

The U.S. National Tsunami Hazard Mitigation Program Summary

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Abstract. This summary provides an executive summary of the individual reports for the five recommendations described in the National Tsunami Hazard Mitigation Implementation Plan. Each individual report describes the recommendation, what has been accomplished, and the impact of these accomplishments toward reducing the impact of tsunamis to U.S. coastal communities. The individual reports also describe recommended activities for the next 5 years. In addition, a case study of Gray's Harbor County, Washington, illustrates the steps taken over the past 5 years to certify a community as TsunamiReady. The summary report is organized to provide background; budgets, accomplishments, and impact for each recommendation; a summary of future recommendations; identification of gaps in the present plan; and options for the future.

1. Background

The April 1992 California earthquake and tsunami brought into focus that the west coast of the U.S. has a major subduction zone capable of producing destructive tsunamis. The 1992 tsunami raised the question as to the preparedness level of west coast residents for a local tsunami. In July 1994 the Senate Appropriations Committee directed the National Oceanic and Atmospheric Administration (NOAA), the federal agency responsible for issuing tsunami warnings, to formulate a plan for reducing the tsunami risks to coastal residents. Within 10 months, NOAA hosted three workshops involving over 50 scientists, emergency planners, and emergency operators from all levels of governments and universities and produced 12 recommendations, which were submitted to the Committee in March 1995. In October 1995 the Committee directed NOAA to form and lead a Federal/State working group to (1) review the 12 recommendations submitted in the 1995 NOAA Report, and (2) develop an action plan and budget. In February 1996 NOAA formed the Tsunami Hazard Mitigation Federal/State Working Group, composed of representatives from the States of Alaska, California, Hawaii, Oregon, and Washington, and three Federal agencies—NOAA, the Federal Emergency Management Agency, and the United States Geological Survey. By April 1996 the Working Group produced and submitted a Tsunami Hazard Mitigation Implementation Plan that provided technical and budgetary guidance for the implementation of five specific Program recommendations:

1. Produce Inundation Maps
2. Improve Seismic Networks
3. Deploy Tsunami Detection Buoys
4. Develop Hazard Mitigation Programs
5. Develop State/NOAA Coordination and Technical Support

These recommendations have been carried out over the past 5 years under the guidance of the Federal/State National Tsunami Hazard Mitigation

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Program (NTHMP) Steering Group. The Steering Group met twice each year to report progress on the five elements, to make funding decisions, and to make adjustments in the Program. Through the use of a web site, e-mails, telephone conference calls, and numerous individual meetings and telephone calls, the Group functioned as a team in implementing the Plan. The web site (<http://www.pmel.noaa.gov/tsunami-hazard/>) contains the minutes for each meeting including progress reports for each element. The web site, designed and maintained by NOAA's Ann Thomason, has also become a valuable Group resource and has won a Key Link web award for its tsunami information content.

Since 1995 the media has shown exceptional interest in tsunami mitigation by broadcasting about 255 stories or about one per week. Tsunami stories related to the Program were included in newspapers, magazine articles, television news stories, television documentaries, radio programs, web stories, trade publications, books, and a comic strip.

Funding of \$2.3M was provided on a year-by-year basis for FY 1997, 1998, 1999, 2000, and 2001 through the Congressional add-on process. For FY 2002, the program is included as part of the President's request to Congress at the \$2.3M level. During the first 5 years, the Program received 96% of the \$11,400,000 requested in the original implementation plan. The \$11,007,510 supplied through NOAA were originally envisioned to be matched by federal, state, and local contributions of \$8,365,000. The actual matching funds from federal, state, and local organizations totaled \$66,389,434 or about \$6.03 match for every \$1.00 made available through the Program. In the following summaries for each recommendation, a funding profile is given for funds received from the NTHMP in dollars, the percentage of the request, and the matching funds source and amount.

2. The Five Recommendations: Budgets, Accomplishments, and Impact

2.1 Produce inundation maps (Reference: González *et al.*—The NTHMP Inundation Mapping Program)

2.1.1 Budget

\$1,901,619 or 149% of request:

Match: Total \$3,985,711 (States \$893,711 + NOAA \$3,092,000)

2.1.2 Accomplishments

a. Inundation Maps: Nineteen inundation modeling and mapping efforts were completed for 88 communities with an estimated population at risk of over a million people.

b. Evacuation Maps: Seven areas were provided with evacuation maps that were developed by State personnel using inundation maps as critical input to the process.

c. Infrastructure Development: The creation of the Tsunami Inundation Mapping Effort (TIME) Center represents the infrastructure necessary to transfer the best available science from research settings to operational applications.

2.1.3 Impact

a. Mitigation tool: A tsunami inundation map is a clarifying, galvanizing catalyst for action by Emergency Managers and citizens alike. Once a map is completed and available for study, previously vague concerns and abstract issues are suddenly and immediately clarified and rendered concrete. At this moment, effective, community-specific planning is truly begun—individual hazards can be identified and mitigation measures can be developed and implemented that are specific to that hazard. A map is thus the fundamental starting point for any effective planning and mitigation program, aiding the evaluation of critical issues such as population and infrastructure vulnerability, and the identification of feasible evacuation routes.

b. Research/Emergency Management partnership: Because the academic scientists are well-respected and influential members of the tsunami research community, their vigorous involvement in hazard mitigation issues has had an important positive impact on the relationship of the tsunami research community to the emergency management community.

2.2 Improve seismic networks (Reference: Oppenheimer—CREST Project)

2.2.1 Budget

\$3,789,108 or 82% of request:

Match: Total \$57,410,000 (USGS and States \$56,850,000 + NOAA \$560,000)

2.2.2 Accomplishments

a. Seismic stations: Installed 56 real-time, broad-band, seismic stations in five states.

b. Software: Installed Earthworm software at each NOAA warning center that allows access to data from regional and global seismic networks.

c. Infrastructure development: The Earthworm software has become a NOAA standard for linking all of the seismic networks in the U.S. This infrastructure now enables the tsunami warning centers to take advantage of improvements in seismic monitoring capability nationwide as well as globally, even though such improvements may be undertaken by other monitoring agencies and organizations.

2.2.3 Impact

a. U.S. earthquakes: Alaska, Hawaii, West Coast: Reduced the time required to locate and determine magnitude from 8 min to 2 min (if staff is on site).

b. Earthquakes outside the U.S.: The time required to locate the earthquake is still governed by the time it takes for the P-waves to reach the most distant station in the network. Formerly, it would take 8–16 min to locate an earthquake, but now the time has been shortened to 1–12 min. The time to determine magnitude has decreased from 5–55 min to 2–20 min.

2.3 Deploy tsunami detection buoys (Reference: Bernard *et al.*—Early detection and real-time reporting of deep-ocean tsunamis)

2.3.1 Budget

\$3,634,764 or 96% of request:

Match: Total \$2,516,743 (NOAA \$2,516,743)

2.3.2 Accomplishments

a. DART: Developed and field tested a real-time, Deep ocean Assessment and Reporting of Tsunamis (DART) system using acoustic modem technology, satellite telemetry, redundant electronics, and World Wide Web dissemination of data (<http://tsunami.pmel.noaa.gov/dartqc/WaveWatcher>).

b. Performance: Prototype DART averaged 95% data return over past 2 years; tests and three earthquakes demonstrated that DART performed as designed.

c. Array: Deployed six-DART array as originally recommendation.

2.3.3 Impact

a. New data: Major upgrade in tsunami data acquisition for NOAA's warning centers to provide faster, more accurate tsunami data.

b. Forecast potential: Using DART data and numerical models, a NOAA tsunami forecasting capability is being developed.

2.4 Develop hazard mitigation programs (Reference: Jonientz-Trisler—Mitigation Strategic Plan)

2.4.1 Budget

\$1,682,019 or 98% of request:

Match: Total \$2,123,980 (States \$1,946,980 + FEMA \$177,000)

2.4.2 Accomplishments

a. Standards: Standardized tsunami evacuation and hazard zone road signs.

b. Publications: A strategic plan (Dengler, 1998) (see Table 2 in Jonientz-Trisler paper for progress), a progress report (Jonientz-Trisler), a survival booklet (Atwater, 1999), *Designing for Tsunamis* guide for local communities (Mintier, 2000), and the TsuInfo newsletter six times/year.

c. Workshops: Sponsored one multistate workshop on local warnings and over 20 workshops within states for education, coordination, and inundation map review.

2.4.3 Impact

Based on two (1994 and 2001) west coast surveys of emergency management community (a few findings):

a. Messages: Percent able to use tsunami messages doubled from 1994 to 2001.

b. Evaluation: 75% indicate improvements since 1994.

c. Factors: Key factor on improvement is better planning and coordination.

d. Future: Majority believe more improvements will take place if public education and better technology are emphasized.

2.5 Develop state/NOAA coordination and technical support: (Reference: Hagemeyer—Develop State/NOAA Coordination)

2.5.1 Budget

No funds requested:

Match: Total \$353,000 (NOAA \$353,000)

2.5.2 Accomplishments

a. Training: Ten warning coordinating meteorologists were trained in tsunami warning procedures.

b. Infrastructure: Each state has some tsunami infrastructure in place to coordinate tsunami activities.

c. Data base: Developed and distributed historical tsunami data base.

d. Agreement: Developed agreement between NOAA and USGS to distribute information on small earthquakes via the Emergency Managers Weather Information Network (EMWIN).

e. NOAA radio: Assisted in relocation of NOAA weather radio transmitter to provide better coverage of Washington coastline.

2.5.3 Impact

a. TsunamiReady: Assimilated products from NTHMP into a TsunamiReady program that recognizes communities that have met minimum criteria to properly respond to NOAA tsunami warnings.

3. Future Activities

3.1 Produce Inundation Maps

1. Complete maps for 391 communities	\$750,000/year
2. Establish Tsunami Community Modeling Activity at TIME	\$300,000/year
3. Develop bathymetric and topographic databases	\$250,000/year
Total	\$1,300,000/year

3.2 Improve Seismic Networks

1. Annual operating costs	\$600,000/year
2. Communications upgrades for speed and redundancy	\$400,000/year
Total	\$1,000,000/year

3.3 Deploy Tsunami Detection Buoys

1. Expand array from 6 to 10 DART buoys	\$1,200,000/year
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3.4 Develop Hazard Mitigation Program

1. Maintain state programs (\$50,000/state/year)	\$250,000/year
2. Maintain multi-state activities	\$50,000/year
3. Workshops and mitigation publications	\$100,000/year
Total	\$400,000/year

3.5 Develop State/NOAA Coordination and Technical Support

1. Certify coastal communities in five states as Tsunami Ready	\$100,000/year
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Grand Total \$4,000,000/year

4. Deficiencies in Existing Program

4.1 Response and recovery

Federal Response Plan needs a tsunami section.

4.2 Partnerships

Need expansion to other agencies, the private sector, and international partners.

4.3 Research and development

Need coordination with research community to address urgent needs (i.e., building code development in inundation zones).

4.4 Administration

Need about \$200,000/year to administer program. No funds are presently identified to cover this expense.

5. Options

5.1 Status quo

Maintain current arrangement and develop program with available resources.

5.2 Expanded status quo

Seek additional funds from partnership agencies.

5.3 Tsunami.net

Create a not-for-profit organization that can seek funds from public, private, philanthropic, and international sources.

6. Conclusions

The first 5 years of the NTHMP have met the initial goals of the program outlined in the Implementation Plan to raise awareness of the affected populations, supply evacuation maps, improve tsunami warning systems, and institutionalize mitigation planning. The culmination of these efforts has enabled the concept of certifying communities as **TsunamiReady** to become a reality.

The TsunamiReady community will save lives within that community. For the community to survive the next tsunami, however, the community must become **tsunami resistant**. This requires a community to examine its vulnerability to tsunamis and make appropriate adjustments in the community infrastructure. The goals of the next 5 years are to significantly increase the number of **tsunami ready** communities and develop the tools necessary to become **tsunami resistant**.

Acknowledgments. I thank the dedicated Steering Group members whose collective efforts have made our coastlines a safer place to live and visit.