NOAA's Tsunami Program
2008–2017
Strategic Plan

July 2008

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Washington, DC 20230

Prepared by the NOAA Tsunami Strategic Planning Team:
Eddie Bernard
Chris Maier
Charles Mccreery
Susan McLean
Jenifer Rhoades
Paul Whitmore

Table of Contents

NOAA's Tsunami Mission is to provide reliable tsunami forecasts and warnings, and to promote community resilience.

Our Vision is for the United States to become a tsunami-resilient Nation by minimizing the loss of life and disruption to economically vital coastal communities from future tsunamis.

Executive Summary

Tsunamis are high impact, low frequency natural hazards. It is not a question of if, but when tsunamis of high impact will occur, causing considerable numbers of fatalities, inflicting major damage to infrastructure, and resulting in significant social upheaval, economic disruption, and environmental degradation to large sections of the United States' coastline. Since 1900, over 200 tsunami events (mostly earthquake-generated) have affected the coasts of the United States and its territories, causing more than 500 deaths. Economic disruption as a result of a major tsunami damaging the ports of Los Angeles and Long Beach, California, is estimated at $1 Billion each day the ports are closed (Borrero et al. 2005). The 53 percent of the U.S. population living in coastal communities in 2003 (Crosset et al. 2004) and at risk from the impacts of a destructive tsunami has grown by 7 million today and is expected to grow by 12 million by 2015. It is estimated that our Nation's coastal communities contribute 60 percent of our Nation's Gross Domestic Product. As the trend continues for coastal economic growth and population density increases, the risk of death and economic damage will climb. In addition, a major ocean-wide tsunami will affect many nations and can have global impact.

The Tsunami Warning and Education Act (33 U.S.C. §§ 3201 *et seq.*) specifies the National Oceanic and Atmospheric Administration (NOAA) as the lead agency responsible for operating the U.S. Tsunami Warning System, and for providing technical assistance and training to the Global Tsunami Warning System. NOAA will report to Congress on U.S. Tsunami Warning System capabilities. NOAA is responsible for organizing the National Tsunami Hazard Mitigation Program (NTHMP), and conducting a tsunami research program.

A sustained national tsunami effort will result in the following outcomes:

- Timely and accurate tsunami forecast and warning products
- Tsunami products that are understandable and usable
- Resilient communities inhabited by a public educated to take appropriate actions
- A sustainable NOAA Tsunami Program populated by dedicated and properly trained staff
- Reliable and coordinated data, communications, and dissemination infrastructure, and the capability to acquire and exchange relevant tsunami data and information that supports the tsunami mission
- Interdisciplinary science and research results leading to more effective and affordable tsunami warning and mitigation products and services
- Technical assistance, training, and capacity development both at global and regional levels, supporting the fully operational tsunami warning system
- Integration with other relevant national, regional, and global ocean and coastal observation, warning, mitigation, and risk management systems.

In June 2005, NOAA established a Tsunami Program to address national tsunami priorities, coordinate with national and international partners, and deploy and manage an enhanced observational network to improve warnings and mitigate the loss of life and damage to property as a result of tsunamis. This plan describes the 10-year strategy to accomplish these goals.

Introduction

Tsunamis can disrupt our Nation's economy. The 2004 Sumatra tsunami killed nearly 250,000 people and caused more than $10 Billion in economic losses to the Asian economy (Munich Re, 2005). This was a stark reminder of the catastrophic impacts that can result from this hazard. On our West Coast, there is a geological feature similar to the fault systems off Sumatra. Estimates of the cost of economic disruption as a result of a major tsunami damaging a port on the West Coast are significant. For example, costs to the ports of Los Angeles and Long Beach, California, are estimated to be $1 billion each day the ports are closed (Borrero, 2005); this estimate does not include a repair of infrastructure. Economic impacts due to the tsunami hazard will increase in the coming decades based on U.S. coastal demographics.

This strategic plan describes the long-term vision for NOAA's Tsunami Program, objectives for the next 10 years (2008–2017), and efficient and effective strategies to achieve the desired outcomes. Achieving these outcomes will ensure continued delivery and advancement of the world's most accurate and reliable tsunami warning and mitigation system, and will improve the tsunami-resilience of coastal communities.

This strategic plan promotes ongoing planning and implementation, led by NOAA's Tsunami Program, to develop and sustain efforts to manage tsunami risk reduction and improve overall coastal community resiliency through a multi-hazard approach. NOAA, with the U.S. Geological Survey (USGS), recently completed a U.S. National Tsunami Hazard Assessment identifying areas of the U.S. coastlines most likely to experience tsunamis. A risk-based tsunami strategic plan, as recommended by the Government Accountability Office, requires additional documentation of historic and pre-historic tsunamis for all U.S. coastlines. The plan also requires the latest scientific data on structural integrity of buildings to understand the interaction of tsunamis with both the man-made and natural environment.

NOAA's Tsunami Program is comprised of five overarching capabilities: hazard assessment, warning guidance, mitigation, research, and international cooperation and intergovernmental coordination. This includes monitoring and observation systems and interdisciplinary research. With its partners, NOAA also promotes tsunami warning guidance, modeling, and mitigation efforts such as outreach and preparedness (public education and training), for U.S. communities at risk.

The Tsunami Program contributes to NOAA's goal to serve society's needs for weather and water information. The Program's main goal is to protect life and property from a tsunami hazard. NOAA accomplishes this goal by providing timely, accurate, reliable, and effective tsunami forecast and warning products to coastal populations and emergency responders within the Tsunami Warning System (TWS) Area of Responsibility (AOR).

The primary operational tasks are to rapidly locate, size, and otherwise characterize tsunami sources, forecast coastal inundation, and assess potential impacts. The TWS provides guidance and graphical products to emergency responders and citizens, allowing them to make well-informed decisions. A robust tsunami mitigation system relies on the free and open exchange and long-term management of high quality data, including real-time observational and retrospective data.

The Program involves the activity of more than one NOAA Line and Staff Office. The Program includes two tsunami warning centers (TWC): the Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, and the West Coast/Alaska Tsunami Warning Center in Palmer, Alaska. These centers work in cooperation with other NOAA units, such as:

- National Weather Service (NWS):
  - Weather Forecast Offices (WFO)
  - National Data Buoy Center
  - Regional Support and Specialized Centers
  - International Tsunami Information Center (ITIC)
- National Ocean Service (NOS):
  - Center for Operational and Oceanographic Products and Services
  - Coastal Services Center including Pacific Service Center
  - National Geodetic Survey
  - Office of Coast Survey
  - Office of Ocean and Coastal and Resource Management
- Oceanic and Atmospheric Research (OAR):
  - Pacific Marine Environmental Laboratory (PMEL)
  - Office of Ocean Exploration
  - Cooperative Research Institutes
- National Environmental Satellite, Data, and Information Service (NESDIS):
  - National Geophysical Data Center (NGDC) and co-located
  - World Data Centers (WDC)
  - Cooperative Research Institutes
- Office of Marine and Aviation Operations (OMAO)
- NOAA's Office of International Affairs
- Office of Satellite Data Processing and Distribution

Each collaboration is crucial to mission performance. NOAA's Tsunami Program is not only matrixed across NOAA, but also is dependent upon its partnerships with other Federal, State, and international agencies.

NOAA Tsunami Program Matrix

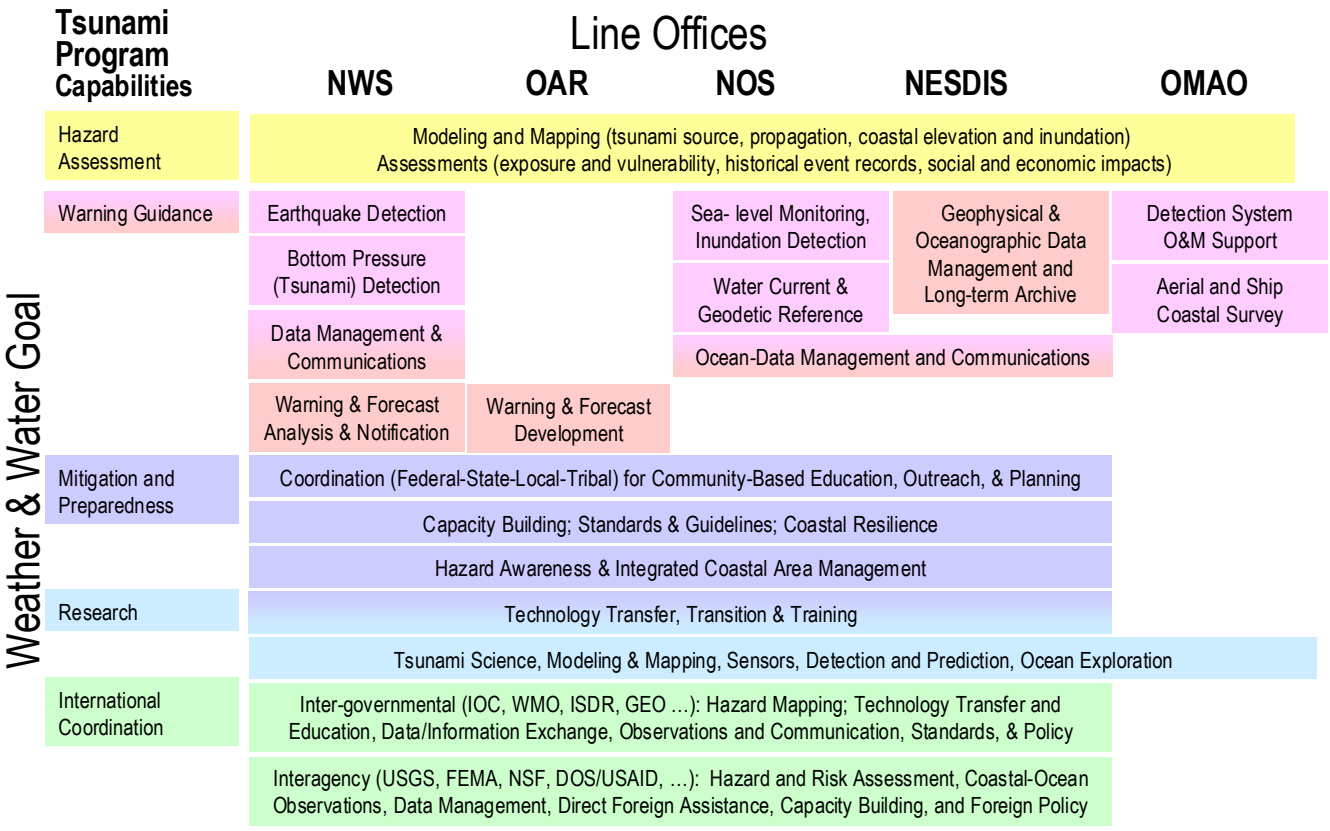


Figure 1. Tsunami Program Matrix.

Customers and Partners

Customers

NOAA's Tsunami Program serves, either directly or indirectly, all people of the United States. Coastal residents, visitors to our coasts, and people who make decisions for coastal communities are our primary customers.

Primary customers:

- Coastal residents and visitors
- State and county emergency managers
- Businesses in tsunami-prone areas
- Local and tribal emergency responders
- Local and tribal land use/planning authorities
- Members of the private sector and academia involved in tsunami resiliency and research
- U.S. Government agencies (e.g., military)
- State Departments of Education and Free Choice Learning Institutions
- Other nations' National Tsunami Focal Points

Partners

A tsunami-resilient Nation can be achieved only by cooperative efforts of multiple agencies, organizations, and individuals across the Nation. We value our relationships with other Federal, State, and local agencies and organizations, although our missions may differ. We recognize that traditional partners—Pacific States and agencies responsible for preparedness, mitigation, response and recovery, and land use guidance—have been key to past successes and remain essential to future progress toward tsunami resiliency. Partnerships will be expanded to work toward common goals of an accurate and reliable tsunami warning and mitigation system and tsunami-resilient coastal communities.

Primary U.S. partners:

- NTHMP member agencies, States, Territories, and Commonwealths
- National Earthquake Hazard Reduction Program led by Department of Commerce's National Institute of Standards and Technology, other member agencies, States, Territories, and Commonwealths
- National Emergency Management (NEMA) members and local, State, Territorial, and Commonwealth emergency management agencies
- Integrated Ocean Observation System (IOOS) member agencies and regional alliances
- Department of Interior, Advanced National Seismic System and National Earthquake Information Center
- National Science Foundation (NSF), Incorporated Research Institutions for Seismology (IRIS), including regional seismic networks and the Global Seismic Network

- Department of Homeland Security: Federal Emergency Management Agency (FEMA) and the U.S. Coast Guard
- Nuclear Regulatory Commission
- U.S. Army Corps of Engineers
- Department of State: Bureau of Oceans and International Environmental and Scientific Affairs, U.S. Office of Disaster Assistance, and U.S. Agency for International Development (USAID)
- American Meteorological Society
- American Geophysical Union
- Universities and scientific organizations
- Media

In addition, NOAA's Tsunami Program provides international warning, training, and data exchange assistance.

Primary international partners

- United Nations Educational, Scientific, and Cultural Organization (UNESCO)
- UNESCO's Intergovernmental Oceanographic Commission (UNESCO/IOC), including the ITIC and PTWC hosted by NOAA
- United Nations World Meteorological Organization (WMO)
- World Meteorological Organization (WMO)/Intergovernmental Oceanographic Commission (IOC) Joint Commission for Marine Meteorology
- International Council for Science (ICSU) and its system of WDCs, including the WDC for Solid Earth Geophysics
- United Nations Environment Programme (UNEP)
- IOC/WMO/ICSU/UNEP Global Ocean Observing System and its components, including the Global Sea Level System and Data Buoy Co-operation Panel
- United Nations International Strategy for Disaster Risk Reduction (ISDR)
- World Bank
- United Nations Development Programme
- United Nations University
- Group on Earth Observations (GEO)
- International Union of Geology and Geophysics—International Association of Seismology and Physics of the Earth's Interior, including the Tsunami Commission and Federation of Digital Broadband Seismograph Networks
- International Association of Emergency Managers (IAEM)
- Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization

10-Year Strategy

NOAA's Tsunami Program has defined outcomes necessary to achieve the basic mission to minimize the threat to life and property due to tsunamis.

- Timely and accurate tsunami forecast and warning products
- Tsunami products that are understandable and usable
- Resilient communities inhabited by a public that is educated to take appropriate actions
- A sustainable Tsunami Program staffed by dedicated and properly trained individuals
- Reliable and coordinated data, communications, and dissemination infrastructure that supports the Tsunami Program
- Interdisciplinary science and research results leading to more effective and affordable tsunami warning and mitigation products and services
- Technical assistance, training, and capacity development both at global and regional levels, supporting the fully operational tsunami warning system
- Integration with other relevant national, regional, and global ocean and coastal observation, warning, mitigation, and risk management systems.
- Effective networks to disseminate tsunami information to the public through partnerships with formal and informal education entities

The Tsunami Warning and Education Act (33 U.S.C. §§ 3201 *et seq.*) defines the architecture of NOAA's Tsunami Program. The Act helps strengthen the Nation's tsunami warning system by: improving and utilizing NOAA's mapping, modeling, and research efforts; ensuring that data and findings are available; supporting increased education and outreach efforts; and improving both domestic and international coordination. The authorization of appropriation provided by the Act is effective through FY 2012 (33 U.S.C. § 3207). The following 10-year strategy is designed to ensure the goals of the Act are met and the Act is reauthorized.

NOAA's Tsunami Program, working with our partners, will focus expertise on warning guidance, research, preparedness, assistance with mitigation efforts, and international coordination. Over the next 10 years, the Program will employ strengthening strategies in five key areas to ensure the outcomes identified above:

1. Tsunami forecasting and warning
2. National Tsunami Hazard Mitigation Program
3. Tsunami research
4. Global Tsunami Warning and Mitigation Network
5. Tsunami Warning and Education Act extension activities

Tsunami Forecasting and Warning

To meet the requirements of 33 U.S.C. § 3203 to operate a program that provides tsunami detection, forecasting, and warnings for the Pacific and Arctic regions and for the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico regions, we will:

Ensure adequate and sustainable staff levels

The Tsunami Program's greatest resource is its staff. To ensure a sustainable system, adequate staff must be available at NWS, TWCs, NWS WFOs, OAR/PMEL, NOS, and NESDIS/NGDC. The Tsunami Program recommends the following:

- Maintain a dedicated program management office
- Maintain a full-time, knowledgeable NTHMP Manager
- Sustain a sufficient workforce necessary to achieve our mission
- Establish job enrichment and growth opportunities for current and new NOAA employees to maintain technical excellence

Ensure reliable and sufficient operational data collection, dissemination, analysis, and product dissemination

The TWCs must be able to respond to any type of tsunami-genic source (e.g., earthquakes, landslides, volcanic eruptions, etc.). The ability to deliver timely tsunami forecasts and warnings is dependent upon the TWCs' ability to acquire, process, and analyze various data types and deliver information to our customers and partners in the least amount of time possible. The NWS WFOs and program partners provide a key component of successful tsunami warning and forecast dissemination and outreach/education. Through the *Strengthen Tsunami Warning System Supplemental of 2005*, our TWCs' ability to respond to tsunami events was enhanced. Our TWCs now operate on a 24/7 basis and have increased access to seismic and sea-level (coastal and deep-sea) information from a variety of national and international sources; however, more must be done to ensure the TWCs will further improve the timeliness, accuracy, and dissemination of tsunami products. To achieve this objective, the following actions must be taken:

- Implement techniques to identify non-tectonic sources
- Expand sea level monitoring so that non-seismic source waves can be observed prior to impact
- Monitor critical observing networks, establish performance standards, and develop a reporting protocol with data providers (e.g., USGS and NTHMP)
- Complete upgrades of Alaska and Hawaii seismic and sea level networks
- Ensure interoperability of the TWCs

- Enhance data collection and processing/analysis capability
- Improve tsunami products and dissemination (e.g., implement Common-Alerting Protocol)
- Maintain all existing and future water level monitoring infrastructure and communication platforms (NOS, TWCs, University of Hawaii Sea Level Center)

Improve product utility and accuracy to customers

An effective TWS is dependent not only on the ability of our TWCs to forecast tsunamis and warn the public but also upon the public receiving, understanding, and responding appropriately to our forecast warning products. NWS WFOs disseminate warnings and forecasts via NOAA Weather Radio All Hazards and the Emergency Alert System and coordinate with emergency managers. NOAA's Tsunami Program is committed to ensuring all customers can receive, understand, and respond appropriately to our forecast and warning products. To improve our product utility and accuracy, we will:

- Address customer-driven product requirements (e.g., site-specific warnings, connection of economic impacts to warning performance)
- Tailor products to a specific emergency manager response so that the products issued lead to appropriate community responses
- Enhance graphical products with geographic information systems capability
- Work with the Operations Subcommittee of the NTHMP and NOAA's Local Forecasts and Warning and Science and Technology Infusion Programs to develop next generation products
- Strengthen partnerships with formal and informal entities

Ensure integration of data and information systems

To provide tsunami forecasts and warnings, NOAA relies on real-time access to global data including seismic, Deep-ocean Assessment and Reporting of Tsunami (DART™) Stations, and coastal water level (tide gauge) data. Some of these monitoring networks operate in support of a variety of applications, including tsunami forecast and warning. For example, coastal tide stations operated by NOS are multi-purpose stations, providing both real-time and long-term water level data, with an established set of standards, deliverables, and operating procedures. The observations required to meet the Tsunami Program's performance measures are documented in the NOAA Consolidated Observation Requirements List database. Each observation requirement is associated with the performance measures it supports, providing direct traceability to the Program's outcomes.

As the number and source of observing systems expand, so does the need for protocols at hardware, firmware, and higher levels to ensure interoperability at the TWCs. In addition to the real-time data, tsunami history and pre-event modeling are taken into account when determining the extent of tsunami risk and potential impact, requiring exchange and coordination on past event data worldwide.

Full and open access to these data is essential for tsunami forecasts and warnings, research, and hazard mitigation and community resilience efforts. The diversity of data formats, management systems, models, and visualization tools complicate the processing, management, and accessibility of tsunami-related data. This diversity limits the reuse of, and access to the data, making it labor intensive to increase knowledge of marine and coastal processes and risks associated with these environments.

To ensure interoperability and integration of data and information systems, NOAA will:

- Encourage all nations to support full and open exchange of data
- Encourage use of common protocols and formats for real-time and retrospective data
- Participate in appropriate data and information standards development
- Develop standards-based Web services.
- Integrate TWC water level data into the respective archive at NGDC

NOAA will support and use data description and distribution methods based on national and international standards and will complement the activities of IOOS through its Data Management and Communications (DMAC) subsystem. The IOOS DMAC subsystem will provide data standards, protocols, and infrastructure linking the global and coastal observing components and enhancing the quality and compatibility of resulting data and information products. Using standards enables integration and sharing of data, as required under 33 U.S.C. § 3203 (d)(2)(F) of the Tsunami Warning and Education Act. The type of protocols supported include, but are not limited to the OpenGIS Web Map, Feature, and Coverage Services: Web Map Service, Web Feature Service, and Web Coverage Service. Other standards will be the World Wide Web Consortium Simple Object Access Protocol and Extensible Markup Language for delivery of retrospective data.

Using these standards-based methods, we can maximize our ability to deliver data and information to users and systems in a manner supporting integration with other data and services. Our efforts in operational data collection and information integration will support and conform to IOOS and Global Earth Observation System of Systems (GEOSS) data management standards.

National Tsunami Hazard Mitigation Program

To meet the requirements of 33 U.S.C. § 3204 to conduct a community-based tsunami hazard mitigation program to improve tsunami preparedness of at-risk areas in the United States and its territories we will:

Promote community preparedness and resilience

Integrating NOAA's hazard prediction and response activities will help the Nation's increasingly vulnerable coastal communities to prepare for, respond to, and rebound from natural disasters (*Advancing NOAA's Priorities Through Regional Collaboration*, 2007). A successful effort requires that NOAA work with Federal, State, and local emergency managers, urban planners, decision makers, and coastal resource managers to develop assessment and decision support tools for at risk communities (Dunbar and Weaver, 2007). This also involves increased public awareness of tsunamis via outreach and education activities.

NOAA's Tsunami Program will promote community preparedness and resilience by:

- Defining inundation model standards to encourage community modeling
- Promoting NTHMP efforts in inundation mapping by providing access to available coastal relief data and information
- Supporting NTHMP in improving community resilience
- Collaborating with NOAA Coastal Community Hazard Resilience and Coastal Zone Management
- Supporting and expanding the TsunamiReady™ Program and adjusting criteria as necessary to best improve tsunami preparedness

Tsunami Research

To meet the requirements of 33 U.S.C. § 3205 to maintain a tsunami research program to develop detection, forecast, communication, and mitigation science and technology, including advanced sensing techniques, information and communication technology, data collection and analysis, and assessment for tsunami tracking and numerical forecast modeling we will:

Support tsunami forecast and warning research

Tsunami research is required to understand tsunami processes and impacts, develop more accurate and efficient models and detection techniques, and advance efficient and effective warning and mitigation measures. NOAA is dedicated to developing and improving tsunami detection, hazard assessment, and forecast tools as well as improving communication and mitigation techniques. To strengthen NOAA's tsunami research capability, we will:

- Support basic and operationally-driven research requirements
- Support research-to-operations activities
- Include integrating social science research to develop and assess community resilience
- Ensure that research and findings are available to the scientific community
- Investigate the use of alternative technology to improve forecasts and warnings
- Conduct research to aid operational cost control

Global Tsunami Warning and Mitigation Network

To meet the requirements of 33 U.S.C. § 3206 to provide technical assistance and training to the Intergovernmental Oceanographic Commission, the World Meteorological Organization, and other international entities, as part of international efforts to develop a fully functional global tsunami forecast and warning system comprising regional tsunami warning networks modeled on the International Tsunami Warning System of the Pacific, we will:

Promote a fully functional global tsunami forecast and warning system

The global tsunami warning and mitigation system is being built from many existing and new national and regional systems and initiatives including the U.S. NTHMP. U.S. technical agencies, including NOAA, are ensuring interoperability and compatibility by developing standards and protocols, identifying and strengthening existing capacities, defining the components contributing to the GEOSS/IOC design for an end-to-end multi-hazard system, converging or harmonizing observation and communication methods, and promoting interoperability arrangements such as data management. NOAA's Tsunami Program will continue to promote a fully functional global tsunami forecast and warning system by:

- Providing technical assistance and training to IOC International Coordination Groups (ICGs) and their member states
- Designating an International Liaison/Training Program Coordinator at ITIC
- Establishing a mechanism for ITIC to report accomplishments to NOAA regarding its responsibilities outlined in 33 U.S.C. §§ 3201 *et seq*.
- Promoting full and open exchange of data by all member states
- Continue to coordinate on warning guidance with the ICGs

Tsunami Warning and Education Act Extension Activities

In January 2007, Congress passed P.L. 109–479, Title VIII, Tsunami Warning and Education Act, to authorize and strengthen tsunami detection, forecast, warning, and mitigation to protect life and property in the United States. To ensure NOAA meets the requirements of P.L. 109–479, codified at 33 U.S.C. §§ 3201 *et seq.,* and establishes a sustainable national tsunami warning and mitigation effort, we will:

Establish a domestic and international training program

The knowledge, skills, and dedication of the Tsunami Program's staff are one of its greatest assets. The Program's success depends upon technical expertise and ability to work effectively with an increasingly diverse clientele. The Program's core workforce must continue to possess technical expertise. The need for management skills will continue to increase as a wider range of partners are brought together. The Program must also effectively train our domestic and international partners to ensure a full understanding of the hazard and mitigation techniques needed to build community resiliency. To meet the objective of establishing a domestic and international training program, the Tsunami Program will:

- Establish an expanded Tsunami Certification Program (i.e., through the University of Washington) that meets IOC requirements to support a sustainable, global Tsunami Warning System
- Improve internal training of the Tsunami Program staff (including Web-based training and support for the Watchstander Exchange Program)
- Enable staff participation in post-tsunami surveys
- Work with State Departments of Education and Free Choice Learning Institutions

Extend and Improve the World Data Center Tsunami Databases

NOAA's Tsunami Program supports full and open exchange of data with other nations and organizations. NOAA operates the WDC for Geophysics and Marine Geology (GMG), in Boulder, Colorado (collocated with NOAA's NGDC). The WDC manages all types of data from the ocean bottom and solid Earth, including geological hazards. Digital data include historical tsunamis, earthquake epicenters, and volcanic eruption data. The WDC emphasizes the economic impact and damage from significant past events. To meet the requirements outlined in the Tsunami Warning and Education Act, we must:

- Consolidate the information in the TWCs' database with the WDC database, and establish replication processes from the WDC to the TWCs
- Establish international data quality standards and incorporate regional databases into the WDC database
- Complete the quality review of retrospective data
- Enhance collaboration with IOC ICGs and with the GEO Program

Improve Organizational Communications

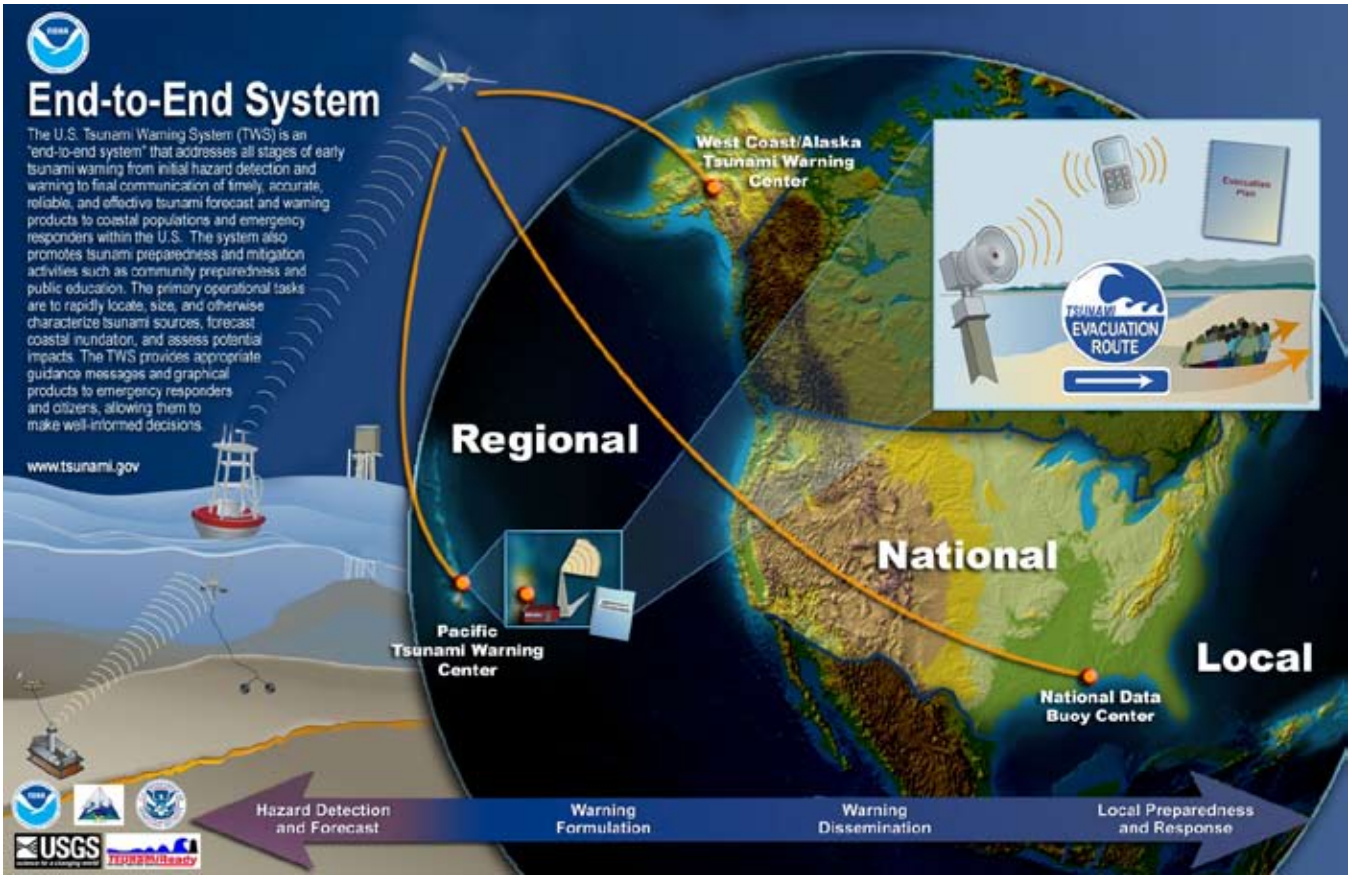
An effective Tsunami Program requires clear, efficient and effective organizational communication. We must be able to articulate the Program's accomplishments and requirements during, immediately after, and in-between tsunami events. The Program's communication strategy is as follows:

- Improve inreach within NOAA (Executive Council, CFO, Office of Program Planning and Integration, Legislative Affairs, Education Council, etc.)
- Develop and implement a "Scorecard for Rapid Event Performance Reporting"
- Integrate content for the tsunami.gov Web site to more comprehensively communicate all aspects of our program
- Update outreach materials to communicate a NOAA-wide program including links to coastal resiliency and multi-hazard approaches

Implementation Strategy

The success of NOAA's Tsunami Program strategic plan will be measured by how well its mission and objectives are met. The following is the Tsunami Program's strategy to achieve these objectives. NOAA will align the over-arching program capabilities to meet requirements of 33 U.S.C. §§ 3201 *et seq*. To meet these objectives, the new capability structure is tsunami forecasts and warning guidance, hazard mitigation and preparedness, research, and international coordination.

Each capability will work with existing partnership structures (e.g., NTHMP) to address the strategic objectives outlined in this plan. The Program will define an action plan that will define steps to be taken, responsible parties, how and when the action will be completed, and required resources. Success will be measured through semi-annual reporting to NOAA's Tsunami Program Manager on the status of the action plan elements.



Appendix 1. Tsunami Program Performance Indicators

Program Performance Measure—PM

Strategic Outcomes	Program Strategies	Performance Indicators/Milestones	Primary Line Office	Contributors
Timely and accurate tsunami forecast and warning products	(1) Ensure reliable and sufficient operational data collection, analysis, and product dissemination (2) Support forecast and warning research (3) Ensure adequate and sustainable staff levels	PM: Maintain probability of detection for a destructive tsunami within the TWC area of responsibility at 100 percent	NWS	NOAA, USGS, States
		PM: Reduce elapsed time from earthquake to Tsunami Message Product issuance for distant events from 22 minutes to 16 minutes by 2013	NWS	NOAA, USGS, States
		PM: Reduce elapsed time from earthquake to Tsunami Message Product issuance for regional events from 10 minutes to 5 minutes by 2013	NWS	NOAA, USGS, States
		PM: Reduce time to cancel a Tsunami Warning or Watch from 3 hours to 2 hours by 2013	NWS	NOAA, USGS, States
		PM: Reduce the geographical extent of tsunami warnings from 25 percent reduction in 2007 to 47 percent reduction in 2013	NWS	OAR, NOS
		PM: Reduce the community cost of tsunami evacuation from $6 Million in 2007 to $4.3 Million in 2013	NWS	OAR, NOS
		PM: Maintain each TWC at a high level of reliability so that tsunami products can be issued at all times	NWS	
		PM: Accurately estimate AOR earthquake location within 15 km of epicenter and magnitude within .17 (compared to official USGS location and magnitude product) by 2013 so that reliable and appropriate products are issued	NWS	USGS, NOAA, States
		PM: Increase the data available from the observational networks to 90 percent by 2013	NWS, NOS	NOAA, USGS, States
		PM: Reduce the cost for the DART™ network operation and maintenance	NWS, OAR	
		Goal: Implement fully operational Site-specific Inundation Forecast Tool resident in the Tsunami Warning Centers	NWS	OAR
		Goal: Improve accuracy of tsunami wave arrival time, duration of the tsunami wave activity, and tsunami wave height forecasts	NWS	OAR

Tsunami products that are understandable and usable by the public	(1) Improve product utility and accuracy to customers (2) Ensure reliable and sufficient operational data collection, analysis and product dissemination (3) Support forecast and warning research	Goal: Reduce geographical extent of tsunami warning by basing warned areas on expected threat versus distance or travel time from epicenter	NWS	OAR
		PM: Maintain high level of TWS product satisfaction measured by post-event surveys	NWS	NTHMP partners
		PM: Increase percentage of response from primary recipients to monthly communications tests from 82 percent to 90 percent by 2013	NWS	NTHMP partners
		Goal: Improve graphical products to provide tsunami travel time maps (2007), warnings, watch, and advisory area maps (2009), energy plots (2010), and site specific impact maps by 2012	NWS	OAR, NTHMP partners
Resilient communities inhabited by a public that is educated to take appropriate actions	(1) Establish a domestic and international training program (2) Promote community preparedness and resilience (3) Support forecast and warning research	PM: Increase the number of TsunamiReady™ communities from 46 to 105 by 2013	NWS	NTHMP partners
		Goal: Strengthen TsunamiReady™ to promote coastal community resilience rather than minimal readiness	NWS	NTHMP partners, NEMA, IAEM, social science partners
		Goal: Develop new performance measures for the “strengthened” TsunamiReady™ Program	NWS	NOS, OAR, NESDIS, NTHMP partners
		Goal: Develop a standard “after action or post event review” for TsunamiReady™ communities that captures best practices and lessons learned to demonstrate the value of the TsunamiReady™ Program	NWS	NOS, OAR, NESDIS, NTHMP partners
		Goal: Expand comprehensive community tsunami awareness pilot programs (e.g., Seaside, Oregon) into other “high hazard” coastal communities	NWS	NOS, OAR, NESDIS
		Goal: Conduct community preparedness visits to coastal communities	NWS	NTHMP partners
		Goal: Develop a scenario and loss estimates for a Cascadia Subduction Zone Event, and the initiation of multi-State planning for a response to such an event	NWS, OAR	NTHMP partners, NEMA, IAEM, social science partners

A sustainable Tsunami Program populated by dedicated and properly trained individuals	(1) Ensure adequate and sustainable staff levels (2) Improve organizational communications (3) Support forecast and warning research	Goal: Hire and train Tsunami Program staff to meet appropriate levels	NWS, OAR, NESDIS, NOS	
Reliable and coordinated data, communications, and dissemination infrastructure that supports the Tsunami Program	(1) Ensure integration of data and information systems (2) Promote a fully functional global tsunami forecast and warning system (3) Extend and improve the World Data Center Tsunami Database	PM: Increase efficiency of archive and distribution of post-event tsunami data	NESDIS	NWS, NOS
Tsunami research program that leads to more effective and affordable tsunami warning products	(1) Develop detection, forecast, communication, and mitigation science and technology	PM: Increase the number of Inundation Forecast Models developed for specific high-risk areas from 26 to 75 by 2013	OAR	NWS, NESDIS
		Goal: Identify science and technology to reduce DART™ operations costs and to use forecast models for mitigation products	NWS, OAR	NESDIS, NTHMP partners
	(2) Coordinate with NWS on technology to be transferred	Goal: Transfer tsunami forecasting technology into warning centers	OAR	NWS, NOS, NESDIS, NSF, NTHMP partners
	(3) Conduct social science research	Goal: Form NSF/NOAA partnership to conduct social science research that evaluates the effectiveness of tsunami warning products	OAR	NWS, NOS, NESDIS, NSF, NTHMP partners

Appendix 2. Tsunami Program Legislative Authorities

1. Legislative mandates directing NOAA to invest in development and operation of warning systems include:

i. Tsunami Warning and Education Act, 33 U.S.C. §§ 3201 *et seq*. Authorizes and strengthens the tsunami detection, forecast, warning, and mitigation program of the National Oceanic and Atmospheric Administration, to be carried out by the National Weather Service, and for other purposes.

ii. Weather Service Organic Act, 15 U.S.C. § 313. Sets forth the primary duties of the National Weather Service, including the requirements that the Secretary of Commerce shall: forecast the weather; issue storm warnings; display weather and flood signals for the benefit of agriculture, commerce, and navigation; gauge and report the flow of rivers; maintain and operate the seacoast telegraph lines and collect and transmit marine intelligence for the benefit of commerce and navigation; report temperature and rain-fall conditions for the cotton interests; display frost and cold-wave signals; distribute meteorological information in the interests of agriculture and commerce; and take the meteorological observations that may be necessary to establish and record the climatic conditions of the United States, or that are essential for the proper execution of the foregoing duties.

iii. Provision of Data for Navigation of Marine, Air Commerce and Research into Geophysical Sciences, 33 U.S.C. §§ 883a - 883i. This provides the basis for NOS [NOAA] navigation service programs as well as OAR and NWS coastal seismic and sea level monitoring duties, including the TWCs, and related data management responsibilities of NESDIS. Sec. 883a authorizes the Secretary of Commerce to conduct hydrographic and topographic surveys, tide and current observations, geodetic control surveys, field surveys for aeronautical charts, and geomagnetic, seismological, gravity, and related geophysical measurements to provide charts and other information for safe marine and air navigation. This information is collected, analyzed, assimilated, and distributed by the Department of Commerce. NOS is designated as the central depository for geomagnetic data, and the Secretary is authorized to collect, correlate and disseminate such data. The Secretary is authorized to conduct developmental work for the improvement of surveying and cartographic methods and instruments and to conduct investigations and research in geophysical sciences (33 U.S.C. § 883d). The Secretary is authorized to enter into cooperative agreements with States, Federal agencies, public or private organizations or individuals, for surveying, mapping and publication activities, and to contract with qualified organizations for National Geodetic Survey functions (33 U.S.C. § 883c) . There is a permanent authorization of appropriations (33 U.S.C. § 883i).

Note further that specific duties of the Coast and Geodetic Survey include operation of the National Geomagnetism Program and Honolulu Geomagnetic Observatory (established 1902) and the U.S. Seismic Sea Wave Warning system at the Honolulu Observatory (established in 1946). In 1949, the PTWC in Ewa Beach, Hawaii, was established to provide warnings from teletsunamis to most countries in the Pacific Basin as well as to Hawaii and all other U.S. interests in the Pacific outside of Alaska and the U.S. West Coast.

The NOAA Administrator has been delegated the authority to perform these functions (Department Organization Order, DOO 10-15).

Appendix 3. Strategic Plan Reference Documents

Advancing NOAA's Priorities through Regional Collaboration, National Oceanic and Atmospheric Administration, March 2007. http://www.ppi.noaa.gov/Regional_Collaboration/Regional_Collaboration_Overview_041307.pdf

Bernard, Eddie N., Lori A. Dengler, and Solomon C. Yim. *National Tsunami Research Plan: Report of a Workshop Sponsored by NSF/NOAA*. NOAA Technical Memorandum OAR PMEL-133, March 2007. http://www.pmel.noaa.gov/pubs/PDF/bern3043/bern3043.pdf

Borrero, Jose, Sungbin Cho, James E. Moore, and Costas Synolakis, "The Regional Economic Cost of a Tsunami Wave Generated by a Submarine Landslide off Palos Verdes, California," in *Infrastructure Risk Management Processes: Natural, Accidental, and Deliberate Hazards*, Craig E. Taylor and Erik Vanmarcke, editors. American Society of Civil Engineers, Council on Disaster Risk Management, Monograph No. 1, May 2005.

Crossett, Kristen M., Thomas J. Culliton, Peter C. Wiley, and Timothy R. Goodspeed, *Population Trends Along the Coastal United States: 1980–2008.* National Oceanic and Atmospheric Administration, Coastal Trends Report Series, September 2004. http://www.oceanservice.noaa.gov/programs/mb/pdfs/coastal_pop_trends_complete.pdf

David, Fred R., *Strategic Management Concepts and Cases*. Prentice Hall, 9th Edition, 2003.

Dunbar, Paula K. and Craig S. Weaver, *U.S. States and Territories National Tsunami Hazard Assessment: Historical Record and Sources for Waves.* National Oceanic and Atmospheric Administration and U.S. Geological Survey, April 2007.

Economic Census Program, Program Assessment and Rating Tool, U.S. Census Bureau, 2004.

Munich Re, *Annual Review: Natural Catastrophes in 2004*. Munich Re Group Knowledge Series, Topics Geo, 2005, 60 pages.

National Science and Technology Council, *Tsunami Risk Reduction for the United States: A Framework for Action.* Joint Report of the Subcommittee on Disaster Reduction and the United States Group on Earth Observations, December 2006.

NOAA's Tsunami Program Charter. http://www.ppi.noaa.gov/Weatherand_Water/ww_pdfs/Tsunami.pdf

Program Assessment and Rating Tool Guidance Manual for NOAA Programs

P.L. 109–424: Tsunami Warning and Education Act, approved December 2006. http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=109_cong_public_laws&docid=f:publ424.109.pdf

Tsunami Program Data Management Plan: An Initial Report on the Management of Environmental Data Required to Minimize the Impact of Tsunamis in the United States. National Oceanic and Atmospheric Administration, December 2006.

United States Group on Earth Observations, *Improved Observations for Disaster Reduction: Near-Term Opportunity Plan,* September 2006.

"U.S. Announces Plan for an Improved Tsunami Detection and Warning System," *NOAA News Online*, January 14, 2005. http://www.noaanews.noaa.gov/stories2005/s2369.htm

Appendix 4. Alignment to NOAA's Weather and Water Goal Team Strategic Goals

Outcomes	Objectives	Tsunami Program Outcomes	Tsunami Program Strategies
Reduced loss of life, injury, and damage to the economy	Increase lead time and accuracy for weather and water warnings and forecasts	Timely and accurate tsunami forecasts and warning products	• Ensure reliable and sufficient operational data collection, analysis, and product dissemination
	Improve predictability of the onset, duration, and impact of hazardous and severe weather and water events	Timely and accurate tsunami forecasts and warning products	• Ensure reliable and sufficient operational data collection, analysis, and product dissemination • Support forecast and warning research
Better, quicker, and more valuable weather and water information to support improved decisions	Increase application and accessibility of weather and water information as the foundation for creating and leveraging public (i.e. Federal, State, local, Tribal), private and academic partnerships	(1) Reliable and coordinated data, communications, and dissemination infrastructure that supports the Tsunami Program (2) Tsunami products that are understandable and usable by the public (3) A sustainable Tsunami Program populated by dedicated and properly trained individuals	• Extend and improve the World Data Center Tsunami Database to meet requirements of 33 U.S.C. §§ 3201 *et seq*. • Ensure integration of data and information systems
	Increase development, application, and transition of advanced science and technology to operations and services	Reliable and coordinated data, communications, and dissemination infrastructure that supports the Tsunami Program	
	Reduce uncertainty associated with weather and water decision tools and assessments	(1) Timely and accurate tsunami forecasts and warning products (2) Tsunami products that are understandable and usable by the public	• Improve product utility and accuracy to customers • Establish a domestic and international training program • Support forecast and warning research

Increased customer satisfaction with weather and water services	Increase coordination of weather and water information and services with integration of local, regional, and global systems	(1) Tsunami products that are understandable and usable by the public (2) Reliable and coordinated data, communications, and dissemination infrastructure that supports the Tsunami Program	• Improve Tsunami Program communication • Promote community preparedness and resilience • Promote a fully functional global tsunami forecast and warning system
	Enhance environmental literacy and improve understanding, value, and use of weather and water information and services	Resilient communities inhabited by a public that is educated to take the appropriate response	• Establish a domestic and international training program • Promote community preparedness and resilience
All Weather and Water Goal outcomes	All Weather and Water Goal objectives	All Tsunami Program outcomes	• Ensure adequate and sustainable staff levels • Ensure reauthorization of the Tsunami Warning and Education Act (33 U.S.C. §§ 3201 *et seq*.)

Appendix 5. Alignment to 33 U.S.C. §§ 3201 *et seq.*, Tsunami Warning and Education Act

Tsunami Program Strategies	**33 U.S.C. §§ 3201 *et seq.* Citation**
Ensure reliable and sufficient operational data collection, analysis, and product dissemination	Sec. 3203 (b)(2) – utilize and maintain an array of robust tsunami detection technologies Sec. 3203 (b)(3) – maintain detection equipment in operational condition to fulfill the detection, forecasting and warning requirements of this Act Sec. 3203 (b)(4) – provide tsunami forecasting capability based on models and measurements, including tsunami inundation models and maps for use in increasing the preparedness of communities, including through the TsunamiReady™ Program Sec. 3203 (b)(5) – maintain data quality and management systems to support the requirements of the program Sec. 3203 (b)(6) – include a cooperative effort among the Administration, the USGS, and the NSF under which the USGS and NSF shall provide rapid and reliable seismic information to the Administration from international and domestic networks.
Support forecast and warning research	Sec. 3203 (d)(2)(F) – making data gathered under this Act and post-warning analyses conducted by the NWS or other relevant Administration offices available to researchers Sec. 3205 (1) – consider other appropriate research to mitigate the impact of tsunamis Sec. 3205 (2) – coordinate with the NWS on technology to be transferred to operations Sec. 3205 (3) – include social science research to develop and assess community warning, education, evacuation materials Sec. 3205 (4) – ensure that research and findings are available to the scientific community.
Extend and improve the WDC Tsunami Database to meeting requirements of 33 U.S.C. §§ 3201 *et seq*.	Sec. 3203 (d)(2)(F) – making data gathered under this Act and post-warning analyses conducted by the NWS or other relevant Administration offices available to researchers Sec. 3203 (e)(1)(B) – develop and execute a plan for the transfer of technology from ongoing research described in Sec. 3205 into the program under this Section Sec. 3206 (d) – Data-Sharing Requirement… when deciding to provide assistance under this section, may take into consideration the data sharing policies and practices of nations proposed to receive such assistance, with a goal of encourage all nations to support full and open exchange of data.
Ensure integration of data and information systems	Sec. 3203 (b)(8) – allow, as practicable, for integration of tsunami detection technologies with other environmental observing technologies.
Improve product utility and accuracy to customers	Sec. 3203 (b)(7) – provide a capability for the dissemination of warnings to at-risk States and tsunami communities through rapid and reliable notification to government officials, and the public, including utilization of and coordination with existing Federal warning systems, including the NOAA Weather Radio All Hazards Program.

Promote community preparedness and resilience	Sec. 3203 (b)(4) – provide tsunami forecasting capability based on models and measurements, including tsunami inundation models and maps for use in increasing the preparedness of communities, including through the TsunamiReady™ Program Sec. 3204 (b)(3) – provide recommendations to the NWS on how to improve the TsunamiReady™ Program, particularly on ways to make communities more tsunami resilient through the use of inundation maps and other mitigation practices Sec. 3204 (c)(2) – promote and improve community outreach and education networks and programs to ensure community readiness including the development of comprehensive coastal risk and vulnerability assessment training and decision support tools, implementation of technical training and public education programs, and providing for certification of prepared communities.
Ensure adequate and sustainable staff levels	33 U.S.C. §§ 3201 *et seq*.
Ensure reauthorization of the Tsunami Warning and Education Act of 2006 (P.L. 109-424)	33 U.S.C. §§ 3201 *et seq*.
Improve Tsunami Program communications	33 U.S.C. §§ 3201 *et seq*.

Appendix 6. Acronyms

AOR	Area of Responsibility (for Tsunami Warning Centers)
DART™	Deep-ocean Assessment and Reporting of Tsunamis
EAS	Emergency Alert System
FEMA	Federal Emergency Management Agency
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
IAEM	International Association of Emergency Managers
ICG	International Coordination Group
ICSU	International Council for Science
IOC	Intergovernmental Oceanographic Commission
IOOS	Integrated Ocean Observing System
ISDR	International Strategy for Disaster Reduction
ITIC	International Tsunami Information Center
NEMA	National Emergency Management Association
NESDIS	National Environmental Satellite, Data, and Information Service
NGDC	National Geophysical Data Center
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSF	National Science Foundation
NTHMP	National Tsunami Hazard Mitigation Program
NWR	NOAA Weather Radio All Hazards
NWS	National Weather Service
O&M	Operations and Maintenance
OAR	Office of Atmospheric Research
OMAO	Office of Marine and Aviation Operations
PMEL	Pacific Marine Environmental Laboratory
SEG	Solid Earth Geophysics
PTWC	Pacific Tsunami Warning Center
TWC	Tsunami Warning Center
TWS	Tsunami Warning System
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USAID	United States Agency for International Development
USGS	United States Geological Survey
WDC	World Data Center
WFO	Weather Forecast Office
WMO	World Meteorological Organization

Appendix 7. State, Territorial, and Commonwealth Partners

Washington
Alaska
Hawaii
California
Oregon
American Samoa
Northern Marianas Islands
Guam
Puerto Rico
U.S. Virgin Islands
Texas
Louisiana
Mississippi
Alabama
Florida
Georgia
South Carolina
North Carolina
Virginia
Maryland
New Jersey
New York
Connecticut
Massachusetts
Maine
New Hampshire
Rhode Island
Delaware