

Planning for Tsunami-Resilient Communities

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Abstract. The National Tsunami Hazard Mitigation Program (NTHMP) Steering Committee consists of representatives from the National Oceanic and Atmospheric Administration (NOAA), the Federal Emergency Management Agency (FEMA), the U.S. Geological Survey (USGS), and the states of Alaska, California, Hawaii, Oregon, and Washington. The program addresses three major components: hazard assessment, warning guidance, and mitigation. The first two components, hazard assessment and warning guidance, are led by physical scientists who, using research and modeling methods, develop products that allow communities to identify their tsunami hazard areas and receive more accurate and timely warning information. The third component, mitigation, is led by the emergency managers who use their experience and networks to translate science and technology into user-friendly planning and education products. Mitigation activities focus on assisting federal, state, and local officials who must plan for and respond to disasters, and for the public that is deeply affected by the impacts of both the disaster and the pre-event planning efforts. The division between the three components softened as NTHMP scientists and emergency managers worked together to develop the best possible products for the users given the best available science, technology, and planning methods using available funds.

Key words: tsunami mitigation, TsunamiReady, tsunami warning, tsunami evacuation, tsunami planning

Abbreviations: EOC – emergency operations center, FEMA – Federal Emergency Management Agency, NOAA – National Oceanic and Atmospheric Administration, NTHMP – National Tsunami Hazard Mitigation Program, NWS – National Weather Service, RCTWC – Redwood Coast Tsunami Work Group, SEMS – Standardized Emergency Management System, TRC – TsunamiReady Communities, USCG – U.S. Coast Guard, USGS – U.S. Geological Survey, WSLTWG – Washington State/Local Tsunami Work Group

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1. Background: Tsunami Planning Needs in 1994

In 1994, prior to the start of the NTHMP, the spectrum of tsunami planning activities in at-risk communities in the program states ranged from very little to quite extensive efforts. On 4 October 1994 a Mw 8.3 earthquake in the Kurile Islands triggered a tsunami warning that highlighted this diversity of planning. Often neighboring communities did not show consistent interpretations or responses to tsunami warning messages. In fact, local emergency managers exhibited a range of emotions including confusion, frustration, and anger in reaction to the 1994 event. State and federal emergency managers asked “Why the inconsistencies and turmoil?” and “What can be done to help communities?”

Local emergency managers from eleven communities in Northern California, Oregon, and Washington answered questions during a brief survey after the event (Jonientz-Trisler, 1994). The questions concerned perceived vulnerability and readiness levels, tsunami “safe” locations in the community, the existence of evacuation routes and plans, safe evacuation times, how well local emergency managers understood the 4 October tsunami warning message, and how they responded, including what methods they used to make decisions. Answers indicated that vulnerability and readiness levels varied, responses to the warning varied greatly, and that the warning information system needed improvement. The study recommended ways for federal and state agencies to assist communities to improve vulnerability and readiness levels. Recommendations suggested agencies should develop a regional strategy to provide more consistency in school tsunami plans and drills; make information more timely and usable; have scientists ask responders what kinds of information systems, formats, and tools they require for effective response; and have responders ask scientists what limits exist for information and tools that they base response decisions upon.

Shortly after the 1994 tsunami, NOAA hosted several state/federal agency meetings to develop a strategy to meet the needs of local communities (Tsunami Hazard Mitigation Federal/State Working Group, 1996). West Coast states focused on the need for an improved warning system that gave better and faster information, while Hawaii focused on the need to reduce “false alarms.” Meeting participants developed a strategy that includes the following goals: (1) raise awareness of affected populations, (2) supply tsunami evacuation maps, (3) improve tsunami warning systems, and (4) incorporate tsunami planning into state and federal all-hazards mitigation programs.

The National Tsunami Hazard Mitigation Program (NTHMP) was formed in 1996 to implement this strategy. The NTHMP wrote a plan for mitigation projects that would promote the development of “tsunami-resilient communities” (Dengler, 1998). The plan lists five goals that describe the nature of a tsunami-resilient community. Tsunami-resilient communities

should: (1) understand the nature of the tsunami hazard, (2) have the tools they need to mitigate the tsunami risk, (3) disseminate information about the tsunami hazard, (4) exchange information with other at-risk areas, and (5) institutionalize planning for a tsunami disaster.

2. Planning Activities that Met the 1994 Needs

A simple plan guided the early years (1996–2001): map the hazard and determine the potential risk level; then inform government officials, residents, and visitors about preparedness, response, and recovery tools such as evacuation brochures, media events, videos, signs, draft legislation, and regulations, and more recently coordination with the TsunamiReady Community Program. NTHMP uses a Tsunami-Resilient Communities Activities Matrix (Table I) to track progress on developing products to meet the goals of the mitigation projects plan. The matrix is broken into planning elements to implement the goals. The Education Planning Element implements both Goal 1 (understanding the nature of the hazard) and Goal 3 (disseminating information about the hazard). Both of the Planning Elements called Tools for Emergency Managers and Building and Land Use Guidance implement Goal 2 (having tools to mitigate the risk). The Information Exchange and Coordination Planning Element implements Goal 4 (exchanging information with other at-risk areas). And the Long-term Tsunami Mitigation Planning Element implements Goal 5 (institutionalize planning for a tsunami disaster). The program uses this information to measure accomplishments and refine goals for future years. The matrix is also a reference to identify existing products.

3. New Strengths Since 1994 and Future Areas of Activity

The first successful accomplishment was the installation of consistent tsunami evacuation signage. Alaska, California, and Washington agreed to adopt Oregon's evacuation sign design (Hawaii already had other signs installed). There is a strong theme of sharing within the NTHMP and time and money is saved by adapting products or pooling resources to develop community products. Other tsunami products, adopted by other states, include educational products such as videos, and information products for targeted audiences like tourists and local officials; tools for emergency managers such as inundation maps, evacuation route brochures, warning programs and guidance, needs assessments and surveys, and some guides for codes, construction, zoning, and land use; information exchange mechanisms like multi-jurisdiction and interdisciplinary workshops and tsunami advisors; and

long-term mitigation activities such as all-hazards planning and formal or informal state and local tsunami work groups. Most of these products did not exist in 1994 in the West Coast states. Hawaii and Alaska were an early source of tsunami knowledge for other states but all five states have greatly improved their stock of tsunami mitigation tools since NTHMP's inception. States preferred to develop in-house expertise to produce inundation maps. In order to address issues of consistency in map production the NOAA Tsunami Inundation Mapping Effort (TIME) Center provides scientific and

Table I. Mitigation Strategic Implementation Plan Accomplishments; Tsunami-Resilient Communities Activities Matrix (August 2003)

Planning elements	NTHMP accomplishments	Future directions
<i>Education element – Goal 1: “Understand the risk,” Goal 3: “Disseminate risk information”</i>		
Evacuation and Educational Signs	Alaska, California, and Washington adopted Oregon’s evacuation sign design. Hawaii had existing signs.	Continue to offer to communities and maintain
Media Materials	Hawaii, Washington report some available	Develop
Public Info Products	All five states have various public information products available	Integrate social science input for successful message to public
Public Service Announcements	Hawaii had existing PSAs, Washington reports some available	Develop with social science input for a successful message to public
Cost/Benefit of Tsunami Mitigation for Businesses	Hawaii is developing a product	Develop
State and Local Videos	All five states have or are developing a tsunami video using local info, including some Native American oral histories	Continue
Curriculum Materials	Hawaii, Washington, and Oregon report available school curriculum	Continue
Library-type Materials	Hawaii and Washington report available library-type materials	Continue
Training Materials	Hawaii and Washington report available training materials	Develop training materials when the need for it is identified

Table I. Continued

Planning elements	NTHMP accomplishments	Future directions
Tsunami Info for Tourists	All five states have tsunami info available for tourists at hotels, restaurants, on the beach, etc.	Integrate social science input for successful message to tourists
Tsunami Info for State and Local	All five states have tsunami info for state and local officials available	Maintain and update
Public Education	All five states have public education materials available	Integrate social science input
<i>Tools for emergency managers element – Goal 2: “Tools to mitigate the risk”</i>		
Inundation Maps	All five states have at least some maps, some have most communities mapped. Obstacles: lack of bathymetry and funds. States that had some inundation maps prior to NTHMP have refined earlier map products based on new technology and modeling methods.	Support bathymetry and funding efforts and partners. Continue to develop maps as bathymetry and funds allow.
Evacuation Routes	All five states have determined at least some evacuation routes with communities	Continue
Evacuation Brochures	Most states have assisted communities in developing evacuation brochures	Continue
Warning Programs	All five states have warning programs	Continue to improve where possible
Local Warning System Guidelines	Hawaii, Oregon, Washington report local warning system guidelines available	Continue development
Guides for Unmapped Communities	Hawaii, Washington report guides for unmapped communities available	Continue development
Community Needs Assessments	All five states have some level of community needs assessments beyond early NTHMP estimates of needs	Continue development with help of social scientists
Surveys	All five states have used tsunami surveys to guide and measure activities	Continue development with help of social scientists

Table I. Continued

Planning elements	NTHMP accomplishments	Future directions
<i>Building and land use guidance element – Goal 2: “Tools to mitigate the risk”</i>		
Codes and Construction Guides	California, Hawaii, Oregon report some available codes and construction guides, Washington reports in development	Continue development
Zoning Regs and Land Use Guides	California, Hawaii, Oregon, Washington report some available zoning regulations and/or land use guides	Continue development
Infrastructure Guides	Hawaii, Washington report some available infrastructure guides	Continue development
Vegetation Guides	Hawaii, Washington report some available vegetation guides	Continue development
Vertical Evac Guides	Hawaii, Washington report some available vertical evacuation guides	Continue development
<i>Information exchange and coordination element – Goal 4: “Exchange information with others”</i>		
Coast Jurisdiction Contact	All five states have contact with their coastal jurisdictions on tsunami planning issues	Continue
Meetings with different disciplines	All five states have fostered meetings between different disciplines that deal with tsunami issues	Continue
Resource Center to catalog products	Hawaii, Washington report available resource center to catalog products	Continue to add materials and to share products
Web Page Development	Hawaii, Oregon, Washington report available web site info and offer links to other tsunami web sites	Continue to update
Work with non-NTHMP States	NTHMP is working to exchange information and products with U.S. territories, the Caribbean, Japan, New Zealand through various members	Continue to support and exchange info with others

Table I. Continued

Planning elements	NTHMP accomplishments	Future directions
Tsunami Workshops	All five states have held some workshops focused on a variety of tsunami issues, some multi-state	Continue to explore issues in workshops
Tsunami Technical Advisor Access	All five states plan to use or have used a technical tsunami advisor before and during tsunami events. Hawaii and Alaska pre-existed.	Continue
<i>Long-term tsunami mitigation element – Goal 5: “Institutionalize tsunami planning”</i>		
State/Local Tsunami Work Groups	Most states have state/local tsunami workgroups bringing more than one county together to work issues. This helps reduce staff turnover effects.	Continue
State Tsunami Mitigation Planning	All five states must plan and assist local jurisdictions in planning for tsunami and other hazards	Continue
Incorporate Tsunami into All-Hazards Planning	All five states at risk to tsunami are incorporating it in their all-hazard mitigation plans through the DMA2000 requirements	Continue
Post-Tsunami Recovery Guide	Hawaii reports this in development. The Mitigation Subcommittee also has made this a priority national product to develop	Develop
Loss Estimation	Hawaii reports this in development. The Mitigation Subcommittee also has discussed this as a priority product	Develop
Local Gov’t Tsunami Planning Guides	California, Hawaii, Oregon, Washington reports this available or in development.	Develop
Tsunami Legislation	Hawaii, Oregon, Washington report some tsunami legislation available or in development	Develop

technical guidance and assistance to states and developed a preliminary set of best practices. There are plans to archive modeling and mapping products and to establish a formal program for systematic review and improvement of existing inundation and evacuation maps (González *et al.*, this issue).

The NTHMP also develops national level products that require more resources than any one state can afford, but apply to all states. Examples include consistent initial public information products, a guidance document about planning and designing for tsunami hazards (National Tsunami Hazard Mitigation Program, 2001), a guidance document for the public about ways to survive a tsunami (Atwater *et al.*, 1999, 2001), a strategic implementation plan for the mitigation component of the NTHMP (Dengler, 1998), a mechanism for disseminating a broad range of tsunami information to local and congressional officials (National Tsunami Hazard Mitigation Program, 1999–2004), a report to Congress and others on the accomplishments of the Mitigation Subcommittee of the NTHMP (Jonientz-Trisler and Mullin, 1999), and a tsunami warning procedures guidance document (Oregon Emergency Management and Oregon Department of Geology and Mineral Industries, 2001). A project recently funded brings engineers from all five states together to address design of a structure that might withstand both severe ground-shaking and tsunami forces. Future projects under discussion now include a tsunami loss projection study for the five states. The NTHMP provides resources and works with local jurisdictions to develop the most effective products possible. One popular product was modified and translated for use by non-English speakers in this country and in South America (Cisternas and Martínez, translators, 2000). Each state has greatly benefited from the NTHMP accomplishments (see Appendix).

A selective list of some NTHMP mitigation products to promote tsunami-resilient communities include

- Signage
 - tsunami hazard zone signs
 - evacuation signs
 - educational signs
- Evacuation Brochures
 - for homes, visitor centers, and hotels
- Published guidance for
 - surviving a tsunami
 - planning and designing for tsunami hazards
 - warning systems procedures
- A newsletter to disseminate and exchange information on tsunami facts, products, activities, and history
- Public information and outreach products
 - tsunami bookmarks that tell what to do

- coffee mugs that show what to do
- trivia puzzles using tsunami facts and words
- family disaster cards, magnets, stickers, and tent cards
- tsunami place mats for restaurants
- coloring books
- ice scrapers
- School curriculum and booklets for children
- Videos

These products can be acquired through information provided on the NTHMP web site (www.pmel.noaa.gov/tsunami-hazard/).

4. Survey Tools Measure Accomplishments

A May 2001 survey was designed by Dr. Trish Bolton to measure the perceived level of readiness and understanding of tsunami risk by local emergency managers using different questions from the 1994 survey, because there had been no tsunami warning event for the West Coast since 1994. The Bolton survey also assessed the use and perception of NTHMP developed and distributed products supplied to local emergency managers. During the evaluation of the May 2001 survey results, a tsunamigenic earthquake near the coast of Peru triggered Pacific-wide watch/warning messages. This allowed the 1994 survey to be repeated in June 2001 (Jonniertz-Trisler, 2001). The results of the June 2001 survey were compared to those of the October 1994 survey, using the same questions to local emergency managers in much the same communities. Asked whether the tsunami information received during the watches/warnings provided a clear community risk and were timely, updated, understandable, usable, and whether the terminology was clear between “watch” and “warning,” local emergency managers responded positively only 36 to 45% of the time in 1994, but responded positively from 79 to 93% of the time in 2001 (Figure 1). Also, the results of the Bolton survey indirectly support many of the survey results from the June 2001 survey. In May most respondents claimed that tsunami readiness was much better. When asked to rate six factors as reasons for this, respondents chose better plans and coordination, better information and public education “What to do” as the top three reasons for the improvement (Table II).

In 2003 following a tsunamigenic earthquake in Japan, a tsunami watch/warning message for Alaska was broadcast providing another opportunity to measure local responder satisfaction level with the warning messages and system. Responses in 2003 to the same six questions asked in 1994 and 2001 elicited the highest levels yet of positive answers for all but one question, and the difference for that question was not statistically significant. The conclusion is that the largest leap in improvement occurred between 1994

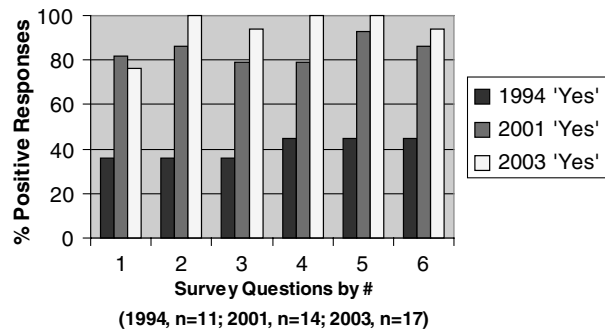


Figure 1. Responses to the questions were dramatically more positive in 2001 than in 1994, indicating that local emergency managers found the improved warning information system much more clear, timely, understandable, and usable than they did in 1994. Answers to the questions in 2003 indicated yet higher levels of satisfaction with the system since the dramatic improvement indicated in 2001. Questions: (1) Based on information provided, was the risk to the community clear to you? (2) Was the information you received on the tsunami timely? (3) Was the information you received on the tsunami updated regularly? (4) Was the information you received on the tsunami understandable? (5) Was the information you received on the tsunami usable? (6) Is present terminology clear regarding “watch” and “warning”?

(36–45% positive response) and 2001 (79–93% positive response), but slightly more improvement (94–100% positive response for all but one question) was measured between 2001 and 2003 overall (Figure 1). NTHMP continues to work with local responders to provide warnings in ways most useful to them.

5. A 5-Year Program Review Measures Accomplishments

During the August 2001 5-year program review, NTHMP members described products and activities and results of three surveys of local

Table II. Survey of 16 local emergency managers showing the factors deemed critical for improvement in their level of tsunami readiness

Factor	Responses (%)
Better plans and coordination	88
Better information	75
Public education: “What to Do”	63
Train responders	38
Better technology	31
Other	19

emergency managers in communities in California, Oregon, and Washington that had been done between 1994 and 2001. Reviewers commented that many of the activities were commendable. They also encouraged more effectiveness in mitigation activities by suggesting the program include social scientists to provide input on how to ensure the right message was being most effectively delivered to users of the information. The program addressed these suggestions by adjusting future goals to incorporate social scientists' input on program activities currently underway (Bernard, this issue).

6. Incorporation of Other Programs and Partners and Plans for the Future

Internally, the NTHMP collaboration among scientists and emergency managers has grown and will continue to do so. The value of working together by interweaving all aspects of the program, such as hazard identification, modeling, mapping, community outreach, evaluation, and planning, is clear. Scientists and emergency managers commonly attend one another's topical meetings and provide input on activities rather than work only within one's specific discipline. Mitigation focuses on the translation of the science and technology into user-friendly planning and education products for federal, state, and local officials who must plan for and respond to disasters, and for the public that is deeply affected by the impacts of both the disaster and the pre-event planning efforts.

Externally, as the 5-year program review suggested, the program will collaborate with other programs and disciplines. One of the successes of the NTHMP has been the collaboration with a National Weather Service (NWS) program, the TsunamiReady Communities (TRC) Program (<http://wcatwc.arh.noaa.gov/tsunamiready/tready.htm>). NWS worked with NTHMP members to design a program based on the StormReady Communities Program. A community must meet certain criteria to be designated a TsunamiReady Community and must continue to meet renewed certification standards in order to keep that designation. These criteria include

- An Emergency Operations Center
- The ability to disseminate a tsunami warning (sirens, local media)
- A tsunami hazard plan
- A community awareness program
- Multiple ways to receive NWS tsunami warnings
 1. Emergency Management Weather Information Network (EMWIN) receiver
 2. NOAA Weather Radio (NWR)
 3. NOAA Weather Wire drop

Currently there are 15 communities designated TsunamiReady, including one tribal nation (Ocean Shores, Long Beach, and the Quinault Indian Nation, WA; Cannon Beach, OR; Homer, Sitka, Seward, and Kodiak, AK; and Crescent City, CA).

NTHMP is seeking the use of social science research to effectively measure the success of planning and education products and to be able to modify them to increase their effectiveness. Initially local emergency managers responded to surveys and attended workshops designed to find out from them what warning messages and protocols were working well and what needed improvement to better serve their needs, for example, warning message format or training in procedures. NTHMP members also researched and compiled a guidance document for local responders describing existing systems, equipment, protocols, and procedures, and their pros and cons (Oregon Emergency Management and the Oregon Department of Geology and Mineral Industries, 2001). Currently, members are working to incorporate tsunamis in several all-hazards programs in the western states, including FEMA's Pre-Disaster Mitigation Grant all-hazards plans required for states and communities. Members are also working with the National Flood Insurance Program Community Rating Service staff to provide input on reasonable credits for tsunami activities, and this will be an incentive for coastal communities to address both flood and tsunami hazards. Finally, members are working toward incorporating tsunami hazard into the existing disaster response and recovery system through providing technical advice and information, and forming some more formal liaison process that can be used shortly after a tsunami disaster occurs.

We began the NTHMP with a vision of helping build "tsunami-resistant communities," but based on the expanding toolbox the NTHMP is developing over the years, the more realistic vision for the program has become "tsunami-resilient communities." This word change does not reflect a change in the goals described in the strategy envisioned in 1998 (Dengler, 1998). We have communities that, short of being picked up and relocated elsewhere, will not be able to oppose the forces of a tsunami that resistance implies. A tsunami-resilient community is one that will take advantage of actions, products, and policies that can help it bounce back from the inevitable tsunami event that will surely come out of the near or far future. A tsunami-resilient community may suffer some inevitable damage, but will have planned, exercised, and educated its citizens and its leaders in ways to save lives, protected as much property as possible, tried to ensure safe locations for critical functions the community needs, and will use lessons from a tsunami event suffered by their community or other communities to improve their level of resilience for future events.

Appendix

A. ALASKA

The state of Alaska has benefited from several NTHMP product developments. Information obtained from tsunameters (González *et al.*, 2003) allows tsunami warnings/watches to be disseminated more accurately to tsunami-prone communities. Through the state's Tsunami Inundation Mapping Program, tsunami inundation maps for communities along the Gulf of Alaska are being generated. Inundation maps for Kodiak City, U.S. Coast Guard (USCG) station, and Women's Bay are complete; maps for Homer and Seldovia are in progress; Sitka and Seward and other communities will be mapped in the future.

The TsunamiReady Community program promotes tsunami hazard preparedness by supporting better and more consistent tsunami awareness and mitigation efforts. The main goal is improvement of public safety during tsunami emergencies. The communities of Seward, Homer, Sitka, and Kodiak are certified "TsunamiReady," and the Borough and City of Kodiak have nearly completed requirements to become TsunamiReady.

The Tsunami Sign Program is a joint NTHMP effort to coordinate and disseminate consistent tsunami information. Alaska contacted all coastal communities at risk to locally generated or distant tsunamis and offered standardized tsunami hazard signs. Signs are now installed in Sitka, Sand Point, Seward, Kodiak, and Homer. Also, the Alaska Department of Parks and Recreation installed signs in Shoup Bay, a remote area inundated to as much as 170 feet above sea level in 1964 and now frequented by hikers and kayakers (Lander and Lockridge, 1989).

Tsunami hazard awareness, education, and outreach are a priority for Alaska. Numerous materials were produced and distributed to communities, businesses, and the public, including school curriculum, coloring books, bookmarks, emergency contact cards, magnets, tent cards, ice scrapers, and decals. Brochures are produced for TsunamiReady Communities and include tsunami information, evacuation route maps, shelter locations, NOAA Weather Radio information, and survival/safety tips.

In conjunction with a "Quake Cottage" program, tsunami preparedness is presented to those communities where a tsunami hazard exists. The "Quake Cottage" is a small van equipped with a shake table that simulates an earthquake. The public can experience the ground shaking associated with a large earthquake in a safe environment. The cottage has been present at many large community events such as Alaska State Fair, the Kodiak Crab Festival, the Ninilchik Fair, the Kenai River Festival, and the Governor's Picnic.

B. CALIFORNIA

California efforts have concentrated on creating the knowledge base essential for building a constituency to support tsunami-planning efforts. This involved creation of a coalition of emergency management representatives of coastal counties, state agencies responsible for regulating development, coastal parks, transportation, and geological mapping. This effort produced a consensus strategic plan for allocating funds for mapping, mitigation planning, guidance development, and the initiation of evacuation planning. The priorities of this State Tsunami Steering Committee have been to complete inundation projections for the 500+ mile coastline, emphasizing the highly populated areas of southern and central California, followed by the less populated coastal areas north of the San Francisco Bay Region.

The availability of local inundation projections and maps by local governments fosters interest in mitigation at both local and state levels. In San Diego, Santa Barbara, Los Angeles, San Mateo, and San Francisco counties, local evacuation planning efforts were initiated in 2000 and 2001. Unfortunately, the events of 11 September 2001 have shifted local priorities and delayed further implementation of local planning. At the state level, the availability of maps is drawing the interest of the California Geological Survey's mandated Hazard Mapping Program. The State's Hazard Mapping Program will address tsunami inundation when recurrence and probabilities of occurrence can be established, consistent with California's earthquake, flood, landslide, and liquefaction risk assessment programs.

In order to ensure a consistent hazard identification and response planning processes among the coastal counties, the California Office of Emergency Services developed and made available a *Local Planning Guidance* to integrate tsunami efforts with the multi-hazard mitigation and preparedness procedures of the State's Standardized Emergency Management System (SEMS).

California served as the project manager for the development of *Designing for Tsunamis*, a guidance document for land use planners and local government development decision makers. The publication provides examples of planning, site development, and building configuration approaches that mitigate the impacts of tsunami inundation.

In the northern counties of Del Norte, Humboldt, and Mendocino, the Redwood Coast Tsunami Work Group (RCTWC) coordinates education and preparedness efforts among local and state agencies.

Similar organizing efforts in southern California have been delayed since the fall of 2001 by the priority placed at federal, state, and local levels of government resulting from the threat of weapons of mass destruction and terrorism (WMD/T) events.

C. HAWAII

The state of Hawaii has directly benefited from several program accomplishments. Operational deployment of six NOAA tsunameters off the Alaska Peninsula and Aleutian Islands, off Pacific Northwest coasts, and in the eastern equatorial Pacific has been successfully accomplished to more accurately evaluate tsunamis approaching Hawaii and other U.S. coasts from afar. Moreover, the government of Chile has purchased one additional tsunameter to enhance the Chile warning system. NOAA will deploy this tsunameter off the Chilean coastline in the fall of 2003. This tsunameter will provide Hawaii with a timely and accurate measure of a Chilean tsunami (e.g., the 1960 Pacific wide destructive tsunami), and is hopefully the first in an internationally supported network of tsunameters that will share vital deep ocean data among all nations affected by tsunamis.

Implementation of operational NOAA tsunami wave forecast is now underway. Prior to the NTHMP, the only NOAA forecast product was time of tsunami wave arrival. Now with a tsunameter network and coastal instruments, tsunami wave forecasts are possible. Such forecasts are essential to reduce “false alarm” tsunami evacuations in Hawaii and all the other Pacific states.

NTHMP upgraded parts of the U.S. Geological Survey’s seismic network and facilitated the use of these data at both the West Coast/Alaska and Pacific Tsunami Warning Centers to more rapidly locate and accurately measure earthquake magnitude and tsunami generation potential.

NTHMP has made possible numerous Hawaii-based tsunami scientific, mitigation, and public awareness initiatives (e.g., distant and local tsunami forecast and shoreline wave inundation models, installation of coastal inundation detectors on the island of Hawaii to rapidly detect locally generated tsunamis, upgraded Civil Defense emergency response capabilities, April Tsunami Awareness Month, media training workshops, public safety videos, etc.).

D. OREGON

In Oregon the focus has been on education, inundation, and evacuation maps, signs, workshops, guidance documents, and legislation. Oregon produced the following educational products: a tsunami video showcasing the Oregon tsunami hazard, grade 7–12 tsunami school curriculum, brochures, and a variety of other materials such as tent cards, stickers, magnets, and bookmarks.

The state produced detailed tsunami inundation maps for six coastal areas. Prior to the detailed maps, simple tsunami inundation maps were developed for the entire coastline as part of legislation (Oregon Senate Bill

379) that limits construction of new critical (e.g., fire stations) and essential (e.g., schools) facilities in the officially designated tsunami inundation zone. Seventeen GIS-based tsunami evacuation maps covering 25 communities were produced using the latest inundation estimates calculated by accepted tsunami modeling methods. The format is consistent and locals have input in designating evacuation routes and format for user-friendly public use of the maps. Prior to these GIS based maps, evacuation maps had been created by local jurisdictions with and without financial assistance from the National Tsunami Hazard Mitigation Program. The goal is to have these evacuation maps for all areas on the coast.

Tsunami signs produced for Oregon include hazard zone, entering and leaving hazard zone, evacuation route, and evacuation site signs. They were distributed and installed in many locations on the coast. A sign installation guidance document was produced to assist in their placement. Interpretive signs, that include tsunami science and tsunami response information, were installed at a number of locations. Oregon is in the process of producing a historical marker sign for Siletz Bay that illustrates the probable impact of the 1700 Cascadia tsunami on a native village.

Three workshops were held: a general tsunami workshop in 1998, a lodging facility planning workshop in 2000, and a tsunami warning workshop in 2002. In addition to the guidance documents mentioned above, a lodging facility planning guidance document and a guide explaining the procedures for compliance with Oregon Senate Bill 379 were also developed. Additional legislation requires schools in the inundation zone to conduct tsunami evacuation drills as well as earthquake drills. Legislation was introduced in the 2003 state legislative session that would require lodging facilities to post tsunami information.

Oregon's tsunami hazard, interpretation, and evacuation signs were used as a model for similar signs in Washington, California, and Alaska to provide consistency for the public who live and travel along the North and West Pacific Coast. Many of Oregon's educational products (brochures, tent cards, stickers, magnets, and bookmarks) were also modified for use in the other states. And although Oregon developed many of its products prior to the NTHMP, the NTHMP funds and accomplishments have allowed Oregon to refine and expand its list of products and activities.

E. WASHINGTON

The state of Washington used the NTHMP Federal/State model to develop its state tsunami mitigation program at a more local level and is guided by the Washington State/Local Tsunami Work Group (WSLTWG). This group recommends priority areas of focus and provides input and active involvement. The group is key in translating the science and technology into usable

information for the public and local officials. The State/Local Tsunami Work Group has developed tsunami brochures to provide information on the tsunami hazard. These brochures include evacuation maps, NOAA Weather Radio information, and tsunami safety tips. In recent years some areas of emphasis include making the warning system more efficient and measuring the effectiveness of tsunami program activities and products for the public (see paper in this edition by George Crawford for more details).

Recently, the WSLTWG adopted the NOAA Weather Radio “All-Hazards” Warning System to warn citizens quickly and effectively of not only tsunami hazards but also other natural or man-made hazards. To implement the NWR strategy and address a gap in warning coverage, the group developed a partnership to add a repeater to the NWR system that provides complete coverage to the coast of Washington and to shipping lanes off the coast. Also, they developed a new notification system to disseminate time-critical tsunami hazard information to the public on beaches and in high-traffic areas. These innovative developments and processes gave rise to the Tsunami Warning/Evacuation Cycle that was also developed. In concert with an array of deep ocean tsunameters, land-based seismic sensors, and warning messages issued by the tsunami warning centers, the NWR provides a means to expeditiously get critical decision-making information to emergency managers, elected officials, and first responders.

The state also examined residents’ and visitors’ perceptions of the tsunami hazard by working with David Johnston, from the Institute of Geological and Nuclear Sciences in New Zealand, who is experienced with hazard perception surveys. An element of the survey focused on the public’s understanding and knowledge of how a tsunami warning is received and disseminated to them and their preparedness to deal with this hazard. One of the findings concluded that approximately half of all students were unaware of the elements of the state’s tsunami warning system or who is responsible for issuing the warning. As a result of Johnston’s study the booklet “How the Smart Family Survived a Tsunami” (elementary edition – K–6) was revised. The booklet now addresses the tsunami warning process, the Washington Tsunami Alert and Notification System, and actions people should take when a tsunami warning is received. It also has information on a family disaster plan and disaster supply kit.

With September designated as Weather Radio Awareness month in Washington, the Work Group’s goal is to have NOAA Weather Radios become as common as smoke detectors in homes and businesses statewide to help protect lives and property from natural and technological hazards.

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