and communicate tsunami hazards and community vulnerability to these hazards. Here is a map for Seaside, Oregon, that shows the tsunami-hazard zone, the safety zone, assembly areas, locations of potential bridge failures, evacuation routing, and estimated evacuation travel speeds needed to reach safety due to a local earthquake and tsunami. (Oregon Department of Geology and Mineral Industries)



Goal 1.1: Tsunami hazard assessments identify areas where risk-reduction planning is needed

Hazard assessment entails all elements related to understanding how and where tsunami waves could be generated and how these waves may impact coastlines. This goal includes efforts to characterize credible seismic and nonseismic tsunami sources, inundation modeling that recognizes the dynamic nature of coastal systems, and modeling of tsunami currents and wave impacts. This information is then used to create user-friendly maps and other products to communicate tsunami hazards to the public. NTHMP projects related to characterizing and mapping tsunami hazards also will strive to include relevant climate considerations, such as projected changes in sea level.

Strategy 1.1.1: Identify and address gaps in tsunami source characterization and modeling

The NTHMP evaluates tsunami hazard assessment methods and continues to improve input parameters for tsunami hazard modeling to produce accurate and consistent maps and products. The NTHMP will further this work through the following activities:

- Develop best practices to achieve consistency in how tsunami source parameters are characterized for various uses, including inundation and evacuation planning, maritime mitigation and response planning, and engineering and construction design.
- Complete tsunami source databases for numerical modeling of all relevant seismic and non-seismic sources, including sources used in deterministic and probabilistic analyses, for specific user groups and planning purposes.
- Develop and promote best practices for the use of consistently developed tsunami sources and products between states and/or with regions.
- Develop guidelines for consistent modeling and mapping of inundation from coseismic deformation and nonseismic tsunamigenic sources, such as submarine mass failures, landslides, volcanoes, and meteorologic/atmospheric phenomena.
- Determine and develop modeling guidelines for how tsunami inundation modeling is

affected by unique physical properties and processes, such as bathymetric and topographic changes, heavy vegetation, the built environment, variable tides (e.g., standards for tidal correction), sea level rise, coseismic deformation, dynamic riverine systems, erosion/deposition of sediment, and debris movement.

- Improve discoverability and accessibility of data (e.g., source characterization, water level, hydrodynamic models, etc.) for advancing tsunami research and model development
- Develop protocols and procedures for reporting and distributing standardized post-tsunami data and for conducting multi-disciplinary field surveys (including natural and social scientists) after observed tsunamis to collect information that can help improve hazard-assessment and risk-assessment methods.

Sediment cores can show layers of sand surrounded by marsh muds. These sand layers provide evidence of past tsunamis and can be used to determine how often they have happened in the past. This core was taken in Cannon Beach, Oregon. (City of Seaside, Oregon)



Strategy 1.1.2: Complete and/or update inundation and evacuation maps for all U.S. coastal communities

NTHMP partners will strive to complete inundation and evacuation maps and related products in consistent and cost-effective ways through the following activities:

- Conduct a geographic gap analysis of tsunami hazard maps and products.
- Complete estimated inundation zones and tsunami-evacuation maps for unmapped coastal regions using established guidelines that are updated, where necessary, to ensure consistency between states and territories.
- Encourage all models and maps funded by NOAA/ NWS grants meet NTHMP guidelines except where they conflict with state/territory-mandated laws or policies.
- Develop bathymetric/topographic data guidelines for regions that have recently experienced a significant event (e.g., hurricane, infrastructure development) that likely resulted in terrain changes. Guidance should address (1) timelines of data collection and availability; and, (2) incorporation into tsunami hazard mapping products.
- Develop scenario-based tsunami-hazard maps for potentially significant events, such as landslide-generated tsunamis, volcano-generated tsunamis, meteotsunamis, inundation related to coseismic deformation from local earthquakes, glacial collapse, earthquake-related seiche, and the potential effects from sea level rise.
- Develop probabilistic tsunami hazard maps where sources are community-models and consistent on a national scale, especially for use in updating ASCE/Building Code “Tsunami Design Zone” maps and in state, regional, and national risk assessments so results will be consistent and comparable to other hazards.
- Provide public access to tsunami-evacuation products consistently across the U.S. by (1) developing a national, online repository and web mapping application for tsunami evacuation maps, and (2) annually updating the inventory of evacuation maps relative to the number of at-risk communities.
- Develop guidelines for communicating wave arrival times and for including them in hazard maps and products.
- Develop decision-support maps and tools that enhance local response activities.

A natural scientist and a city emergency manager in Alaska working together to create a tsunami evacuation map. (Alaska Earthquake Center)



Strategy 1.1.3: Identify and address tsunami hazard assessment and product requirements that support the maritime industry

Harbors damaged during recent tsunamis have demonstrated the need for NTHMP products specifically focused on maritime communities (Wilson et al. 2012). The NTHMP will evaluate new hazard assessment tools and methodologies to support maritime communities through the following activities:

- Complete guidelines and develop hazard-assessment products that address various uses, such as supporting response, mitigation, and recovery planning and that address various elements of the maritime community (e.g., vessel size, hazard level, offshore depth, harbor configuration, and debris susceptibility).
- Develop guidelines for analysis of modeled tsunami currents/vorticity and forces on structures
- Develop a unified place for accessing data from water level observations to support near-real-time and post-event analyses of maritime impacts from tsunamis.
- Promote periodic review of hydrodynamic tsunami modeling through a process to update published model benchmarks.
- Conduct analysis and modeling of tsunami debris movement based on various scenarios within ports and harbors to identify areas most likely to be impacted during future tsunamis.



Observations from coastal water-level stations help the tsunami warning centers issue accurate tsunami alerts. (NOAA)

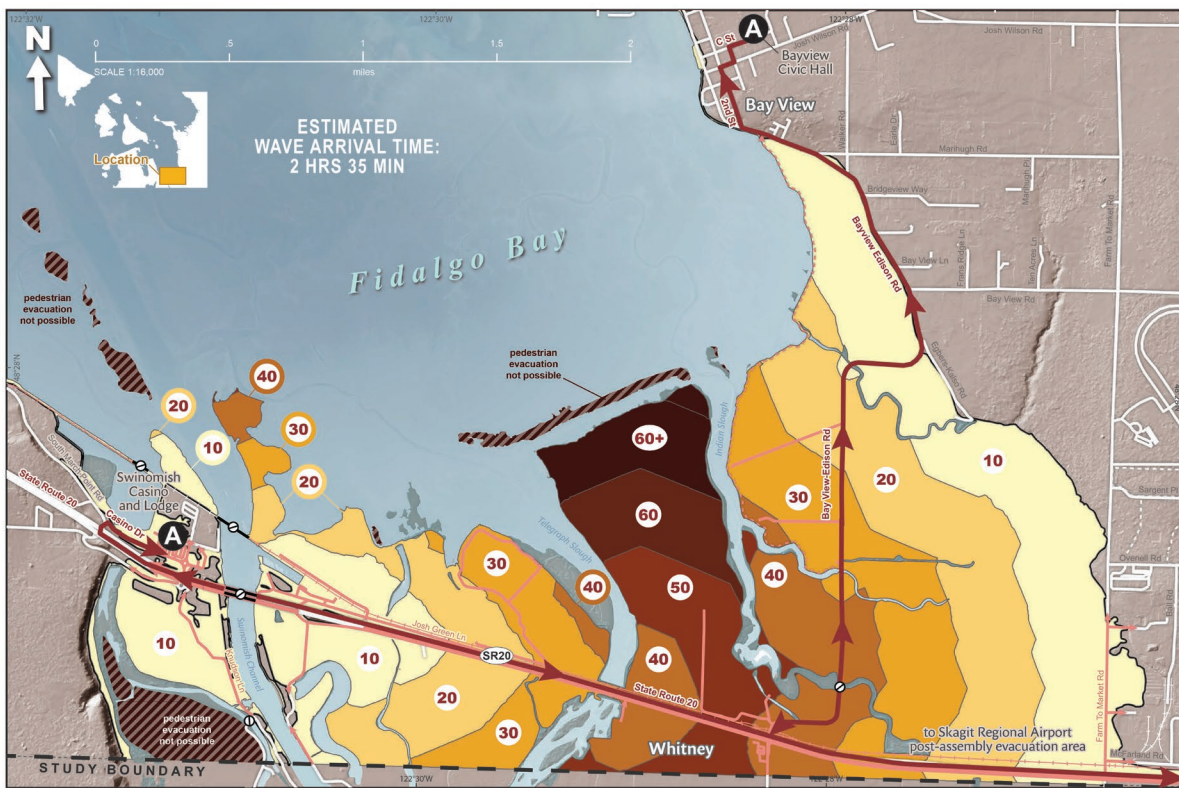
Ports and harbors can be significantly impacted from local and distant tsunamis. This picture shows extensive harbor damage in Crescent City, California, following the 2011 Tohoku earthquake and tsunami disaster that originated in Japan. (NOAA/NCEI)



- Support studies based on evidence-based approaches from the social and behavioral sciences to determine if at-risk individuals in areas susceptible to local tsunamis are able to recognize natural cues of tsunamis and to take self-protective actions.
- Complete guidelines and products for pedestrian evacuation modeling and mapping in at-risk communities with credible local tsunami threats, including the potential impacts of preceding earthquakes on key egress routes and consideration of vulnerable populations, including traditionally underrepresented or marginalized groups and those with access and functional needs.
- Conduct evacuation-potential studies to identify and inventory coastal communities across the U.S. where there may not be sufficient time to evacuate before tsunami-wave arrival.

Communities with local tsunami threats are of primary concern; however, evacuation studies may be warranted in communities with only distant threats if there are large numbers of people in hazard zones and limited egress options to support vehicular evacuations.

- Complete guidelines and products for vehicular evacuation modeling in at-risk communities with credible distant tsunami threats.
- Provide public access to information regarding population exposure, demographic sensitivity, and evacuation potential to tsunamis by developing a national, online repository and consistent web mapping application.
- Conduct feasibility studies and risk analyses for potential vertical evacuation structures where there is insufficient time to evacuate before wave arrival, including engineering considerations and social and economic constraints of at-risk communities.



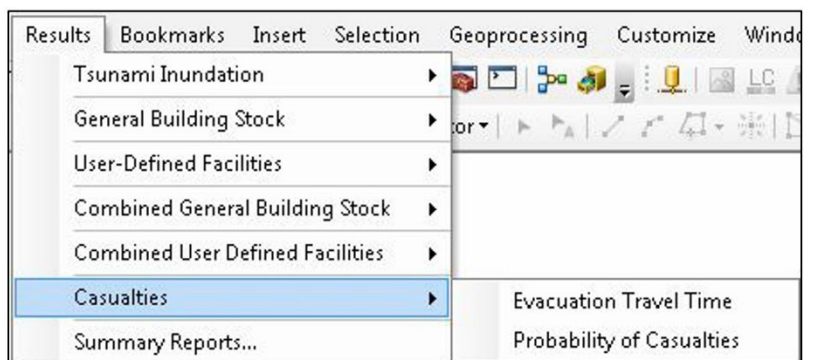
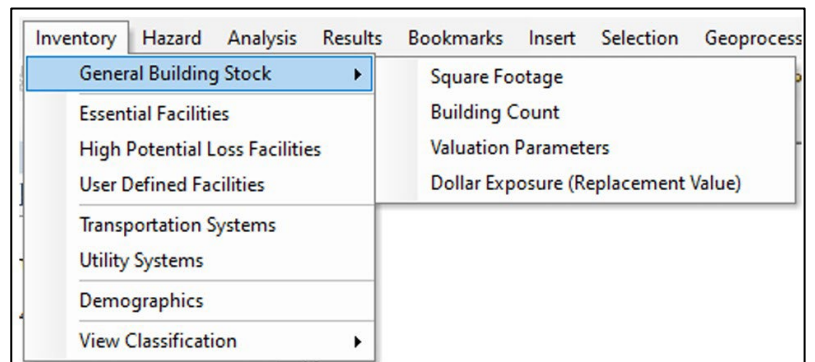
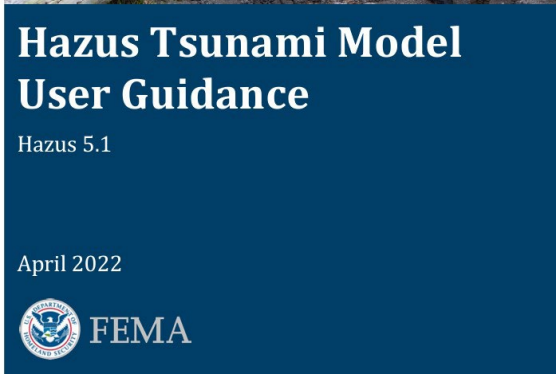
Computer-based evacuation modeling can estimate how long it may take for people to move out of hazard zones before tsunami waves arrive. Here is an example of a pedestrian travel-time map for an area east of Anacortes, Washington. (Washington Department of Natural Resources)

Strategy 1.2.2: Support the development and appropriate use of tsunami loss-estimation methods and tools, such as Hazus and the National Risk Index

Loss estimation approaches and studies provide insights on the potential impacts to the local economy, critical and essential infrastructure, natural resources, and built environment of coastal communities. Use of probabilistic tsunami hazard analysis products is encouraged so that risk analyses will produce more comparable and consistent results nationally. The NTHMP and its partners can help federal agencies, coastal states, communities and other stakeholders understand the potential for tsunami-related losses through the following activities:

- Provide technical assistance to FEMA for the tsunami module of the Hazus loss-estimation software and for the National Risk Index, such as providing input data; validating and improving modeling approaches; and reviewing documentation on methods, product guidance, and interpretation of results.

- Work with FEMA to expand the Hazus tsunami module to all U.S. coastal regions
- Develop and implement a strategy for local use and product guidance of the tsunami module of FEMA's Hazus loss-estimation software.
- Develop common language for use by NTHMP partners on how the public should interpret and use tsunami-related data in the National Risk Index
- Provide funding, technical assistance, and other support to states, communities and other stakeholders to undertake risk and loss assessment analyses using Hazus and other related risk assessment tools.
- Develop methods and conduct studies currently not in the Hazus tsunami module that examine other aspects of tsunami risk assessments, such as impact forces on structures, damage models for assessing maritime-infrastructure impacts and maritime-debris generation, aspects of social equity, threats to regional infrastructure, potential changes in societal risk due to climate change, correlation of tsunami inundation areas with existing hurricane evacuation zones especially in lower risk tsunami hazard regions, and threats to coastal ecosystems and natural resources.



The Hazus tsunami model developed by FEMA provides users with the ability to estimate community impacts, including building losses, economic losses, and casualties, from tsunami scenarios. (FEMA)

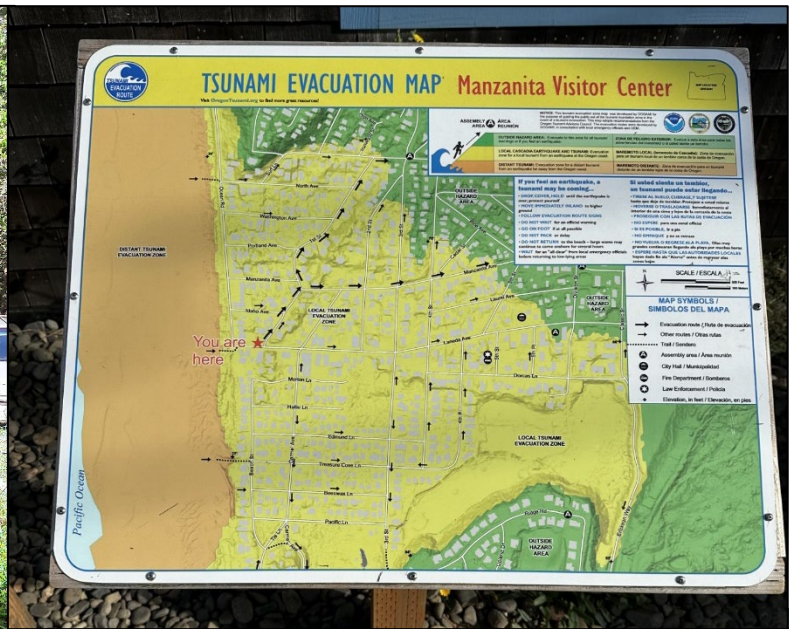
Theme 2: Tsunami Education and Preparedness

Education and preparedness refer to activities that help coastal communities and visitors understand their risk and the actions they can take to protect lives, property, and businesses from tsunamis. To strengthen these efforts, NTHMP partners and stakeholders work together and share their education and preparedness experiences.

Following significant life-loss tsunamis (2004 Indian Ocean, 2009 Samoa, 2010 Chile, 2011 Japan), much emphasis has been placed on the

importance of educating the public to be prepared for evacuation. The NTHMP focuses on improving education and preparedness activities to facilitate the ultimate desired outcome: at-risk individuals know what to do before, during, and after a tsunami. NTHMP partners also seek to develop and implement equitable education and preparedness efforts that recognize the potential limitations of some at-risk individuals and that support traditionally underserved and/or marginalized populations.

Tsunami outreach can involve public evacuation drills (upper left, Puerto Rico Tsunami Team), evacuation kiosks (upper right, USGS), and murals (lower, Puerto Rico Tsunami Team).



Goal 2.1: At-risk populations are informed and prepared to respond appropriately to tsunamis

It is important to promote and share innovative and effective education and preparedness efforts and model practices to help inform local populations and reach broad audiences. Community education networks and programs encourage readiness through activities that include risk assessment training, technical training, and public education and outreach programs.

Strategy 2.1.1: Engage public and private schools and institutions of higher learning in tsunami preparedness

The NTHMP will continue to support development and dissemination of tsunami education and preparedness materials and activities geared for K-12 and higher education in tsunami-prone areas. Leveraging existing curricula such as the Alaska Tsunami Education Program, Washington State's Earthquake and Tsunami Education Program, and the Puerto Rico K-12 Curriculum will save development costs. Internationally recognized events, such as the annual Great ShakeOut earthquake and tsunami drill and CARIBE WAVE, are other such opportunities for leveraging existing momentum and resources.



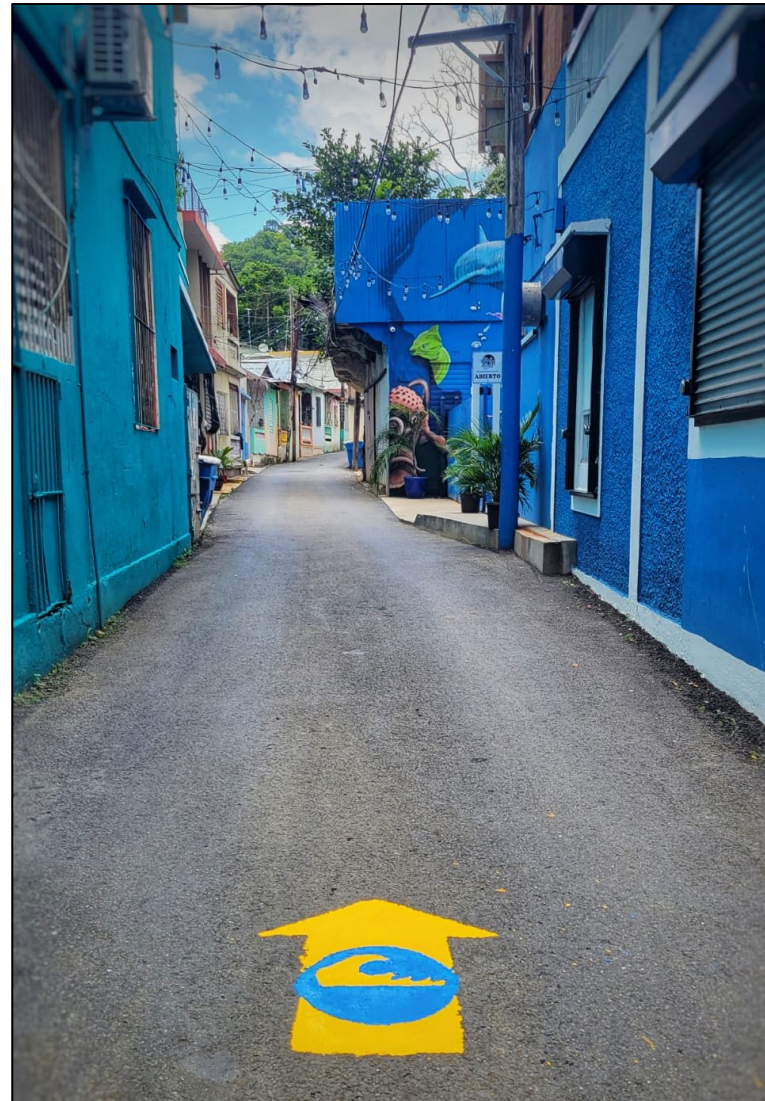
Simple infographics can demonstrate how people should quickly move to high ground to avoid tsunami waves. (Southern California Earthquake Center for above image, Washington Emergency Management Division for image below)



Strategy 2.1.2: Develop, update, and disseminate consistent outreach materials

NTHMP partners will incorporate lessons learned, updated scientific knowledge vetted by NTHMP partners and stakeholders, best practices gleaned from the social sciences, and enhanced public safety and maritime response recommendations into new and updated outreach materials. They will further this work through the following activities:

- Improve the discoverability and accessibility of NTHMP outreach and education products, including updates and sustained maintenance of NTHMP and NTHMP partner web pages.
- Expand usage of equitable outreach products that recognize the specific needs and constraints of uniquely vulnerable, underserved and/or marginalized populations to reduce societal inequities in tsunami preparedness, such as including American Sign Language (ASL), video captioning, formatting digital materials for screen reader software, and other aspects of improving accessibility in materials and in dissemination.
- Strive for consistency of content while customizing outreach materials to reflect local practices, policies, culture, and language.
- Integrate tsunami content into multi-hazard outreach materials to leverage limited resources and opportunities for engaging the public
- Develop local outreach materials that discuss mitigation strategies to reduce loss of life in areas with insufficient time to evacuate to natural high ground, such as evacuation training, the creation of new evacuation paths, and vertical evacuation structures.
- Produce outreach materials tailored to specific uses, such as materials that address preparedness and response for maritime communities.
- Maintain and improve the online repository of outreach materials developed using NTHMP funding to support the wider use of products among partner states and territories.
- Collaborate with local, state, regional and/or international partners to develop consistent outreach materials based on the best available content and approaches that elicit appropriate public protective actions



Tsunami-evacuation guidance can include painting directions on the road (upper image, Puerto Rico Tsunami Team) and signage (lower image, California Geological Survey).

Strategy 2.1.3: Conduct training and outreach events and campaigns

NTHMP partners will promote and share innovative and effective outreach efforts and events to better inform the public and extend their reach. They will also provide training to emergency managers, first responders, the military, and other key partners through FEMA-certified and other relevant tsunami courses.

Strategy 2.1.4: Conduct social science evaluation of tsunami outreach and incorporate findings into outreach efforts

Evaluation of the effectiveness of tsunami outreach efforts is particularly needed in coastal communities threatened by local tsunamis, where at-risk individuals will need to quickly take protective actions that will be informed by outreach before an event. NTHMP partners will work to improve the development and implementation of outreach efforts through the following activities:

- Develop guidelines as to what constitutes effective public outreach as it relates to tsunami preparedness and make these guidelines publicly available.
- Evaluate tsunami outreach efforts to determine their effectiveness and the level of preparedness in their communities. They will use the results to adjust their outreach efforts as needed to improve understanding and response.



Social-science research is needed to determine if the public understands tsunami signage. This sign is technically correct because high ground is available in both directions. However, it may also confuse people during an evacuation. (Washington Emergency Management Division)

One approach for providing tsunami outreach involves booths at local fairs or conferences, such as the Lincoln County (OR) Preparedness Fair (left) or the Washington Maritime Expo (Oregon Department of Geology and Mineral Industries, Washington Emergency Management Division)





TsunamiReady® signs help provide visual cues to residents and visitors that tsunamis are a community threat and that the community is taking steps to protect them. (California Geological Survey)

Goal 2.2: New TsunamiReady® sites established and existing locations maintained

TsunamiReady® is a voluntary community recognition program of the NWS that promotes tsunami preparedness as an active collaboration among federal, state, tribal, and local emergency management agencies, community leaders, and the public. The main goal of the program is to improve public safety before, during, and after tsunami emergencies. The UN Ocean Decade Tsunami Programme has established the goal of 100% of communities at risk are prepared for and resilient to tsunamis by 2030. The effective implementation of TsunamiReady® in the U.S. supports this aspiration.

Strategy 2.2.1 Recognize TsunamiReady® Communities

The National Weather Service in cooperation with the NTHMP developed the TsunamiReady® program guidelines for recognition. By meeting the fundamental guidelines, communities demonstrate a uniform level of capability to mitigate, prepare for, and respond to tsunamis. NTHMP partners will continue to work with communities to help them meet these guidelines and become recognized as TsunamiReady® by the NWS. This requires strong coordination between NWS Weather Forecast Offices and NTHMP state partners, which could be enhanced by forming state or regional TsunamiReady® Boards. The NTHMP will work with the NWS to explore ways to better integrate maritime communities (i.e., ports and harbors) into the TsunamiReady® recognition process. TsunamiReady® efforts will benefit from the development of a strategy based on a gap analysis to ensure that all communities at risk and its underserved and vulnerable populations are prepared for tsunamis.



The city of Bayamón, Puerto Rico, receives TsunamiReady® recognition. (Puerto Rico Tsunami Team)

Strategy 2.2.2: Increase number of recognized TsunamiReady® Tier 2 Communities

For some communities, in-time evacuation of all at-risk populations may not be possible. These communities need to take additional measures. In cooperation with the NTHMP, the NWS designed TsunamiReady® Tier 2 to help high-risk communities better prepare for and mitigate their heightened tsunami risk and reach a higher level of disaster resilience.

Tier 2 guidelines include developing evacuation plans, including vertical evacuation plans if it is unlikely that at-risk populations would be able to reach safety before arrival of the first wave, and incorporating tsunamis into general disaster response, recovery, and debris management plans. NTHMP partners will promote Tier 2 recognition and help communities improve their tsunami resilience.

Results of evacuation-potential studies (Strategy 1.2.1 in the Hazard and Risk Assessment section) can be used to identify communities that may have insufficient time to evacuate before tsunami-wave arrival and that would benefit from being recognized as a Tier 2 community.

Dedicated outreach for Tier 2 communities can be implemented to ensure that community leaders are aware of mitigation strategies to reduce loss of life, such as evacuation training and exercises, the creation of new evacuation paths to natural high ground, and vertical evacuation structures.



Strategy 2.2.3: Increase number of designated TsunamiReady® Supporters

A TsunamiReady® Supporter is an organization, business, facility, or local government entity that is actively engaged in tsunami planning and preparedness but does not have the ability to meet all the formal recognition guidelines. Through the TsunamiReady® Supporter component of the TsunamiReady® program, smaller communities, maritime organizations, and private sector entities can also be recognized for their preparedness efforts. Improving tsunami-related planning and preparedness of these entities not only will support efforts to save lives from future tsunamis but can also support the Blue Economy of coastal and maritime communities, in terms of economic growth, improved livelihoods, and job creation.

NTHMP partners will help identify potential TsunamiReady® Supporters; conduct outreach to leaders and staff; provide them with maps, outreach materials, and signage; and, in some locations, conduct site visits to verify that they meet TsunamiReady® Supporter criteria.



(Above) Puerto Rico has many organizations and businesses, such as hotels and health centers, that are recognized as TsunamiReady® supporters. (Puerto Rico Tsunami Team)

(Left) The community of Manila, California, became recognized as the first TsunamiReady® Tier 2 community in 2019. (Redwood Coast Tsunami Work Group)

Strategy 2.2.4: Determine and promote best practices for tsunami risk-reduction in TsunamiReady® communities

NTHMP partners can continue to support TsunamiReady® communities by helping them to evaluate their performance and identify gaps before, during, and after exercises or live events. New social-science studies also can be conducted to determine how to best prepare communities for tsunamis, especially for local events where at-risk individuals will need to take protective actions with no official warning. Insights can be applied to improve their existing outreach efforts, plans, and procedures.

Strategy 2.2.5: Evaluate TsunamiReady® criteria and re-establish TsunamiReady® boards (where necessary)

The TsunamiReady® recognition is a NWS sponsored program to recognize communities for their preparation for tsunamis. There are several communities which are recognized as TsunamiReady®, and have signs stating so, when in fact the community does not have any viable options for evacuation in a local tsunami event. These signs may promote a false sense of security for residents and visitors in these communities. The NTHMP can work with NWS to re-establish TsunamiReady® Boards in states and territories to evaluate the TsunamiReady® recognition for communities where there is no evacuation option. The TsunamiReady® Boards can review the findings of the 2011 National Academy Report on the Tsunami Program which summarized that the TsunamiReady® program is lacking: metrics to assess readiness and needs, criteria to assess performance during a tsunami, accountability measures, and criteria on what constitutes effective public outreach/preparedness.

Attaining or retaining TsunamiReady® recognition involves meetings to review criteria and to determine how to best meet them based on local conditions (Puerto Rico Tsunami Team)



Goal 2.3: Local tsunami preparedness efforts are supported

Engagement of stakeholders at all levels is a critical element of tsunami education and preparedness. Staff from coastal businesses and the tourism and maritime industries are key partners in tsunami preparedness, mitigation, and response. Active involvement of these and other stakeholders in exercises and the delivery of tsunami outreach is essential to building a sense of community ownership and commitment to public safety. NTHMP partners will engage stakeholders at all levels to enhance all aspects of tsunami mitigation, preparedness, and response capabilities.

Strategy 2.3.1: Conduct exercises that include tsunami scenarios to improve future response

Exercises enhance the efficiency and effectiveness of tsunami disaster management during a real event. Exercises also are an opportunity to enhance collaboration among federal, state, tribal, local, and nongovernmental organizations and leverage resources. Through local, regional and national exercises, NTHMP state partners will identify gaps and lessons learned that can help improve tsunami emergency response plans. Exercises range from drills to table-top, functional, and full-scale exercises. They can be conducted specifically for tsunamis, or tsunamis can be

included in broader multi-hazard exercises. NTHMP partners will further the use of exercises through the following activities:

- Promote the design, development, and evaluation of annual exercise plans, including After Action Reports after each exercise
- Prepare scenarios with associated timelines and messages and test communication systems
- Promote and work with local partners to organize community evacuation drills and maritime response drills to educate the public.

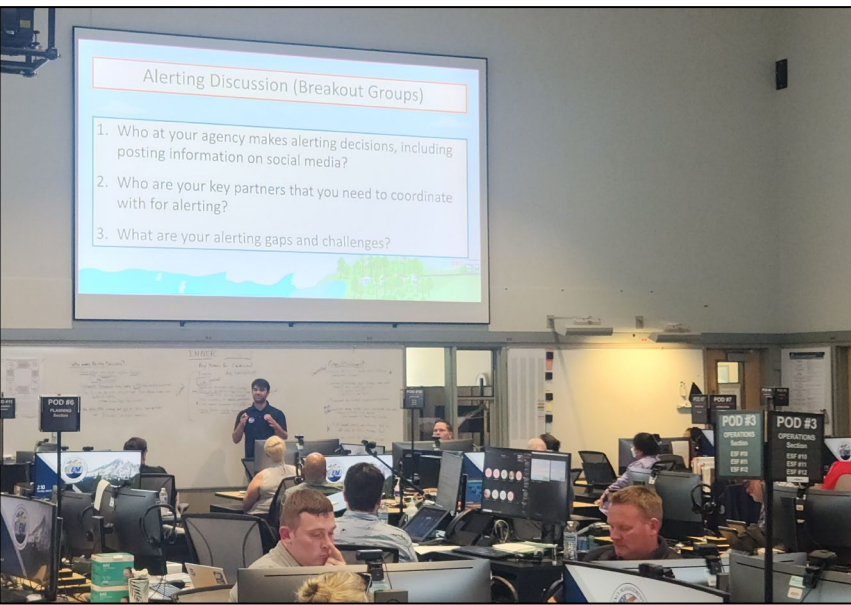
Strategy 2.3.2: Promote effective planning for tsunami preparedness

NTHMP partners are a significant resource in helping coastal communities prepare their at-risk populations for future tsunamis. They will promote best practices in tsunami preparedness through the following activities:

- Provide technical assistance and guidance to states and local communities on state-of-the-art tsunami preparedness plans that elicit appropriate public protective actions
- Create a publicly accessible, digital database of actions taken by TsunamiReady® communities to share best practices and other resources among U.S. coastal communities
- Consider best practices in non-US, at-risk communities in preparing for and becoming resilient to tsunamis through programs like the UNESCO/IOC Tsunami Ready Recognition Programme.

Exercises, like this one held in Washington, provide a forum for emergency managers to discuss their roles and responses during a tsunami. (Washington Emergency Management Division)

Evacuation drills help communities practice how they should react during a real tsunami. This picture shows a drill involving elementary schoolchildren in Saipan, Commonwealth of the Northern Marianas Islands. (CNMI Homeland Security & Emergency Management)



Theme 3: Mitigation and Recovery

The NTHMP envisions tsunami-resilient communities achieved through sound mitigation and recovery products and practices. Mitigation includes any actions taken to reduce or eliminate the long-term risk to human life and property from tsunami hazards; for example, vertical evacuation structures and evacuation routes, strengthening of maritime infrastructure, relocating of essential structures or equipment, etc.

Recovery includes the capabilities necessary to assist communities affected by an incident to recover effectively from tsunami hazards. In addition to repairing damaged structures, it includes the continuation or restoration of services critical to supporting the physical, emotional, and financial well-being of impacted community members. It also includes the restoration and

strengthening of key systems and resource assets that are critical to the economic stability, vitality, and long-term sustainability of the communities themselves. Tsunami mitigation and recovery planning that is aligned with climate-change adaptation strategies play vital roles in the overall resiliency of a community.

Comprehensive tsunami mitigation and recovery planning is becoming an area of greater focus for the NTHMP, which parallels the increasing emphasis on disaster mitigation across the globe through initiatives like the 2015 Sendai Framework and the 2021 United Nations Decade of Ocean Science. A number of NTHMP partners and stakeholders are already engaged in mitigation- and recovery-related initiatives, including maritime mitigation and recovery and tsunami debris planning, but much more is needed to ensure coastal communities are sufficiently resilient to their tsunami hazards.



The 2009 Samoa earthquake and tsunami caused widespread destruction in Pago Pago, American Samoa (NOAA). Recovery required significant efforts to manage debris, repair damaged structures, and rebuild communities.

An independent study conducted at the request of Congress confirmed that hazard mitigation activities reduce future losses and benefit society as a whole. A 2017 update to the original study found “mitigation funding can save the nation \$6 in future disaster costs, for every \$1 spent on hazard mitigation” (MMC 2006, 2017). The findings of another study conducted following two major earthquakes suggested that pre-disaster recovery plans facilitate housing reconstruction and allow communities to take advantage of postdisaster windows of opportunity to more effectively integrate mitigation into recovery (Wu and Lindell 2004). When it comes to tsunamis, the 2013 U.S. Geological Survey study also demonstrated the importance of resilience strategies, which include addressing tsunamis in all types of planning, mitigation and pre-disaster recovery planning in particular (Ross et al. 2013).

Through TWERA, Congress made recommendations for the NTHMP to improve mitigation and recovery planning, recognizing that this can improve community resilience. Similarly, the NTHMP external review report recommended that the NTHMP consider creating a new subcommittee or entity to focus more direct attention on mitigation and recovery planning (Goltz et al. 2017). In 2019 the NTHMP formally established the Mitigation and Recovery Planning Work Group (MRPWG) to address NTHMP Strategic Plan goals and strategies with regard to tsunami mitigation and recovery planning. The four annual work plan items of this workgroup include tsunami debris planning and guidance, funding strategies for tsunami mitigation and recovery products and actions, tsunami maritime mitigation and recovery guidance, and use and communication of probabilistic tsunami hazard assessments (PTHA) and other hazard products.



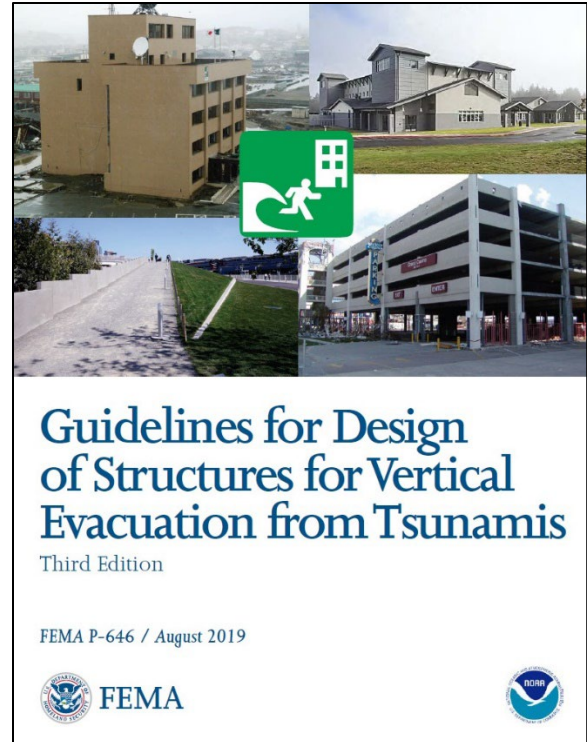
Emergency supply caches outside of tsunami-hazard zones can help communities in the immediate aftermath of a tsunami disaster. This cache of emergency supplies is located uphill from the community of Cannon Beach, Oregon. (Oregon Department of Geology and Mineral Industries)

Goal 3.1: Mitigation and recovery strategies are developed for long-term community planning

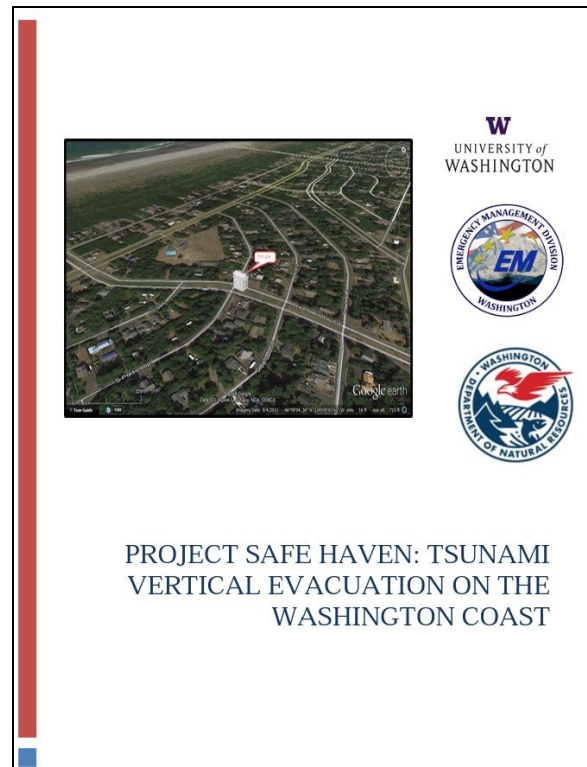
Mitigation and recovery are important and inherently interconnected phases of the emergency management cycle. Both require a long-term vision to devise strategies and implement steps to reduce the impacts of tsunamis and plan for recovery in their wake. To help achieve this goal, the NTHMP will consider recommendations from the 2017 NTHMP external review report (Goltz et al. 2017) and the 2021 TSTAP report to ensure long-term mitigation and recovery strategies are developed and available for at-risk communities.

Strategy 3.1.1: Develop guidelines and model practices for mitigation and recovery for communities and critical infrastructure

NTHMP partners can identify mitigation and recovery needs through stakeholder engagement. This input will be used in the NTHMP’s consideration of methods to address tsunami mitigation and recovery and incorporation of them into future actions. This may include activities such as developing NTHMP guidelines and model practices for maritime mitigation and recovery, debris planning, evacuation route wayfinding, and other related topics. Developing these guidelines and practices requires engagement of stakeholders at all levels of government, nonprofit organizations, and private industry. Guidelines should directly address the tsunami-specific vulnerabilities and needs of historically marginalized populations such as: Indigenous peoples, including both federally recognized and unrecognized tribal nations; gender and sexual minorities; Black, Indigenous, and People of Color (BIPOC); people with access and functional needs; people of low socioeconomic status; and people experiencing any form of housing instability.



Vertical-evacuation structures provide places for people to escape tsunami waves if there is not enough time to reach natural high ground. Federal (top) and State (bottom) guidance documents help communities understand how and where to build them.



Strategy 3.1.2. Develop resources and model practices for the funding of mitigation and recovery projects

One of the biggest barriers to initiating local mitigation and response projects is funding. While the NTHMP cannot directly fund mitigation and recovery projects, it can help communities by developing resources and model practices for identifying and securing the funding of tsunami mitigation and recovery projects such as vertical evacuation structures, maritime strategies, community relocation, etc. This can include guidance on applying for grants and resources on available state and federal grant opportunities.

Strategy 3.1.3 Provide subject matter expertise to improve the tsunami portion of FEMA's National Risk Index and RiskMAP products

The National Risk Index is an online mapping application from FEMA that identifies communities most at risk to 18 natural hazards. This application visualizes natural hazard risk metrics and includes data about expected annual losses from natural hazards, social vulnerability and community resilience. The NTHMP and its partners can continue to support improvements to the tsunami portion of FEMA's National Risk Index and RiskMAP products by providing subject matter expertise to ensure they incorporate the best available tsunami modeling, mapping, and risk information. This in turn will strengthen tsunami mitigation and response planning at the federal level and provide communities with a valuable tool to use when applying for grant funding. This effort is important NRI products could be used to determine local mitigation funding.



Vertical-evacuation structures provide places for people to escape tsunami waves if there is not enough time to reach natural high ground. Examples include a rooftop refuge at Ocosta Elementary School near Westport, WA (upper left), a rooftop refuge at the Hatfield Marine Science Center in Newport, Oregon (lower left), and the Auntie Lee Vertical Evacuation Structure in Tokeland, Washington (right).

Strategy 3.1.4: Provide NTHMP expertise and coordinate with building code developers to incorporate best available tsunami modeling and mapping, risk assessments, and best practices into hazard designation maps

The NTHMP can advise and provide tsunami hazard information to entities such as the American Society of Civil Engineers (ASCE) to use in building code design and provide policy recommendations for tsunami loads in building codes. If and where appropriate, the NTHMP and its partners may support and encourage the adoption of new and updated tsunami hazard information into building codes, including limitations on the development of new critical facilities in mapped inundation zones and the inclusion of risk category 2 facilities in state and local codes.

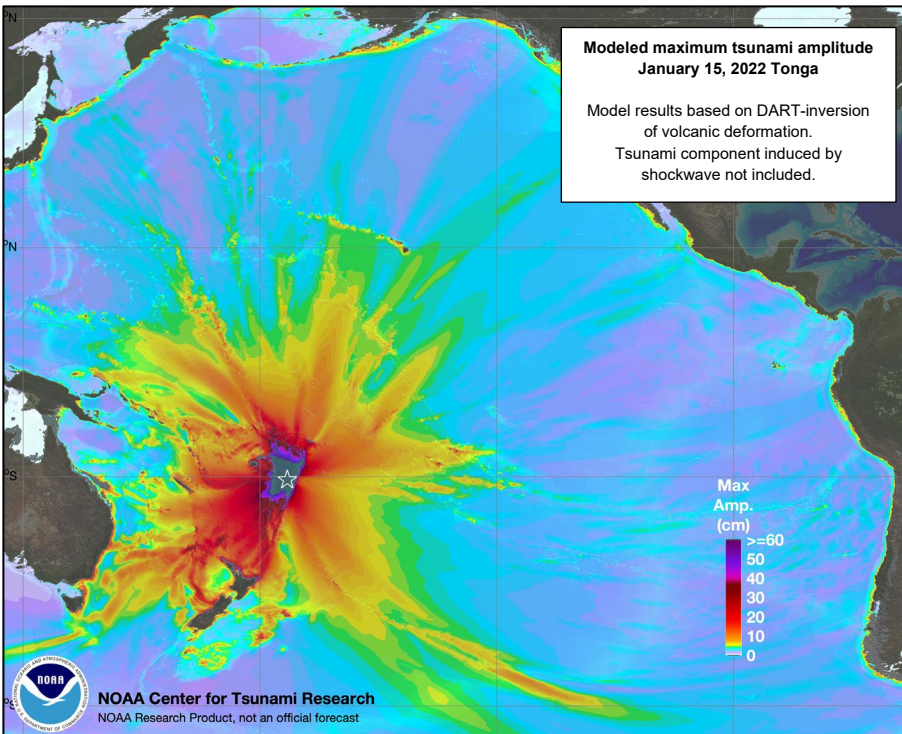
Strategy 3.1.5: Incorporate non-seismic sources and long-term impacts of climate change on coastal communities into tsunami mitigation and recovery planning

Local tsunami hazard mitigation and recovery planning must consider all potential tsunami sources, including non-seismic sources.

Recognizing the connection between the long-term impacts of climate change and tsunami hazards, the NTHMP and its partners may also encourage the incorporation of climate change into tsunami mitigation and response planning whenever possible. This aligns with the 2021 TSTAP report's recommendation that NOAA develop guidance and products for tsunami mitigation/recovery consistent with and leveraging climate adaptation strategies.

Tsunamis can be generated by volcanic eruptions. This map created by the NOAA Center for Tsunami Research shows modeled maximum tsunami amplitudes from the January 15, 2022, eruption of the Hunga Tonga-Hunga Ha'apa Volcano. (NOAA)

Tsunamis also can be generated by landslides. A 1949 landslide into Puget Sound created a series of tsunami waves that reflected off the opposite shore and damaged waterfront homes (lower right of image). The slide occurred three days after the magnitude-7.1 Olympia earthquake. (NOAA)



Goal 3.2: Mitigation and recovery strategies are initiated and incorporated into long-term community planning

Despite the importance of mitigation and recovery to building resilience, many communities struggle to initiate and maintain such work. The NTHMP and its partners may help ensure mitigation and recovery strategies are initiated and incorporated into long-term planning for at-risk communities by supporting initiatives like updated building codes, the incorporation of climate change and sea level rise into tsunami hazard planning and elevating local community planning efforts. It can also leverage partnerships with stakeholders responsible for coastal mitigation and recovery at all levels of government to implement guidelines and model practices.

Strategy 3.2.1: Implement guidelines and model practices for mitigation and recovery

The NTHMP may develop an implementation plan involving stakeholders to determine the most effective way to implement mitigation and recovery guidelines and model practices at a local level. This guidance may include maritime mitigation and recovery, debris planning, evacuation route wayfinding, relocation of high-risk infrastructure and/or equipment, and other related topics. NTHMP partners and stakeholders responsible for coastal mitigation and recovery planning include state and local emergency management agencies and building commissions, FEMA, the U.S. Army Corps of Engineers, harbor and community engineers, and land-use planning departments. Consultation with scientists and engineers involved with probabilistic tsunami hazard analysis and damage assessments is also essential to determining capabilities.

Strategy 3.2.2: Increase local stakeholder capacity by supporting tsunami mitigation and recovery efforts

The NTHMP and its partners may leverage their experience and expertise to increase the capacity of local stakeholders in implementing short and long-term tsunami mitigation and recovery projects by supporting stakeholder efforts in areas such as maritime mitigation and recovery, debris planning, relocation, and evacuation route wayfinding. Support may include conducting wayfinding or vertical evacuation assessments, providing tsunami signage, or developing site-specific maritime modeling and mapping.



State emergency managers work with communities to determine the most efficient and effective ways to evacuate to high ground during a tsunami. Here is an example of wayfinding efforts on the Washington Coast. (Washington Emergency Management)

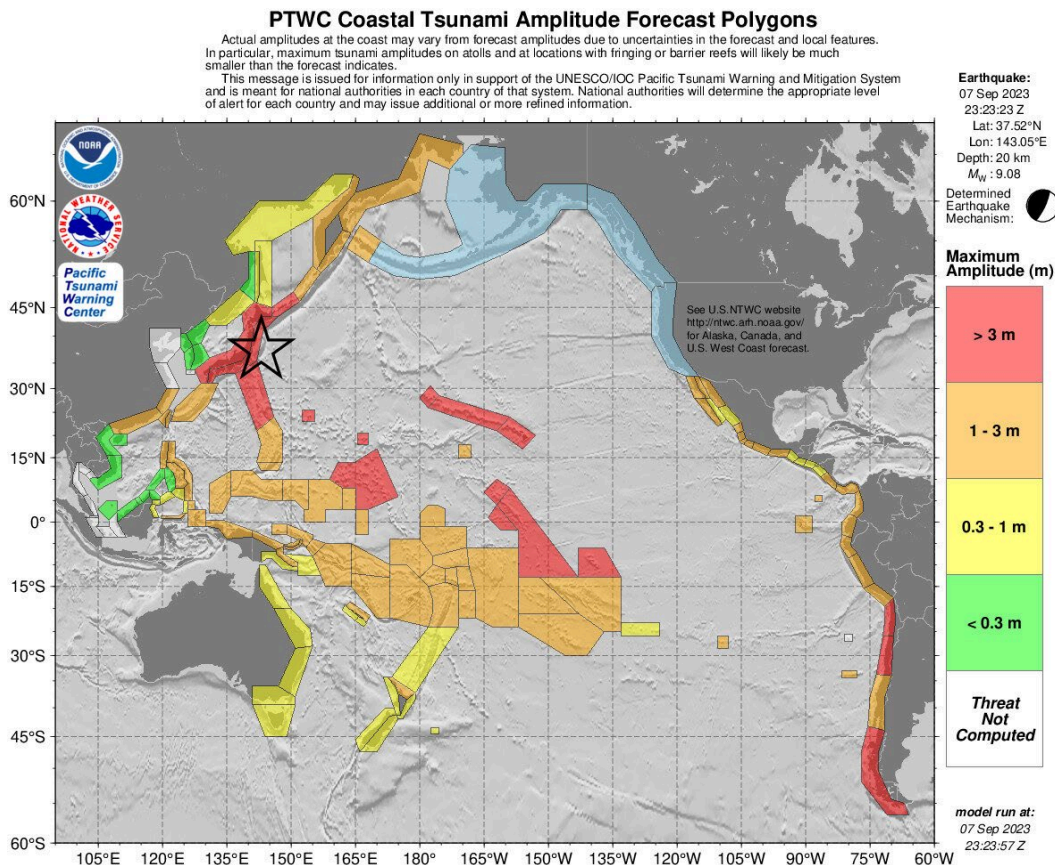
Theme 4: Alert, Warning, and Response

NTHMP partners and stakeholders—federal, state, tribal, and local—share the same interests in and commitment to accurate, timely, reliable, and effective alert, warning, and response when a tsunami occurs from a seismic or non-seismic source. Thus, the NTHMP provides a valuable forum for the development of warning coordination strategies related to the content and delivery of U.S. Tsunami Warning System products as well as associated state-level products.

The NTHMP provides guidance to the NOAA-led U.S. Tsunami Warning System on Tsunami Warning Center (TWC) domestic messages and helps ensure the local delivery of these products. In this role, it supports local warning point reception and dissemination and provides for coordination of U.S. Tsunami Warning System

exercises and tests. The NTHMP has served as a strong, successful, and important warning coordination resource, enabling direct routine communication between NTHMP state partners and the Tsunami Warning Centers regarding the effectiveness of notification protocols and continual improvement efforts.

The NTHMP has a unique role in that it is a collaborative environment for the NOAA led TWCs and the state and federal partners to work together on bolstering the alert, warning, and response capabilities of the TWCs and the states through NTHMP fostered discussions, product development, and understanding of user needs and requirements. The following goals and strategies are aimed at bolstering the alert, warning, and response capabilities of the NTHMP partners.



Example of an international product created by the Pacific Tsunami Warning Center in Honolulu, Hawaii. This graphic shows the maximum tsunami amplitude for certain areas across the Pacific Ocean based on a hypothetical tsunami. Products covering Alaska and the conterminous United States are created by the National Tsunami Warning Center in Palmer, Alaska. (NOAA)

Goal 4.1 Tsunami Warning Center products are understandable, effective, and actionable

The Tsunami Warning Centers issue tsunami warnings, advisories, and watches to alert populations along U.S. coastlines about potentially life-threatening and damaging tsunamis in coastal areas, including ports and harbors. The text products must be clear and concise, so government officials and the general public quickly understand the situation and respond effectively. The clarity of the alerting products is particularly important since they are issued so infrequently. Any accompanying graphical products, including those disseminated via the tsunami.gov website or through social media, should be straightforward and support the textual content.

There are ways the TWCs can enhance the tsunami bulletin products to meet the requirements of stakeholders making life-safety decisions based on the information available in the tsunami bulletins. Enhancing impact-based decision support services from NOAA and the TWCs to provide critical information to stakeholders based on their feedback is critical to effectively deliver a complete actionable message for local tsunami impacts. A few examples of ways the tsunami alert

bulletins could improve are to include information on the tsunami wave arrival and how that coincides with the tidal stage and possible storm surge, provide measured and forecasted current speed information (critical information for the maritime industry), as well as map products to depict forecasted inundation extent and flow depths based on the best available models.

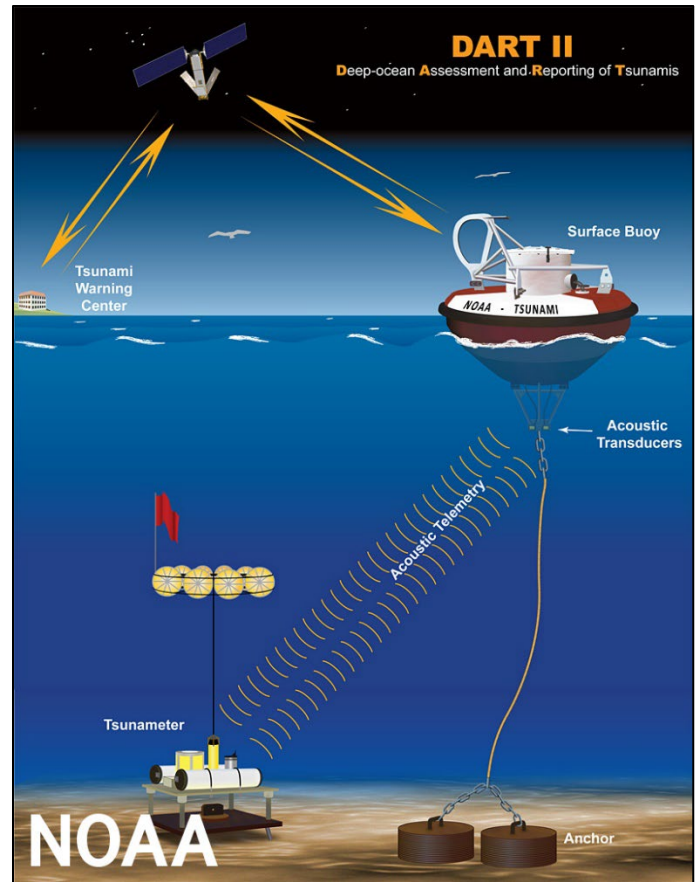
Much more frequently, the Tsunami Warning Centers issue Tsunami Information Statements for earthquakes near U.S. coastlines that may have been felt strongly but that do not present a tsunami threat. Tsunami Information Statements are also issued for large distant earthquakes that either do not present an immediate tsunami threat or any tsunami threat to the U.S. coastlines covered by the product. Because these products are issued much more frequently than warnings, advisories, or watches, aside from their content they provide a means for routinely maintaining an awareness with partners regarding potential tsunami threats and a means of regularly exercising the communication channels for the TWC tsunami products.



Scientists at the U.S. NOAA/NWS tsunami warning centers monitor for tsunamis and the earthquakes that cause them. This picture shows the Pacific Tsunami Warning Center Director demonstrating to military personnel procedures for responding to a tsunami. (U.S. Department of Defense)

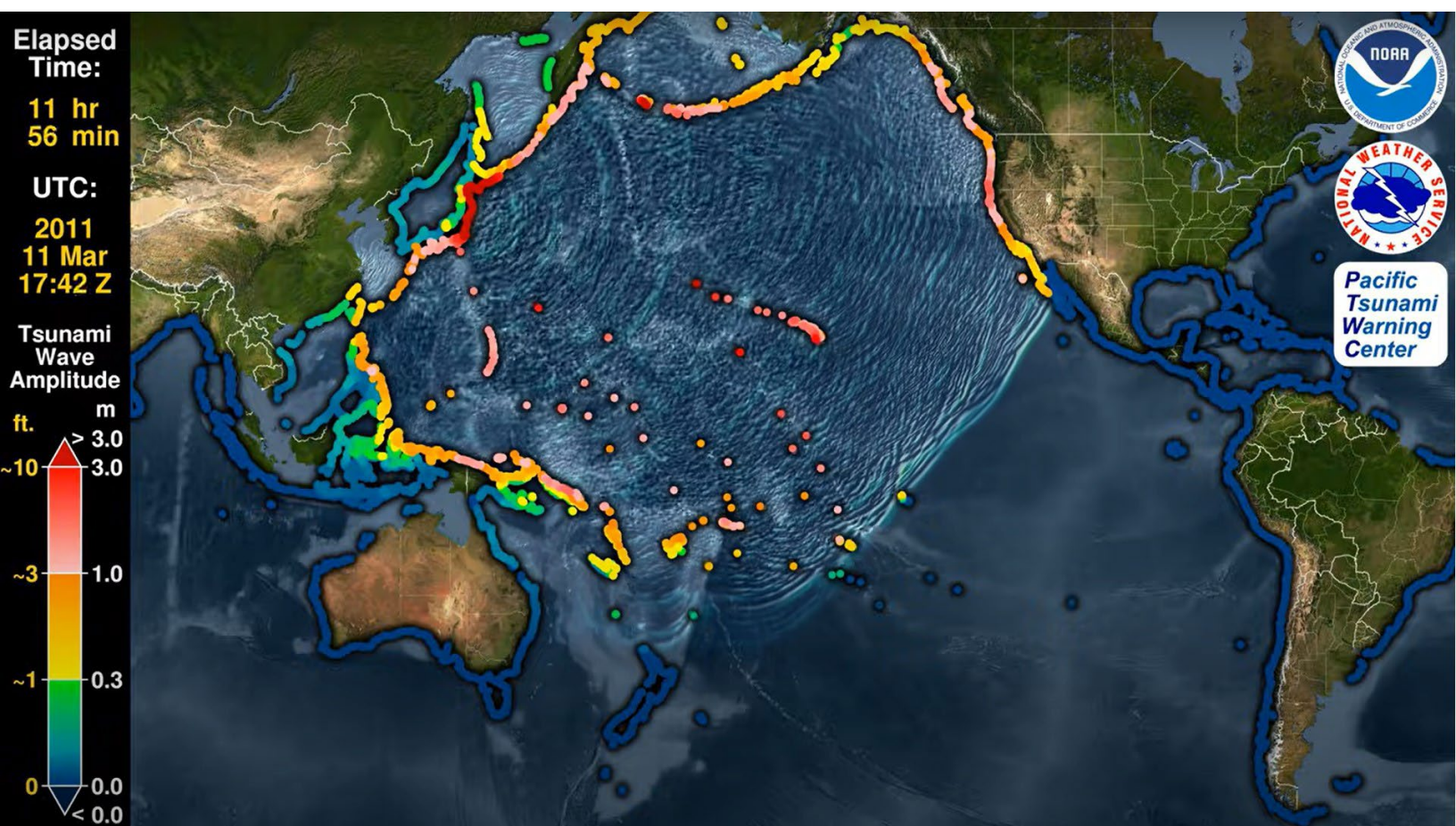
Strategy 4.1.1 Provide guidance to refine Tsunami Warning Center and related state-level products

Due to the wealth of detailed and graphical information generated by the most recent forecasting technologies, as well as the rapidly changing uncertainties associated with this information as an event plays out, NTHMP partners will work closely with the TWCs to decide what information to share with emergency managers and what information to share with the public. The TWCs in support of local National Weather Service Forecast Offices, other NOAA line offices, and NTHMP state partners will engage communities through workshops and training to support correct interpretation, communication, and testing of new graphical or other products that convey more detailed and timelier (e.g., first hour) information at the state and territorial level to better enable states to serve their communities.



Tsunami observation systems provide information on wave creation and propagation to the tsunami warning centers. (NOAA)

Example of a product created by the Pacific Tsunami Warning Center in Honolulu, Hawaii. This screen capture from an animation shows the maximum tsunami amplitude for certain areas across the Pacific Ocean based on a hypothetical tsunami. (NOAA)



Strategy 4.1.2 Provide stakeholder requirements to the Tsunami Warning Centers and NOAA Leadership through the WCS

For tsunami alerts to be effective the TWCs and NOAA need to better understand what different end users require. The NTHMP can facilitate the development of stakeholder requirements for effective alerting. There are limitations to the existing software and systems that the TWCs operate, and with clear guidance from the users on what information is necessary to make impact-based decisions, NOAA can then improve these systems and/or update them to adapt to the needs of the locals where the disaster is occurring. User requirements could include items such as: enhanced granularity to alert regions; statements of potential forecasts and impacts within the first hour(s); map products to support forecasted tsunami inundation areas; uncertainty with updates as the event progresses and certainty increases; forecasted wave arrival time, wave height, and forecasted inundation extent within 10 minutes of the onset of the event for each County, Borough, or Community. These requirements should address earthquake and non-earthquake tsunami sources such as landslides, volcanic events, and other tsunami generating phenomena.

The NTHMP can use this feedback to provide guidance on how to convey this critical alert information more clearly on tsunami.gov and via text alerts to make it easier to view and understand the overall threat while at the same time making it easier to find the products and information for areas of interest.

NTHMP recommends that NOAA fully understand all avenues for tsunami-related information throughout the event and service cycle to support a fully integrated and unified science, alert, education, risk, and mitigation message.

Example of a text-based, tsunami warning product from the NWS National Tsunami Warning Center.

```

WEPA41 PAAQ 110851
TSUWCA

BULLETIN
TSUNAMI MESSAGE NUMBER 4
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
1251 AM PST FRI MAR 11 2011

THE WARNING AND ADVISORY STATUS REGIONS HAVE CHANGED IN THIS
MESSAGE.

...THE TSUNAMI WARNING CONTINUES IN EFFECT FOR THE COASTAL AREAS
OF CALIFORNIA AND OREGON FROM POINT CONCEPCION CALIFORNIA TO THE
OREGON-WASHINGTON BORDER...

...THE TSUNAMI WARNING CONTINUES IN EFFECT FOR THE COASTAL AREAS
OF ALASKA FROM AMCHITKA PASS ALASKA/125 MILES W OF ADAK/ TO ATTU
ALASKA...

...THE TSUNAMI ADVISORY CONTINUES IN EFFECT FOR THE COASTAL AREAS
OF CALIFORNIA FROM THE CALIFORNIA-MEXICO BORDER TO POINT CONCEP-
TION CALIFORNIA...

...THE TSUNAMI ADVISORY CONTINUES IN EFFECT FOR THE COASTAL AREAS
OF WASHINGTON - BRITISH COLUMBIA AND ALASKA FROM THE ORE-
GON-WASHINGTON BORDER TO AMCHITKA PASS ALASKA/125 MILES W OF
ADAK/...

RECOMMENDED ACTIONS

A TSUNAMI HAS BEEN GENERATED WHICH IS EXPECTED TO CAUSE DAMAGE
TO THE WARNING AND/OR ADVISORY REGIONS LISTED IN THE HEADLINE.
PERSONS IN LOW-LYING COASTAL AREAS SHOULD BE ALERT TO INSTRUC-
TIONS FROM THEIR LOCAL EMERGENCY OFFICIALS. EVACUATIONS ARE ONLY
ORDERED BY EMERGENCY RESPONSE AGENCIES.

- PERSONS IN TSUNAMI WARNING COASTAL AREAS SHOULD MOVE INLAND TO
HIGHER GROUND.

- PERSONS IN TSUNAMI ADVISORY COASTAL AREAS SHOULD MOVE OUT OF
THE WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.

MEASUREMENTS OR REPORTS OF TSUNAMI ACTIVITY

LOCATION          LAT      LON      TIME      AMPL
-----
TOSASHIMIZU JAPAN 32.8N   132.9E  0747UTC   00.9FT/00.27M
TOKAI JAPAN      33.8N   137.6E  0645UTC   00.8FT/00.25M
OFUNATO JAPAN    39.0N   141.8E  0605UTC   10.8FT/03.29M
HANASAKI JAPAN   43.3N   145.6E  0643UTC   09.3FT/02.82M
BOSO JAPAN       34.8N   140.8E  0609UTC   02.6FT/00.78M

TIME - TIME OF MEASUREMENT
AMPL - TSUNAMI AMPLITUDES ARE MEASURED RELATIVE TO NORMAL SEA
LEVEL. IT IS ...NOT... CREST-TO-TROUGH WAVE HEIGHT. VALUES ARE GIVEN IN
BOTH METERS(M) AND FEET(FT).

DEEP OCEAN SENSORS INDICATE A LARGE TSUNAMI HAS BEEN GENERATED.

PRELIMINARY EARTHQUAKE PARAMETERS
MAGNITUDE - 8.9
TIME      - 2046 AKST MAR 10 2011
          - 2146 PST MAR 10 2011
          - 0546 UTC MAR 11 2011
LOCATION    - 38.3 NORTH 142.4 EAST
          - NEAR EAST COAST OF HONSHU JAPAN
DEPTH     - 12 MILES/20 KM

```

Strategy 4.1.3 Improve the availability of TWC products and alerts for underserved and vulnerable communities

There is a need for better understanding the alerting needs of underserved and vulnerable communities. The goal is to be able to provide these life-safety alerts equitably to all people. Some people cannot read alerts/tsunami bulletins (they could be blind, or speak a different language etc.), and some people do not have internet or cell service and must rely on NOAA weather radios (but may not be able to afford them or even know they exist), these are just a couple examples of how underserved populations do not have equal access to alert information. There are many accessibility issues surrounding people in tsunami hazard areas and there needs to be a more concerted effort to enhance the accuracy and availability of alert information. There are also additional funding needs for accessibility aids (strobes on sirens, NOAA weather radio attachments, translations, etc.), and secondary issues like internet availability, or lack of NOAA Weather Radio and/or cell service in remote areas. By understanding the gaps and requirements of all end users the NTHMP can help to ensure that the alert messaging is being provided equitably to all impacted people.

Strategy 4.1.4 Support the National Weather Service Hazard Simplification Project

The NWS is implementing the Hazard Simplification Project, which involves the removal of the term “Advisory” from all NWS alerts. If this decision is executed for tsunami alerts as well, it will have cascading impacts on the tsunami warning system, tsunami alert bulletins, and local reception (and understanding) of tsunami messages. If the tsunami advisory term is removed, the TWCs, NWS, and all NTHMP partner states and territories will need to assess their tsunami alerting systems, as well as the products and messaging that will need to be updated and socialized to ensure people know what actions to take with the new/replacement alert message. New alert products will then need to be produced,

tested, and exercised to familiarize the bulletins with the impacted parties, and public information campaigns conducted to educate the public about the changes.

The NTHMP supports NOAA’s effort to create clear and actionable tsunami alert messages that meet the needs of Federal, Military, State, and Local response partners. The NTHMP encourages NOAA and partners to use social, behavioral, and economic studies to further understand the impacts of significant messaging changes and alert levels before any changes are implemented. The NTHMP also encourages NOAA to fully describe to NTHMP any known impacts from significant messaging changes prior to implementation.



Example of a beach kiosk in Puerto Rico written in Spanish and English that describes tsunami alert levels from the National Weather Service. (Puerto Rico Tsunami Team)

Goal 4.2 Forecast dissemination is effective and reliable

One of the biggest challenges facing the U.S. Tsunami Warning System is the rapid and effective delivery of tsunami products (i.e., messages) to emergency managers and populations at risk. The TWCs deliver products via multiple and redundant NWS dissemination routes. These products provide guidance to state and local emergency managers to help them make decisions regarding evacuation. For proper operation of the U.S. Tsunami Warning System, emergency managers must reliably receive, be alerted to, and distribute these products and derived instructional information to those at risk. As a key partner in the U.S. Tsunami Warning System, the NTHMP will continue to work with the TWCs to support the effective dissemination of accurate and consistent information to its stakeholders.

Strategy 4.2.1: Coordinate periodic system-wide communication tests and encourage authorities to participate and provide feedback

The NTHMP supports periodic system-wide communication tests that vary in level and frequency and use communication channels appropriate to the test level. The NTHMP will encourage state partners to participate in these tests and make recommendations to the TWCs regarding updates to the warning notification process based on lessons learned and new dissemination procedures (e.g., broadcast text messages). These tests should include both TWCs and their core partners as well as exercises where backup of the TWCs are tested. These tests should require core partners to respond to acknowledge receipt of the test message so that TWCs ensure the tests are being received by the local decision makers.

Periodic system-wide communication tests ensure that the NWS tsunami warning centers and its partners will be able to warn people of imminent tsunami waves.

Strategy 4.2.2: Dedicate outreach and exercise efforts for underrepresented communities and entities who are critical to tsunami alerting and response

Many of the partners who locals will rely on during a tsunami event have not been fully engaged in past tsunami exercises and discussions. A dedicated outreach effort to core federal partners such as: the U.S. Coast Guard, the Army Corps of Engineers, the U.S. Navy, FEMA, and USGS to learn more about their tsunami response plans, alerting needs, and exercise capability would greatly improve working with these entities in a large tsunami event at both the federal and state level. At a more local level, understanding which communities and populations are likely to be the most impacted by tsunami events (e.g., liveaboards in harbors), supporting efforts to connect with those groups, exercise with them and understand their alerting and response needs is critical to ensuring equitable response in a disaster.

Strategy 4.2.3: Improve local warning reception capabilities

Before communities can disseminate tsunami information to people at risk, they must be able to reliably receive tsunami information from the Tsunami Warning Centers and state operations centers, a foundational requirement for TsunamiReady® recognition. NTHMP partners will work with underserved at-risk communities to improve warning reception capabilities and ensure redundancy in warning reception methods.

TSUNAMI WARNING COMMUNICATIONS TEST

Del Norte, Humboldt, and Mendocino Counties

WHEN: Wednesday, March 29, 2023, between 11:00 a.m. and 12:00 Noon

WHERE: Del Norte, Humboldt, and Mendocino counties.

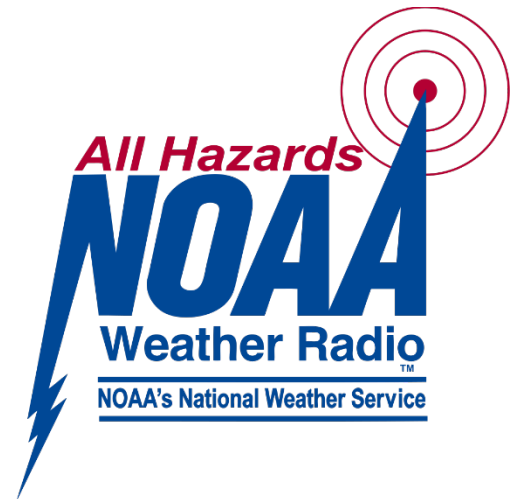
HOW: Interruptions of TV* and Radio Stations, and activation of NOAA Weather Radios and Outdoor Sirens.

**Not all Cable and Satellite TV Stations may be able to participate*

WHY: To test the Tsunami Warning System to ensure it works properly during a real tsunami emergency.

Strategy 4.2.4: Improve local warning dissemination capabilities

People cannot respond to a tsunami if they are not aware it exists. NTHMP partners will work with underserved at-risk communities to improve warning dissemination capabilities and ensure redundancy in warning dissemination methods. These methods include platforms such as: tsunami sirens, NOAA weather radio receivers, social media, wireless emergency alerting, and third-party opt-in alert dissemination applications. These improvements may include creating multiple methods for emergency communication and integrating forecast information into local response planning. Dissemination at the local level is also a foundational requirement for TsunamiReady® recognition. Barriers to receiving warnings, such as language differences, disabilities, and remoteness, may exist in certain communities and should be addressed for warnings to be fully disseminated.



NOAA Weather Radio is an automated 24-hour network of VHF FM weather radio stations in the United States that broadcast weather information directly from a nearby National Weather Service office. (NOAA)



Sirens can alert people of an imminent tsunami, providing they have been trained to understand and respond to an alert. Here is a siren being installed along the Washington coast. (WA Emergency Management Division)

Goal 4.3 Tsunami response is effective

The U.S. Tsunami Warning System is only effective if community-level response activities are successful. NTHMP partners will continue to work closely with communities to help ensure effective tsunami response. NTHMP patterns should work with the TWCs to understand their seismic and non-seismic tsunami sources and develop strategies to monitor, detect, alert, and respond to tsunamigenic events. NTHMP partners should also continue to educate the public to not wait for an official notification if they feel or observe the natural warning signs of a tsunami, such as intense ground shaking or the water rapidly receding along the coast.

Strategy 4.3.1: Support and provide tools to enhance community-level response planning

To help ensure effective tsunami response, NTHMP partners will continue to support and provide tools to enhance community-level response planning. This will include response playbooks, tsunami observer programs, training, exercises, and plan review for communities and harbors and will consider specific improvements to real-time response activities. Since a local tsunami may arrive before an official warning, this support will emphasize including public education about self-evacuation based on natural tsunami warning signs in emergency response planning.



Simple outreach products help people understand what to do if they are in tsunami-hazard zone. (Southern California Earthquake Center).

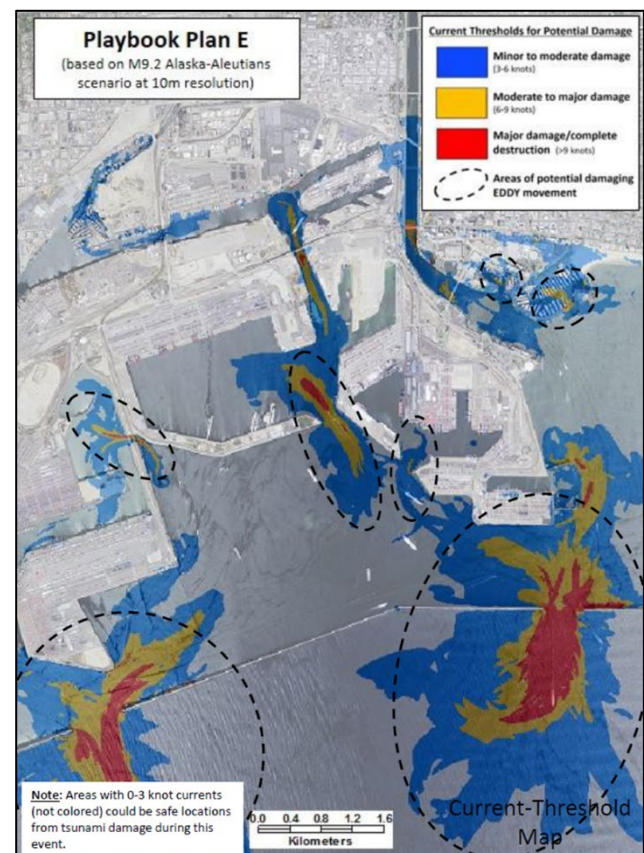
Response Tsunami Playbooks like this map developed for the maritime community in Long Beach, California, help local officials make decisions when distant-source tsunamis occur. (California Geological Survey)

Strategy 4.3.2: Align NTHMP partner alerting and response

As tsunami forecast dissemination is refined, it provides opportunities for additional refinement in alerting and response. Where applicable and beneficial, NTHMP partners should seek to align tsunami alerting and response across jurisdictions and include historically marginalized and tsunami vulnerable populations into response planning (especially for evacuation, guidance, and best practices). This ensures tsunami alerting and response is as accurate, timely, reliable, effective, and equitable across the nation as possible.

Strategy 4.3.3: Collaborate with USGS on testing and consistent messaging of ShakeAlert earthquake messaging and tsunami alerting

The NTHMP encourages NOAA and NTHMP partners to collaborate with other public and partner safety messaging agencies developing mass notification services that could impact a tsunami message's delivery, interpretation, and appropriate public and partner action.

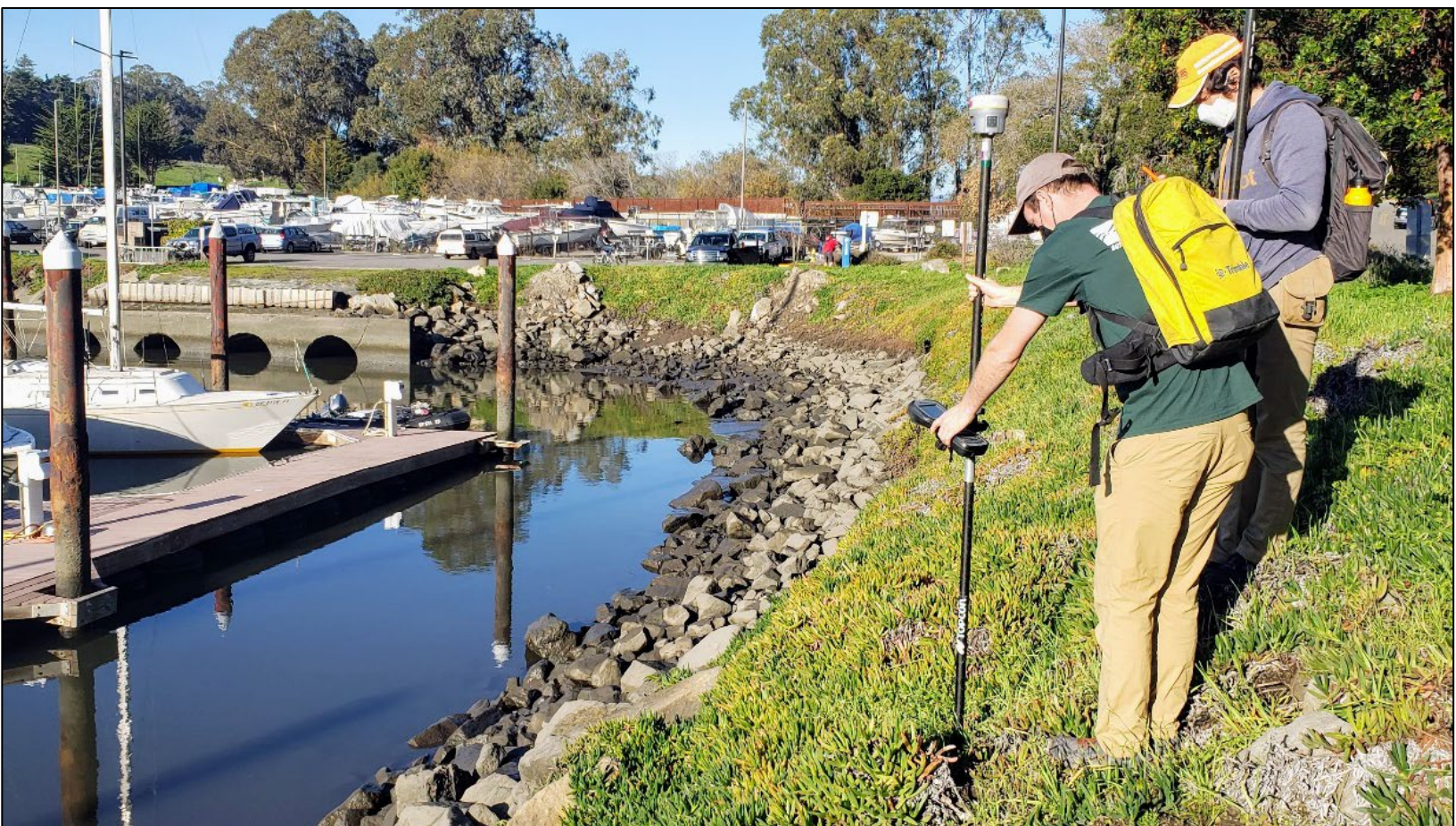


Goal 4.4 Field data collection and communication efforts are coordinated after a tsunami

Post-tsunami field surveys represent a unique learning opportunity for tsunami modelers, social scientists, and emergency managers to gain access to information to validate models and assess the response to an event. Due to the rapid mobilization (after emergency rescue efforts are completed) and response required of field teams during and after an event, and since field surveys may involve several teams working in the same geographical area, coordination is paramount to maximize distribution of resources across the disaster area and to avoid duplication of effort. Coordination can also support consistency of terms and measurements used by different field teams.

Post-tsunami field surveys are also critical for assessing the accuracy of TWC forecast models. Without such surveys, the only ground truth is from sparsely spaced coastal sea level gauges and there is no ground truth for inundation forecasts.

During the post-event process, NTHMP encourages continuous communication with TWCs to support public messaging of resultant tsunami impacts and understanding following an event. This effort completes the communication event cycle for the public and partners to fully understand an impactful tsunami event and be more prepared for the next one.



Post-tsunami field surveys are critical for improving our mapping tsunami hazard zones and for assessing the accuracy of forecast models from NWS tsunami warning centers. Here is a field team comprised of U.S. Geological Survey and California Geological Survey personnel surveying the maximum inundation in Santa Cruz Harbor from a distant tsunami in 2022. (California Geological Survey)

Strategy 4.4.1: Support and implement post-tsunami event protocol for U.S. states and territories

Effective and efficient post-tsunami field surveys require the coordination and collaboration of multiple partners—both governmental and nongovernmental—working in a disaster zone. The ultimate goal of field surveys is the collection of ephemeral data that may be of immediate use to response and recovery personnel, as well as share new findings and lessons learned to better understand, prepare for, and mitigate tsunamis elsewhere in the US. Given the importance of this data, the NTHMP will work with its stakeholders to develop guidance and plans to initiate post-tsunami field team protocols for implementation through NTHMP state, territorial, and Tribal partners. In some cases, communities may be isolated after a local earthquake and tsunami; therefore, NTHMP efforts will also include a local training program that encourages the establishment of community-based field teams. NTHMP plans will include pre-event efforts to effectively coordinate the collection of post-tsunami data and to make the data available to federal, state, local, territorial, and Tribal agencies and organizations. National NTHMP efforts will provide guidance for specific plans developed by individual agencies, states, Tribal entities, and territories.

Strategy 4.4.2: Exercise field data collection efforts locally, regionally, and nationally

Field data collection is an important part of understanding the tsunami and the impacts to both the natural and built environment. These data collection techniques include tide-gauge marigrams, security camera footage, post-tsunami questionnaires, and field teams that are real-time observers and post-tsunami data collectors. To successfully implement local, regional and national post-event data collection these efforts need to be exercised at all levels on a regular basis. Practicing

data collection, coordination, and communication now, before the next event impacting a city, county, state, territory, or the entire western U.S. coastline (as an example), is critical for effective post-event response during the next event. NTHMP partners should develop and/or familiarize themselves with local, national, and international protocols for post-tsunami data collection, and work with their NTHMP partners and colleagues to exercise data collection every year, or as frequently as they are able, ideally no less than every five years.



A U.S. Geological Survey researcher documenting the maximum inundation in Santa Cruz Harbor from a distant tsunami in 2022. (California Geological Survey)

Implementation and Execution

To achieve the goals and strategies proposed by this strategic plan, all NTHMP partners and stakeholders should understand how, and strive to ensure, their actions support it. The NTHMP Coordinating Committee will be responsible for implementing this plan.

Each subcommittee will use this overarching strategic plan to set its own goals for one- to five-year implementation plans. They will use these plans to guide and track their activities and will provide annual status reports to the Coordinating Committee. Subcommittees will update plans annually based on capabilities and funding.

The NTHMP will support the implementation of this strategic plan through NOAA/NWS grant-funded activities that help advance the plan's goals and

strategies. With funds from NOAA/NWS and others, NTHMP state partners will lead the effort to implement the plan within their jurisdictions.

Reviews of the NTHMP, when conducted, will provide data to evaluate progress in achieving strategic and programmatic outcomes and to seek more effective ways to accomplish the NTHMP mission. A program review should consider awareness, preparedness, and mitigation involving measurable changes at the community level. It should also consider challenges, risks, external factors, and other events that may affect outcomes. Tsunamis, changes in legislation, and other budgetary factors, for example, may require periodic refinement of the NTHMP's strategic direction. A review of the NTHMP should be conducted every five years to inform strategic planning.

The NTHMP includes representatives from NOAA, FEMA, the USGS, and 28 U.S. coastal states and territories. This group picture of attendees at the 2023 NTHMP meeting held in Portland, Oregon, shows many of the people who will work together in the coming years to implement strategic actions summarized in this plan.



Appendix A: NTHMP Strategic Plan Work Group

The former NTHMP chair, **Dr. Grant Cooper**, appointed the following people to write the 2024-2029 NTHMP strategic plan:

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The work group and production of this strategic plan was facilitated by **Ian Sears**, former NTHMP administrator, National Weather Service Tsunami Services Program, Silver Spring, Maryland.

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