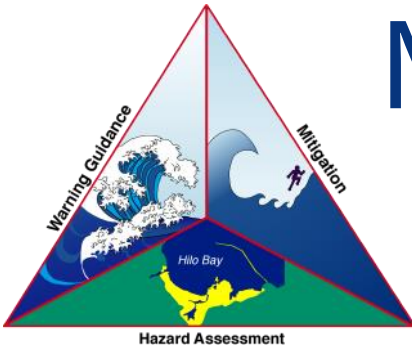


National Tsunami Hazard Mitigation Program Strategic Plan

2018-2023



February 20, 2018

MESSAGE FROM THE CHAIR

It is my pleasure to share with you the National Tsunami Hazard Mitigation Program's (NTHMP) 2018–2023 strategic plan.

Tasked with improving tsunami readiness, 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 partners. As highlighted in the 2017 NTHMP external program review (Goltz et al. 2017), this collaboration enhances cost effectiveness and improves the program's ability to implement consistent national policies and projects at the local level.

The NTHMP has four overarching strategic themes for 2018–2023:

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

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 and recommendations from the NTHMP external program review. Additionally, this plan underscores the importance of social science to improve products and services to benefit at-risk communities.

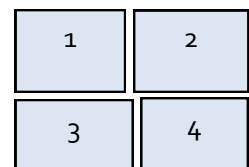
I would like to acknowledge the contributions of the NTHMP Strategic Plan Work Group (Appendix A) in developing this document and to express my appreciation to the NTHMP administrator for coordinating the work group's efforts and ensuring all partners had a voice in the process.

Grant Cooper, PhD
Chair, National Tsunami Hazard Mitigation Program
Western Region Director, NOAA/National Weather Service



Cover Captions:

1. Stakeholder engagement in Oregon's map development and use improves quality and effectiveness of maps.
2. Schools in California conduct tsunami walks to practice evacuation routes.
3. Guam conducts public outreach at malls during National Preparedness Month.
4. Tsunami signage and sirens at Washington's Fort Worden State Park provide valuable public safety information.



EXECUTIVE SUMMARY

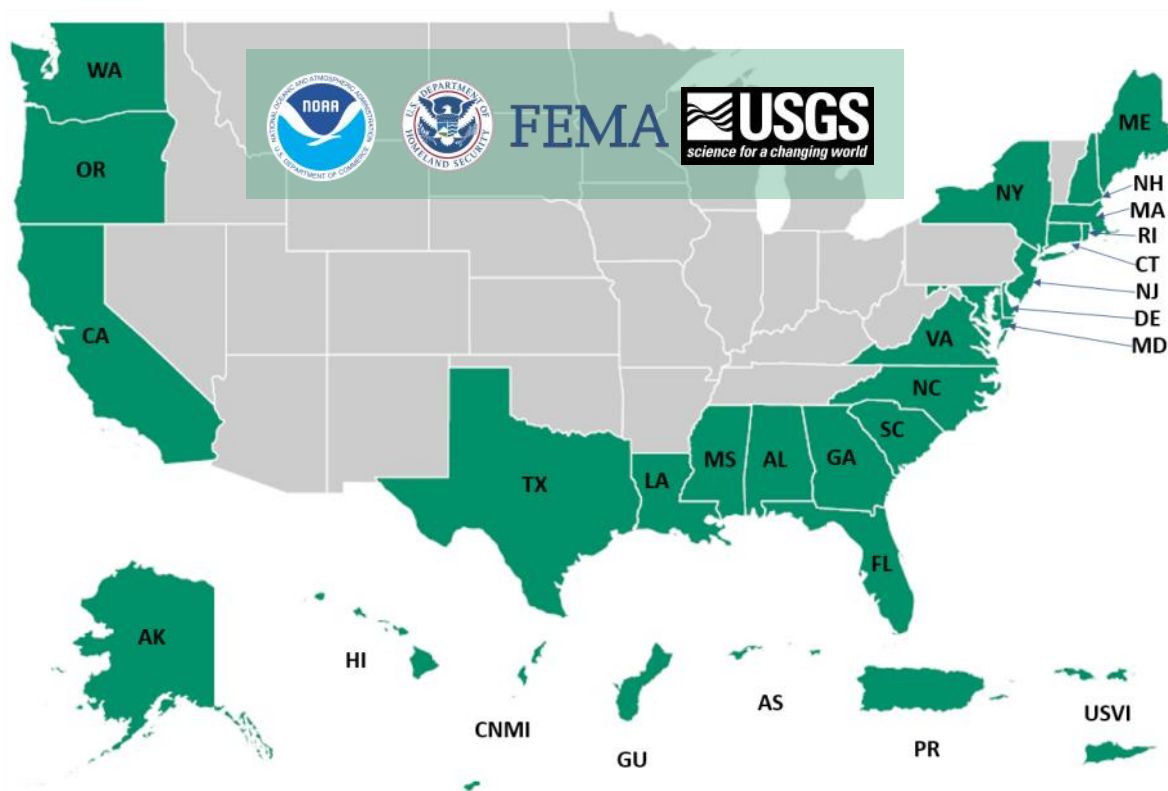
The success of the National Tsunami Hazard Mitigation Program is built upon the model of scientists and practitioners working collaboratively on behalf of states, territories, and stakeholders. The program's 2018-2023 strategic plan advances its mission and vision through goals and strategies that strengthen tsunami preparedness, mitigation, mapping, modeling, and warning coordination.

Theme	Goals	Strategies
Hazard and Risk Assessment	Tsunami hazard assessments support decision-making	<ul style="list-style-type: none"> – Identify and address gaps in tsunami source characterization and modeling – Complete inundation and evacuation maps for all unmapped U.S. coastal communities – Identify and address tsunami hazard assessment and product requirements
	U.S. tsunami risk assessment methodologies are developed and properly applied	<ul style="list-style-type: none"> – Provide technical assistance for risk assessments – Develop and implement a strategy for using HAZUS and create product guidance
Tsunami Education and Preparedness	At-risk populations are informed and prepared to respond appropriately to tsunamis	<ul style="list-style-type: none"> – Engage public schools and institutions of higher learning in tsunami preparedness – Develop, update, and disseminate consistent outreach materials – Conduct training and outreach events and campaigns – Conduct social science evaluation of tsunami outreach and incorporate findings into outreach efforts
	New TsunamiReady® sites are established and existing sites maintained	<ul style="list-style-type: none"> – Recognize TsunamiReady Communities – Increase number of recognized TsunamiReady Tier 2 Communities – Increase number of designated TsunamiReady Supporters
	Exercises are effectively supported	<ul style="list-style-type: none"> – Conduct exercises that include tsunami scenarios
	Stakeholders are adequately engaged	<ul style="list-style-type: none"> – Engage stakeholders in tsunami preparedness and response
Mitigation and Recovery	Mitigation and recovery strategies are initiated and incorporated into long-term community planning	<ul style="list-style-type: none"> – Develop guidelines and model practices for mitigation and recovery for communities and critical infrastructure – Implement guidelines and model practices for mitigation and recovery
Alert, Warning, and Response	Tsunami Warning Center products are understandable, effective, and actionable	<ul style="list-style-type: none"> – Provide guidance to refine Tsunami Warning Center and related state products
	Forecast dissemination is effective and reliable	<ul style="list-style-type: none"> – Encourage authorities to receive and respond to Tsunami Warning Center products – Improve local warning point reception capabilities – Improve local warning dissemination capabilities
	Tsunami response is effective	<ul style="list-style-type: none"> – Support and provide tools to enhance community-level response planning
	Field data collection efforts are coordinated after a tsunami	<ul style="list-style-type: none"> – Support and implement post-tsunami event protocol for U.S. states and territories

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National Tsunami Hazard Mitigation Program Partners



INTRODUCTION

Since its inception, the National Tsunami Hazard Mitigation Program (NTHMP) has focused on helping U.S. coastal communities prepare for tsunamis. Tsunamis pose a major threat to coasts around the world. The impacts to people and property from the 2004 Indian Ocean tsunami (≈230,000 fatalities in 15 countries) and 2011 Japan tsunami (≈18,000 fatalities in Japan alone; costliest modern natural disaster at \$243 billion in 2017 dollars) emphasize the need to improve not only tsunami preparedness and response, but also tsunami mitigation and recovery planning efforts in U.S. states and territories.¹

According to recent research (Dunbar and Weaver 2015), a large U.S. tsunami could affect millions of people and cause billions of dollars in damage. Tsunamis cannot be prevented, but their impacts on life, property, and the economy can be greatly reduced.

Efforts to reduce such impacts are essential where large local tsunamis pose the greatest threat, but they are also important where damaging tsunamis may come from distant shores. For example, the U.S. Geological Survey studied the potential impacts to California from a large tsunami originating offshore Alaska. Their findings suggest that 80-90 percent of the damage and the costs to the state associated with years of recovery could be preventable with detailed



The 2004 Indian Ocean tsunami reinforced the importance of the work of the NTHMP and brought greater awareness to the threat posed to coastlines around the world. Source: U.S. Navy, Jon Gesch

NTHMP Mission and Vision

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

Vision: Reduced loss of life and property when a tsunami strikes any U.S. state or territory and resilient communities that are prepared for tsunami hazards

mitigation, response, and recovery planning efforts (Ross et al. 2013).

To address these needs, the NTHMP's 2018–2023 strategic plan acknowledges the important roles played by a variety of federal, state, and territory partners; builds on progress made in the past; and institutionalizes those efforts. Ultimately, the plan aims to enhance the Nation's efforts to become more resilient to tsunamis.

Foundation

Today's NTHMP includes the National Oceanic and Atmospheric Administration (NOAA), the Federal Emergency Management Agency (FEMA), the U.S. Geological Survey, and 28 U.S. coastal states and territories.² This strong and active partnership connects states and federal agencies to bring together the expertise and experiences necessary to reduce tsunami impacts by protecting lives and reducing economic losses at the community level.

¹ Statistics as reported in the Global Historical Tsunami Database as of January 26, 2018 (NCEI/WDS n.d.).

² Throughout this report, "states" refers to U.S. states and territories with ocean coastlines.

NTHMP activities affect, either directly or indirectly, everyone in the United States. Important stakeholders 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.

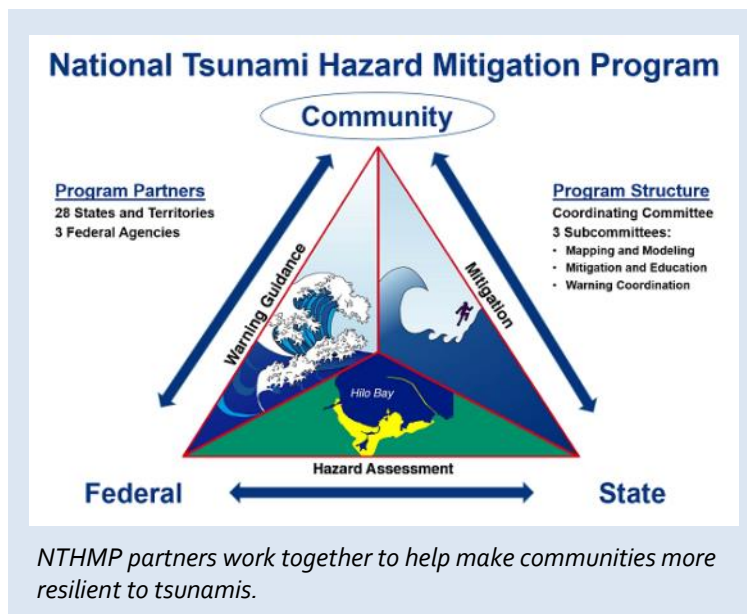
Policy Context

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 includes recommendations to 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 a 2017 external program review during plan



development. These recommendations include 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 low-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).

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 partners for projects that support the mission and vision of the NTHMP and its strategic plan. Project examples include developing guidelines for inundation maps, promoting community outreach and education

networks to improve community tsunami resilience, encouraging the adoption of tsunami warning and mitigation measures, conducting tsunami research, and providing tsunami public outreach through websites.

Further information about the structure and organization of the NTHMP as well as the grants program can be found on the NTHMP website.³

STRATEGIC THEMES

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. In addition to the themes, there are cross-cutting

initiatives that the strategies rely on and use for the development of better products. These initiatives include developing and implementing a process for prioritizing research needs and applications to promote life safety through nationally consistent products. To improve consistency, the NTHMP will develop product guidelines and assess their application. The NTHMP will make every effort to incorporate social science research into product development to generate products that are easily understood and useable for all stakeholders.

The goals and strategies to meet the four themes are described herein.



In 1997, the NTHMP voted to adopt the tsunami evacuation signage developed by Oregon. Today, signs like those shown here on Tinian in the Northern Mariana Islands can be seen in the tsunami hazard zones of a number of NTHMP state partners.

³ See <http://nws.weather.gov/nthmp/>.

THEME 1: HAZARD AND RISK ASSESSMENT

The NTHMP supports development of accurate, consistent, and cost-effective tsunami hazard and risk assessments.

Effective tsunami hazard planning begins with scientifically based assessments of the hazard for at-risk communities. This includes using mapping tools and products to define where, for emergency preparedness and other uses, the tsunami hazard exists. NTHMP partners develop these tools and products to provide emergency managers with the information they need to create evacuation maps and plans.

Although substantial progress has been made in the development of mapping guidelines and products,⁴ more tsunami hazard and risk assessment work remains to be done. The NTHMP will assess/revise

and develop new and improved hazard and risk assessment activities and products based on lessons learned from recent tsunamis and expanded partner and stakeholder requirements. New activities and products are discussed in this theme and in Theme 3: Mitigation and Recovery and Theme 4: Alert, Warning, and Response.

Goal 1.1: Tsunami hazard assessments support decision-making

Hazard assessment entails all elements related to developing and producing tsunami map products. This includes tsunami source characterization; inundation modeling; consideration of all potential tsunami sources, including submarine mass failure (landslides) and meteotsunamis; and examination of tsunami currents and wave impacts.

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

The NTHMP evaluates tsunami hazard assessment tools 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:

- ◆ Complete a tsunami source database/catalog with consistent schema that includes all sources (seismic and nonseismic) used for tsunami modeling.
- ◆ Develop guidelines for consistent modeling and mapping of landslide-induced tsunamis and/or meteotsunamis.
- ◆ Determine how unique physical properties, including subtle terrain changes, variable tides, erosion/deposition of sediment, and debris movement, affect tsunami inundation modeling.



Tsunami evacuation maps in Puerto Rico are based on NTHMP modeling and mapping guidelines.

⁴ See past NTHMP annual reports and publications: <http://nws.weather.gov/nthmp/publications.html>.

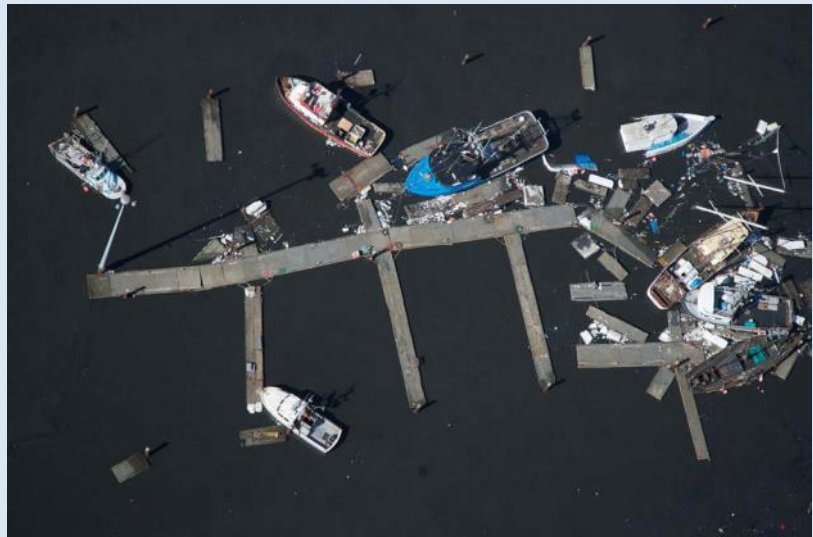
Strategy 1.1.2: Complete inundation and evacuation maps for all unmapped U.S. coastal communities

A fundamental purpose of the NTHMP is to enhance life safety during tsunamis. To achieve this purpose, NTHMP partners will strive to complete inundation and evacuation maps, which are vital for community response and planning, 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 for nonmapped coastal regions using established guidelines.
- ◆ Ensure all models and maps funded by NOAA/ NWS grants meet NTHMP guidelines except where they conflict with state/territory-mandated laws or policies.

Strategy 1.1.3: Identify and address tsunami hazard assessment and product requirements

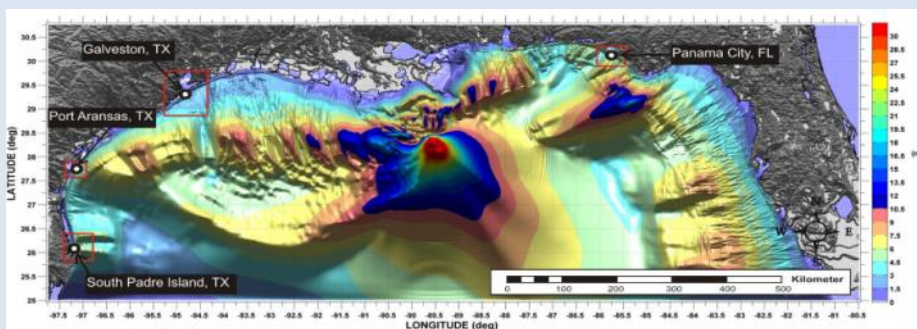
Tsunami hazard assessment and product requirements are important to coastal communities and other NTHMP stakeholders, like the maritime industry. Harbors damaged during recent tsunamis



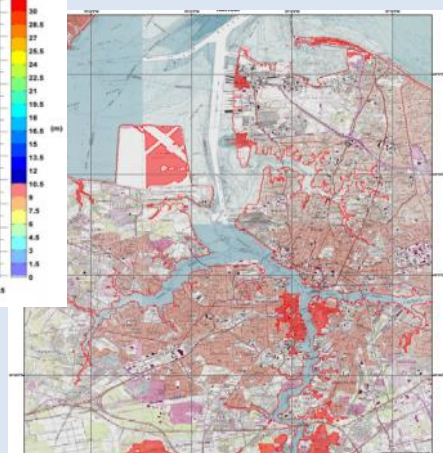
Dock and vessel damage in California harbors following the 2011 Japan tsunami approximated \$100 million statewide combining public and private losses (2017 dollars).

have demonstrated the need for maritime tsunami hazard assessments (Wilson et al. 2012). To help meet stakeholder requirements and improve tsunami resilience, the NTHMP will evaluate new hazard assessment tools and methodologies and develop guidelines for products for evacuation, maritime, land-use, and construction planning. This includes the following activities:

- ◆ Complete guidelines and products for community-level evacuation modeling and mapping in at-risk communities.
- ◆ Complete guidelines and develop products that address various elements of the maritime



Recognizing a tsunami threat also exists for U.S. Gulf and East Coasts, NTHMP partners continue to model and map tsunami inundation in these regions to better understand and depict the hazard. Shown here: Model output of maximum tsunami wave amplitude generated by a submarine landslide in the Gulf of Mexico (left) and a tsunami inundation map of Norfolk, Virginia, based on four modeled sources (right).



community (e.g., vessel size, hazard level, and harbor configuration).

- ◆ Develop guidelines for analysis of modeled tsunami currents/vorticity and forces on structures.

- ◆ Promote periodic review of hydrodynamic tsunami modeling through a process to update published model benchmarks.

Goal 1.2: U.S. tsunami risk assessment methodologies are developed and properly applied

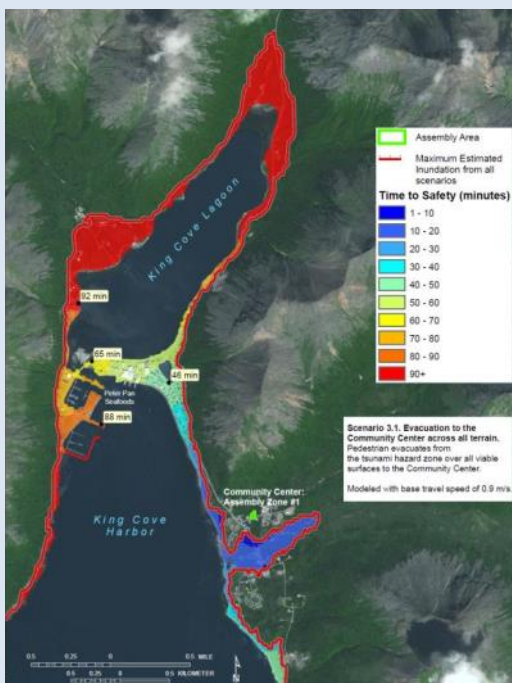
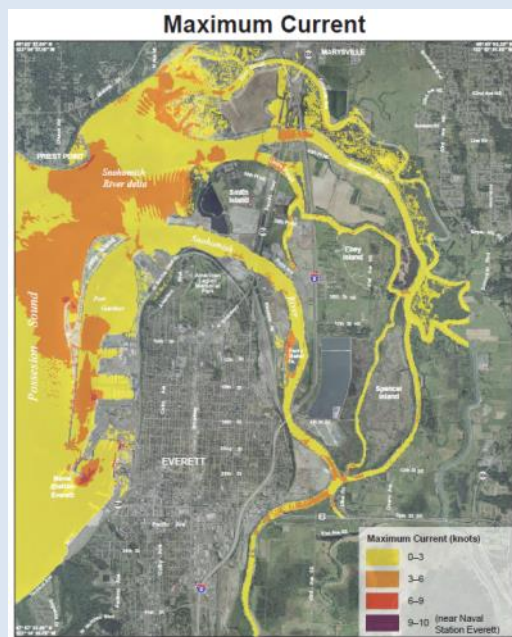
The NTHMP provides support to partners and stakeholders for the application of FEMA's HAZUS loss-estimation tool for tsunamis through technical assistance, model input data, and supporting documentation.

Strategy 1.2.1: Provide technical assistance for risk assessments

The tsunami module for FEMA's HAZUS loss-estimation tool may require technical assistance. The NTHMP and its partners will help communities by providing model input data and validation and interpretation of results.

Strategy 1.2.2: Develop and implement a strategy for using HAZUS and create product guidance

The tsunami module for FEMA's HAZUS includes module documentation and guidance for its use. The NTHMP will review these documents, determine their completeness, and develop supporting documentation for gaps, as needed.



Map products based on recent advancements in modeling can improve public safety. Shown here: Damaging current potential around Everett, Washington (top), and pedestrian travel-time to safety for King Cove, Alaska (bottom).



Launched by FEMA in spring 2017, the HAZUS tsunami module is being used by NTHMP partners to better understand how tsunamis may affect their communities.

THEME 2: TSUNAMI EDUCATION AND PREPAREDNESS

Education and preparedness refer to activities that help coastal communities, residents, and visitors understand their risk and the actions they can take to protect lives and property 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 during a tsunami.

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 schools and institutions of higher learning in tsunami preparedness

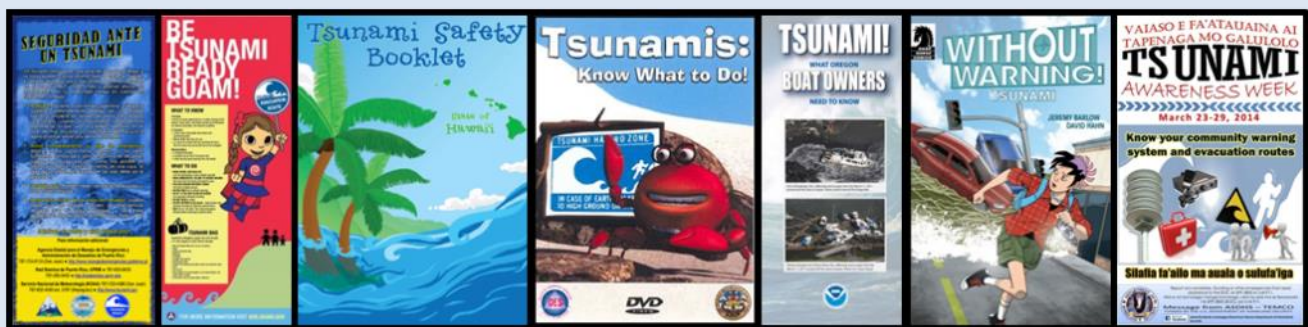
The NTHMP will continue to support development and dissemination of tsunami education and preparedness materials and activities geared for K-12 and higher education in tsunami-prone areas. Leveraging existing curricula such as the Alaska Tsunami Education Program, Washington State's Earthquake and Tsunami Education Program, and the Puerto Rico K-12 Curriculum will save development costs.

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, and enhanced public safety recommendations into new and updated outreach materials. They will strive for consistency of content while customizing their materials to reflect local practices, policies, culture, and language.

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 and first responders through FEMA-certified and other relevant tsunami courses.



NTHMP tsunami outreach products come in a multitude of formats and target a variety of audiences.



Local festivals like Cordova, Alaska's annual Salmon Jam are good public outreach opportunities.

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

NTHMP partners will 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.

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

TsunamiReady is a voluntary community recognition program of the NWS that promotes tsunami preparedness as an active collaboration among federal, state, 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.

Strategy 2.2.1 Recognize TsunamiReady Communities

The TsunamiReady program developed guidelines for recognition in cooperation with the NTHMP. 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.

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 recovery and debris management plans. NTHMP partners will promote Tier 2 recognition and help communities improve their tsunami resilience.

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



Aligned with the NWS TsunamiReady program, the Hawaii Hazards Awareness and Resilience Program (HHARP) is a multihazard program that helps communities build resilience to hazard impacts. Shown here, the HHARP Resource Kit and a TsunamiReady sign (inset).

TsunamiReady Supporter component of the TsunamiReady program, smaller communities and private sector entities can also be commended for their preparedness efforts.

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.

Goal 2.3: Exercises are effectively supported

Exercises enhance the efficiency and effectiveness of tsunami disaster management during a real event.

Strategy 2.3.1: Conduct exercises that include tsunami scenarios

Through 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 multihazard exercises. To support exercises, the Tsunami Warning Centers and state partners can prepare scenarios with associated timelines and messages and test communication systems.



As part of Tsunami Preparedness Week and the Caribe Wave tsunami exercise, schools in the U.S. Virgin Islands conduct tsunami evacuation drills.



In 2017, the first Oregon Tsunami Conference brought together stakeholders from government, academia, the private sector, and the volunteer emergency response community to discuss local tsunami science and preparedness best practices from a wide range of fields.

Exercises are an opportunity to enhance collaboration among federal, state, local, and nongovernmental organizations and leverage resources. They may also include community evacuation drills and be used to educate the public.

Goal 2.4: Stakeholders are adequately engaged

Engagement of stakeholders at all levels is a critical element of tsunami education and preparedness.

Strategy 2.4.1: Engage stakeholders in tsunami preparedness and response

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.

THEME 3: MITIGATION AND RECOVERY

The NTHMP envisions tsunami-resilient communities achieved through sound mitigation and recovery products and practices. Comprehensive tsunami mitigation and recovery planning is becoming a new focus for the NTHMP. A number of NTHMP partners and stakeholders are already engaged in mitigation- and recovery-related initiatives.⁵

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).⁶ The findings of another study conducted following two major earthquakes suggested that predisaster 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 aforementioned U.S. Geological Survey study also demonstrated the importance of resilience strategies, which include addressing tsunamis in all types of planning, mitigation and predisaster 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).

Goal 3.1: Mitigation and recovery strategies are initiated and incorporated into long-term community planning

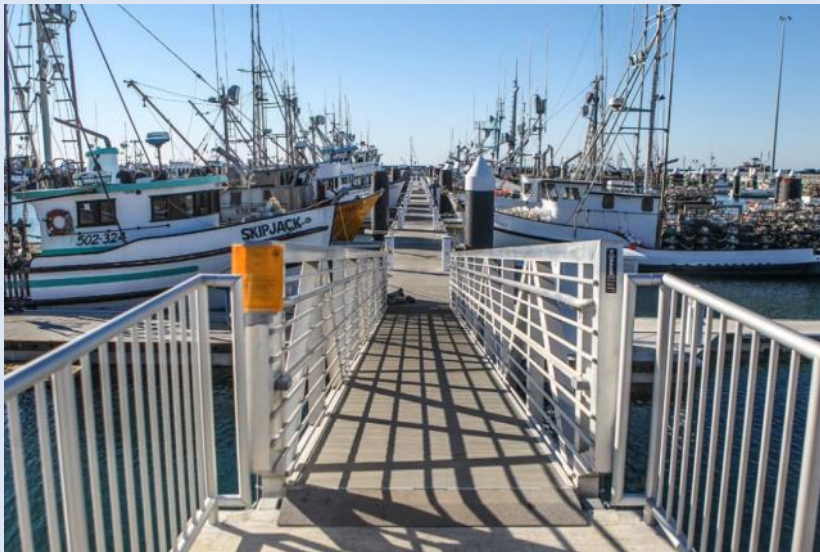
Mitigation and recovery are important phases of the emergency management cycle. Both require a long-



As a result of the NTHMP-supported Project Safe Haven, the Ocosta Elementary School in Westport, Washington, was the first tsunami vertical evacuation structure in the United States when it opened in 2016. Source: Pete Eckert, Eckert & Eckert Photography

⁵ See past NTHMP annual reports and publications: <http://nws.weather.gov/nthmp/publications.html>.

⁶ This study was based on 23 years of federally funded mitigation grants provided by FEMA, the U.S. Economic Development Administration, and the U.S. Department of Housing and Urban Development.



Following the 2011 Japan tsunami, California's Crescent City Harbor was rebuilt to be "tsunami resistant" with mitigation funding from federal, state, and local sources.

mitigation and recovery and incorporate them into future actions. This may include developing NTHMP guidelines and model practices for mitigation and recovery. Developing these guidelines and practices and implementing them would require engagement of stakeholders at all levels of government and private industry.

Strategy 3.1.2: Implement guidelines and model practices for mitigation and recovery

The NTHMP may develop an implementation plan involving stakeholders to determine the most

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).

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

The NTHMP may encourage states to identify mitigation and recovery needs through stakeholder engagement. This input will be used in the NTHMP's consideration of methods to address tsunami

effective way to implement mitigation and recovery guidelines and model practices at a local level. 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.



The TsuInfo Alert newsletter (left) and the TsunamiZone.org website (right) are NTHMP-supported resources that further the sharing of tsunami news, best practices, and awareness and preparedness activities.



THEME 4: ALERT, WARNING, AND RESPONSE

All NTHMP partners and stakeholders—federal, state, tribal, and local—share the same interests in and commitment to accurate and timely alert, warning, and response when a tsunami occurs. 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 domestic messages and helps assure 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 communication between NTHMP state partners and the Tsunami Warning Centers regarding the effectiveness of notification protocols and continual improvement efforts.

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. These products must be clear and concise so government officials and the general public know how to respond. The clarity of these text products is particularly important since they are issued so infrequently. Accompanying graphical products should be straightforward and support the textual content.



The website Tsunami.gov is one of a number of dissemination routes used by the Tsunami Warning Centers during tsunamis.

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

Due to the wealth of graphical information generated by the most recent forecasting technologies, NTHMP partners will work closely with the Tsunami Warning Centers to decide what information to share with emergency managers and what information to share with the general public. The Tsunami Warning Centers, other NOAA offices, and NTHMP state partners will engage product-recipient communities through workshops and training to support correct interpretation, communication, and testing of new graphical products.

Goal 4.2: Forecast dissemination is effective and reliable

One of the biggest challenges facing the U.S. Tsunami Warning System is the delivery of tsunami products (i.e., messages) to emergency managers and populations at risk. The Tsunami Warning Centers 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 and distribute these products to those at risk. As a key partner in the U.S. Tsunami Warning System, the NTHMP will continue to work with the Tsunami Warning Centers to support the provision of accurate and consistent information to its stakeholders.

Strategy 4.2.1: Encourage authorities to receive and respond to Tsunami Warning Center products

The NTHMP will coordinate 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 Tsunami Warning Centers regarding updates to the warning notification process based on lessons learned and new dissemination procedures (e.g., broadcast text messages).

Strategy 4.2.2: Improve local warning point 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 at-risk communities to improve warning reception capabilities.

Strategy 4.2.3: Improve local warning dissemination capabilities

People cannot respond to a tsunami if they are not aware it exists. NTHMP partners will work with at-risk communities to improve dissemination capabilities. These improvements may include creating multiple methods for emergency communication and integrating forecast information into local response planning. Dissemination is also a foundational requirement for TsunamiReady recognition.

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.

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 training, exercises, and plan review for communities and harbors and will consider specific improvements to real-time response activities. Since a



Sirens play an important role in warning dissemination for some NTHMP partners like Washington (above), the U.S. Virgin Islands (top inset), and American Samoa (bottom inset).

local tsunami may arrive before an official warning, this support will emphasize including public education about self-evacuation based on *natural* tsunami warnings in emergency response planning.

Goal 4.4: Field data collection 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 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.

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 personnel and will contribute to efforts to better understand, prepare for, and mitigate tsunamis. Given the importance of this data, the NTHMP will work with its stakeholders to develop plans to initiate post-tsunami field team protocols for implementation through NTHMP state partners.

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.

APPENDIX A:2018-2023 NTHMP STRATEGIC PLAN WORK GROUP

The NTHMP chair, **Dr. Grant Cooper**, appointed the following people to write the 2018-2023 NTHMP strategic plan:

Mr. Mike Angove, National Weather Service Tsunami Services Program, Silver Spring, Maryland

Dr. Diego Arcas, NOAA Pacific Marine Environmental Lab, Seattle, Washington

Ms. Tamra Biasco, Federal Emergency Management Agency Region X, Lynnwood, Washington

Ms. Corina Forson, Washington Department of Natural Resources, Olympia, Washington

Dr. Juan Horrillo, Texas A&M University at Galveston, Galveston, Texas

Mr. Kevin Miller, California Governor's Office of Emergency Services, San Francisco, California

Mr. Kevin Richards, Hawaii Emergency Management Agency, Honolulu, Hawaii

Dr. Althea Rizzo, Oregon Office of Emergency Management, Salem, Oregon

Ms. Christa von Hillebrandt-Andrade, National Weather Service Caribbean Tsunami Warning Program, Mayagüez, Puerto Rico

Mr. Rick Wilson, California Geological Survey, Sacramento, California

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

APPENDIX B: GLOSSARY

Evacuation map: A graphical representation of coastal areas that outlines the hazard zones and designates limits beyond which people must be evacuated to avoid harm from tsunami waves. Evacuation routes and assembly areas are generally designated to ensure efficient movement of people out of the evacuation area and to areas of safety. Tsunami evacuation maps should be based on tsunami inundation model outputs or the best available science (from NWS n.d.-e).

Forecast: A quantitative estimate of any property of the tsunami hazard that is made in advance. Properties that may be forecast include the time of initial wave arrival, the time of maximum wave arrival, the amplitude of the maximum tsunami waves, and the duration of the tsunami hazard (from IOC 2016).

Goal: A desired result or outcome of the NTHMP strategic plan. Goals are associated with overarching themes and are addressed through specific strategies.

Hazard assessment: An assessment of a community's tsunami hazards conducted to identify populations and assets at risk and the level of that risk. It requires knowledge of probable tsunami sources, the likelihood of occurrence, and the characteristics of tsunamis from those sources at different places along the coast. A complete tsunami hazard assessment depends on data related to relevant historical tsunamis and potential tsunami sources, bathymetric and near-shore topographic data, and development of tsunami inundation models, maps, and forecast tools (adapted from IOC 2016 and Dunbar and Weaver 2015).

HAZUS: A nationally applicable standardized methodology developed by FEMA that contains models for estimating potential losses from earthquakes, hurricanes floods, and tsunamis (adapted from FEMA n.d.).

Impacts: Loss of life, injuries, damage, and other losses associated with a tsunami. Impacts include both the physical damage to coastal property and infrastructure as well as the economic and societal damage inflicted on a community.

Infrastructure: The basic physical and organizational structures and facilities (e.g., buildings, roads, and power supplies) needed for the operation of a society or enterprise.

Inundation mapping: Cartographic (paper) maps, spatial imagery, interactive and static web-based maps, and other digital maps that delineate the landward extent of flooding from tsunami waves. The purpose of tsunami inundation mapping is to aid development of derivative tsunami hazard mitigation products, including evacuation maps, land-use planning maps, regulatory maps, probabilistic tsunami hazard maps, tsunami animations, and flow depth and velocity time series, among others (from MMS 2016b).

Inundation modeling: The numerical computer code(s) used to simulate tsunami generation at any number of sources, propagation across a body of water, and inundation of normally dry land (from MMS 2016a).

K-12 education: The U.S. publicly supported school system structured into grades prior to college from kindergarten (K) through 12th grade (12).

Mitigation: Action to reduce or eliminate the long-term risk to human life and property (adapted from MES 2009).

Outreach: A set of activities designed to bring tsunami information, education, and awareness to at-risk communities and populations as well as the efforts to engage these communities and populations in tsunami mitigation and preparedness activities.

Post-tsunami field survey: A reconnaissance survey of the effects of a tsunami on a coastal area in the hours or days following a tsunami to collect as much detailed data as possible before impact signs begin to disappear. Uses of the data collected include support for emergency response, hazard assessment, model validation, and other aspects of tsunami mitigation (adapted from IOC 2016).

Preparedness: Any action taken (including planning) to enhance response to a warning or threat (from MES 2009).

Recovery: The capabilities necessary to assist communities affected by an incident to recover effectively. 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 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 (adapted from FEMA 2016).

Resilience: The ability to prepare and plan for, absorb, recover from, or more successfully adapt to actual or potential adverse events (from NRC 2012).

Response: Emergency actions coordinated as needed among local, state, and federal government authorities based on hazardous conditions or forecast information of imminent tsunami impact and after a tsunami has occurred.

Risk: The potential for adverse effects from the occurrence of a particular hazardous event, which is derived from the combination of physical hazards, the exposure, and vulnerabilities (physical and social) (from NRC 2012).

Risk assessment: An evaluation of the potential impacts associated with a hazard. Risk assessment provides estimates of potential losses to lives and property (combining the physical characteristics of potential hazards with data on exposure, vulnerability, and mitigation measures) and some estimate of annual likelihood of occurrence (adapted from NRC 2012).

Source: Point or area of tsunami origin, most commonly a large earthquake below or near the ocean floor. Landslides, volcanic activity, certain types of weather (which are responsible for meteotsunamis), and near-earth objects (e.g., asteroids, comets) (adapted from NWS n.d.-b).

Strategy: A plan or action designed to achieve a specific outcome or long-term goal of the NTHMP strategic plan.

Theme: A high-level topic within the NTHMP strategic.

Tsunami Advisory: The official product issued when a tsunami with the potential to generate strong currents or waves dangerous to those in or very near the water is imminent, expected, or occurring. The threat may continue for several hours after initial arrival, but significant inundation is not expected for areas under an advisory (from NWS n.d.-c).

Tsunami Warning: The official product issued when a tsunami with the potential to generate widespread inundation is imminent, expected, or occurring. Warnings alert the public that dangerous coastal flooding accompanied by powerful currents is possible and may continue for several hours after initial arrival. Warnings alert emergency management officials to take action for the entire tsunami hazard zone. Appropriate actions to be taken by local officials may include the evacuation of low-lying coastal areas, and the repositioning of ships to deep waters when there is time to safely do so. Warnings may be updated, adjusted geographically, downgraded, or canceled based on updated information and analysis. (from NWS n.d.-c).

Tsunami Watch: The official product issued when a tsunami may later impact the watch area. The watch may be upgraded to a warning or advisory or canceled based on updated information and analysis. Emergency management officials and the public should prepare to take action (from NWS n.d.-c).

TsunamiReady Community: An Indian tribal government, local government entity, or facility that has the authority and ability to adopt the TsunamiReady recognition guidelines within its jurisdiction and has been recognized as TsunamiReady by the NWS (adapted from NWS n.d.-e).

TsunamiReady program: The voluntary community recognition program of the NWS that promotes tsunami hazard preparedness as an active collaboration among federal, state/territory, 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 (from NWS n.d.-d).

TsunamiReady Supporter: An organization, business, facility, or local government entity that has authority to adopt the TsunamiReady recognition guidelines within its purview, actively promotes the principals of TsunamiReady, but does not have the ability to meet all of the recognition guidelines and has been designated as a supporter by the NWS (adapted from NWS n.d.-e).

TsunamiReady Tier 2: A level of the TsunamiReady program designed to help high-risk communities more completely prepare for and mitigate heightened tsunami risks and reach a higher level of disaster resilience (adapted from NWS 2015b).

U.S. Tsunami Warning System: An end-to-end system led by NOAA that operates in partnership with other federal, state, territorial, international, and local organizations as well as industry. Major components include: observation systems to rapidly detect tsunami generating earthquakes and tsunamis, models to forecast tsunami impacts, timely and accurate messaging, decision-support services during events to enhance community response, and preparedness and mitigation activities that enhance response to a tsunami threat and reduce or eliminate potential impacts.

Vertical evacuation: Evacuation of at-risk populations from potential inundation areas into buildings and structures specifically designed for or adapted to this purpose. Vertical evacuation may be the only way of evacuation in islands or peninsulas with no areas of high ground.

Vulnerability: The potential for harm to the community and relates to physical assets (building design and strength), social capital (community structure, trust, and family networks), and political access (ability to get government help and affect policies and decisions). Vulnerability also refers to how sensitive a population may be to a hazard or to disruptions caused by the hazard (from NRC 2012).

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