

# CRS Report for Congress

## Tsunamis: Monitoring, Detection, and Early Warning Systems

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# Tsunamis: Monitoring, Detection, and Early Warning Systems

## Summary

Congress is concerned about the possible vulnerability of U.S. coastal areas to tsunamis and the adequacy of early warning for coastal areas. This stems from a December 26, 2004, tsunami that devastated many coastal areas around the northern Indian Ocean, where few tsunami early warning systems had operated. Caused by a strong underwater earthquake off the coast of Sumatra, Indonesia, the tsunami claimed an estimated 220,000 lives. Nations affected by the 2004 tsunami, assisted by other countries, launched a multilateral effort to develop a network for regional tsunami detection and warning of coastal populations around the Indian Ocean, the Indian Ocean Tsunami Warning System (IOTWS). The UNESCO Intergovernmental Oceanographic Commission (IOC) leads that international effort. To leverage costs of the IOTWS, IOC members have suggested using extant ocean observation and monitoring networks, data collection systems, marine buoys and tide gage networks, and global telecommunications systems. This may pose the technical challenge of standardizing communication protocols to ensure interoperability of international systems. Also, supporters of the IOTWS consider a fully deployed U.S. network an important component of a future *global* tsunami warning capability.

In January 2005, President Bush proposed to expand U.S. tsunami detection and early warning coverage. Implementing that plan was expected to cost almost \$30 million dollars to build the infrastructure for detection and warning and maintain operations over the long-term. Some U.S. lawmakers argued that the benefits far outweighed the costs; however, others questioned whether the risks of tsunamis outside the Pacific Basin justified the investment. In July 2005, President Bush released a plan to expand the U.S. network from its currently operating six Deep Ocean Assessment and Reporting of Tsunamis (DART) buoys to a planned 39 for monitoring the Pacific and Atlantic Oceans, Gulf of Mexico, and Caribbean Sea. Congress passed emergency appropriations for FY2005 and approved funding through FY2007 to procure and deploy a comprehensive detection and warning network. Amounts allocated for FY2006 enabled the National Weather Service to begin expansion of the network and provided for longer-term operations and maintenance. For FY2008, the President requested funding to complete the U.S. network. Also, the 109<sup>th</sup> Congress passed the Tsunami Warning and Education Act (P.L. 109-424) addressing tsunami-related social issues.

Some developed countries around the Indian Ocean were operating tsunami warning systems when the 2004 disaster occurred, but they guarded only their Pacific shores. Disaster management experts contend that any warning system is most useful where there are expansive regional or local-based emergency management capabilities. Some areas devastated by the tsunami lacked a local communication infrastructure to disseminate tsunami warnings, leaving officials incapable of rapidly alerting populations to evacuate or to take appropriate safety precautions. Experts assert that emergency planning is not only about issuing warnings, but also educating indigenous people and visitors about tsunami dangers, communicating evacuation options clearly, and adapting to potential risks. This report will not be updated.

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# Tsunamis: Monitoring, Detection, and Early Warning Systems

## Introduction

On December 26, 2004, a tsunami disaster was triggered by an underwater earthquake off the west coast of northern Sumatra in Indonesia.<sup>1</sup> Based on physical evidence of displacement of the sea floor, U.S. seismologists determined the earthquake to have been a  $M_w$  9.2.<sup>2</sup> The ensuing tsunami devastated many coastal areas around the northern Indian Ocean and, with the earthquake, caused economic upheaval in many areas. International disaster agencies estimated that more than 220,000 people may have lost their lives as a direct result of the tsunami.<sup>3</sup> The disaster prompted some Members of the 109<sup>th</sup> Congress to raise questions about (1) the possibility of tsunamis occurring in U.S. coastal areas, (2) the extent to which these areas are currently monitored, (3) how tsunamis might be detected, and (4) whether there is a national capacity to issue evacuation warnings for tsunamis.

On January 5, 2005, the House Science Committee, the House Coastal Caucus, and the House Oceans Caucus co-sponsored a briefing organized by the U.S. Geological Survey (USGS) of the Department of the Interior whose purpose was to consider possible implications of the type of the tsunami disaster that occurred in the Indian Ocean for the United States. Experts from USGS and the National Oceanic and Atmospheric Administration (NOAA) of the Department of Commerce delivered presentations about the scientific circumstances surrounding the Indian Ocean tsunami and discussed international capabilities for tsunami monitoring, detection, and early warning.<sup>4</sup>

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<sup>1</sup> A tsunami is a seismic sea wave (or a series of waves) usually generated by an underwater earthquake or landslide, but occasionally caused by volcanic eruption or major landslide *into* the ocean. Tsunami is translated from Japanese as “harbor wave.”

<sup>2</sup>  $M_w$ , the moment of magnitude, is a way to measure the force of an earthquake’s total seismic energy released as a function of rock rigidity in the fault, the total area of contact where friction occurs, and the amount of slippage (or displacement). It is used for earthquakes greater than M8.2 on the Richter scale.

<sup>3</sup> U.N. World Health Organization, Department of Health Measurement and Information Systems, “Asian Tsunami: Death-Toll Addiction and its Downside,” by Michel Thieren. Available at [<http://www.who.int/bulletin/volumes/83/2/82.pdf>].

<sup>4</sup> Presenters at that briefing included, David Applegate, Science Advisor for Earthquake and Geological Hazards at the USGS; General David Johnson, Assistant Director of NOAA’s National Weather Service; Gregg Withee, Assistant Director for NOAA Satellite and Information Services; and Eddie Bernard, Associate Director of NOAA’s Pacific Marine Environmental Laboratory (teleconferencing from Seattle, WA).

Scientists and emergency experts who assessed the damage after the December 26, 2004, tsunami disaster found that there were few, if any, systems for monitoring tsunamis in the Indian Ocean, and little, if any, capability to warn populations locally. Some nations affected by the tsunami, including Australia and Indonesia, did have tsunami early warning systems, but they monitored only their Pacific shores where they perceived the greatest threat.<sup>5</sup> Due to the geographic proximity of many human settlements to where the tsunami was generated, and without ability to receive tsunami warnings rapidly, post-disaster assessments indicate that for Indonesia's Indian Ocean coastal populations emergency communications would have been useless in many cases. Other findings show that many indigenous people and tourists were not educated about the dangers of tsunamis or aware of the physical warning signs of an onset of a tsunami. Also, for some communities, no backup procedure to issue evacuation alerts was included in local or regional emergency plans if "lifelines" such as electric utilities and telecommunications were disrupted.<sup>6</sup>

On January 29, 2005, the House Committee on Science, and on February 2, 2005, the Senate Committee on Commerce, Science, and Transportation held hearings about the need for expanding tsunami early warning protection for the United States and its possessions. Also discussed were long-term goals for guarding non-U.S. coastal regions. Legislation introduced in the 109<sup>th</sup> Congress prior to these hearings by Senator Lieberman of Connecticut (S. 34) and Senator Inouye of Hawaii (S. 50) called for a rapid U.S. response to upgrade existing U.S. capacity for tsunami warning in the Pacific, and to expand operations to include the Atlantic Ocean, the Gulf of Mexico, and the Caribbean Sea. Senator Inouye's bill was closely aligned with President Bush's proposal for U.S. tsunami protection released on January 14, 2005.<sup>7</sup> In addition, S. 50 addressed related social issues such as tsunami disaster education, emergency preparedness, adaptation, and mitigation. (See "**Appendix A.**")

Although most deadly tsunamis have occurred historically in the western Pacific Ocean, examples of recorded events and empirical scientific evidence for the eastern Pacific and North Atlantic Oceans go back centuries. In 1692, a tsunami generated by massive underwater landslides in the Atlantic Puerto Rican Trench reached Jamaica's coast, causing an estimated 2,000 deaths. In 1775, a tsunami struck in the eastern Atlantic Ocean on the coast of Portugal, killing an estimated 60,000 people. In 1929, a tsunami generated in the Grand Banks region of the east coast of Canada

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<sup>5</sup> General David L. Johnson, "NOAA Tsunami and Natural Disaster Information," Jan. 5, 2005 House briefing.

<sup>6</sup> Lifelines are emergency response services, hospitals, other care facilities, energy and water delivery systems, telecommunications, and electronic commerce. See U.S. Congress, Senate, Committee on Commerce Science and Transportation, *Earthquake Hazards Reduction Act, Report to Accompany S. 910*, 105<sup>th</sup> Cong., 1<sup>st</sup> sess., S.Rept. 105-59 (Washington: GPO, 1997), p. 3.

<sup>7</sup> U.S. Office of Science and Technology Policy, "U.S. Announces Plan for Improved Tsunami Detection and Warning System," press release, *OSTP News*, Jan. 14, 2005, available at [<http://www.ostp.gov/html/Tsunamiplanrelease.pdf>], accessed Dec. 1, 2006. See also Eli Kintisch, "South Asia Tsunami: U.S. Clamor Grows for Global Network of Sensors," *Science*, vol. 307, Jan. 14, 2005, p. 191.

hit Newfoundland, killing 51 people. It was the third lethal tsunami for Canada's Atlantic Coast within 150 years.<sup>8</sup>

## **A Global Tsunami Early Warning System?**

In the wake of the 2004 tsunami disaster in the Indian Ocean, many international agencies expected that there would be technical, financial, and political challenges to overcome before a multinational tsunami early warning network could be established for the Indian Ocean or other international earthquake-prone areas, such as the Black Sea. In some ways, those developed nations that had the resources and capability to establish their own regional emergency management networks for disaster warning and those who had executed comprehensive disaster plans were able to avoid some of the challenges.

### **Challenges**

After the Indian Ocean tsunami disaster, international science agencies called for an inventory of existing capacity for tsunami monitoring, detection, and warning systems that would be conducted under the auspices of the United Nations. That inventory would provide a baseline from which outstanding requirements for such a network would be determined. Government policy analysts raised technological and national security issues as a consequence of building and sharing a truly "global" tsunami early warning network. Technological issues included international standards for tsunami warning instrumentation, data collection, and communications protocols required of systems that would receive data and relay warnings. National security issues included proposed open access to and sabotage of international telecommunication networks. Also, U.S. intelligence experts were concerned that certain data collected could be considered sensitive and might reveal methodologies that could compromise U.S. and other nations' intelligence-gathering operations.

Development of a "truly global" tsunami early warning system with a capability for issuing regional and local warnings has required involvement of many nations with widely varying technological capabilities and financial resources. Reports indicate that international political leaders expected that most of the responsibility for paying for such a system would fall on the wealthiest nations. Resources to procure state-of-the-art monitoring and detection technology, including scientific instruments, platforms, and communications networks; to sustain international cost sharing; and to provide long-term operations and maintenance of such systems appear to be the most critical obstacle toward achieving a collaborative international effort for tsunami detection and early warning.

At a January 2005 House briefing, Assistant Director of NOAA for Satellite and Information Services, Gregg Withee, raised another issue when he testified that some

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<sup>8</sup> Statistics on deaths resulting from tsunamis were compiled by CRS from online sources, including data from the Tsunami Laboratory of Novosibirsk, Russia, NOAA's National Geophysical Data Center, the University of Southern California, Tsunami Research Group, and others. See [<http://geology.about.com/library/bl/bltsunamideathtable.htm>].

nations in the Indian Ocean, including India, and elsewhere, maintained proprietary rights to their real-time satellite data, meaning that global monitoring and disaster response institutions would have to pay for the data.<sup>9</sup> Some of these data, Withee asserted, could be critical for detecting and tracking tsunamis in the Indian Ocean and assessing post-disaster damage.

## International Proposals

On January 6, 2005, the United Nations proposed an international effort to develop a tsunami early warning capacity for potentially vulnerable populations located on Indian Ocean coasts. That endeavor is spearheaded by the U.N. Educational, Scientific, and Cultural Organization (UNESCO) Intergovernmental Oceanographic Commission (IOC). In addition, Australia, Japan, Thailand, and India initiated individual efforts to expand existing monitoring capacity for Indian Ocean coastlines.<sup>10</sup> The United States — a member of UNESCO — became involved in the international effort early on. The Government of Thailand held a ministerial meeting in Phuket, January 28-29, 2005, on tsunami early warning protection for the Indian Ocean and Southeast Asia. President Bush's Science Advisor and Director of the Office of Science and Technology Policy, John Marburger III, represented the United States.<sup>11</sup> This meeting was followed by an IOC summit in Paris, France, in March 2005. Attendees included representatives from Indian Ocean countries affected by the December 26, 2004, tsunami, and IOC members. The Director of the UN International Strategy for Disaster Reduction (ISDR) chaired the event.<sup>12</sup> IOC officials stated the session was the first of its kind to firm up plans and commitments for an internationally coordinated tsunami early warning system for the Indian Ocean, including soliciting various member countries' financial pledges.

**Communication of Tsunami Warnings.** The Director of NOAA's National Weather Service (NWS), Brig. Gen. David L. Johnson, USAF, (Ret.) — who also testified in January 2005 congressional hearings on U.S. tsunami early warning capabilities — emphasized that in addition to a network to monitor and

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<sup>9</sup> Gregg Withee, January 5, 2005 House briefing. Stefan Maus of NOAA's National Geophysical Data Center (NGDC) of the NOAA Environmental Satellite program (NESDIS) visited India October 22 to November 20, 2005 to enhance the exchange of geomagnetic data for space weather, main field, and crustal field modeling. See [[http://www.ngdc.noaa.gov/products/news\\_archive\\_2005.html](http://www.ngdc.noaa.gov/products/news_archive_2005.html)].

<sup>10</sup> British Broadcasting Corporation, "Indian Ocean Tsunami Warning System," *BBC News*, Dec. 23, 2005, available at [<http://news.bbc.co.uk/2/hi/science/nature/4524642.stm>]. "Thailand, India and Indonesia are forging ahead with their own systems and Australia, Malaysia and Singapore are planning to develop warning capacities."

<sup>11</sup> U.S. Executive Office of the President, Office of Science and Technology Policy, "OSTP Director John Marburger to Head U.S. Delegation at Thai-Sponsored Meeting to Develop Tsunami Early Warning System for Indian Ocean and Southeast Asia," press release, Jan. 27, 2005.

<sup>12</sup> UN ISDR, "Meeting in Paris to Plan Tsunami Early-Warning System," Press Release: IHA/1019 (Geneva, Mar. 1, 2005). See also, ISDR, *Proposed Strategy for Building Resilience to Tsunamis in the Indian Ocean 2006-2008*, Jan. 27, 2006. Available at [<http://www.unisdr.org/asiapacific/ap-iotsunami/proposed-TEWS-strategy-2006-2008.pdf>].

detect possible tsunamis, emergency communication infrastructures are critical for disseminating tsunami warnings regionally or locally so as to safeguard Indian, western Atlantic, and far Pacific Oceans' coastal populations. He noted that in some regions at risk for tsunamis, local disaster management capabilities may be inadequate or non-existent.

Johnson emphasized that NOAA's responsibilities for tsunami warnings terminate after communications are relayed to the Federal Emergency Management Agency (FEMA) in the Department of Homeland Security and to international emergency management officials.<sup>13</sup> He added that in the United States local or regional forecasts and warnings of severe weather issued by NWS weather forecast offices are often picked up and distributed by local emergency managers and the broadcast media and that the NWS broadcasts warnings directly to individuals and institutions (e.g., public schools possessing NOAA Weather Radio receivers).

NOAA's Administrator, Vice Admiral Conrad C. Lautenbacher, Jr. (Ret. Navy), leads the U.S. effort for developing and implementing an international, collaborative Global Earth Observing System of Systems (GEOSS). This initiative also addresses building capacity for global tsunami early detection and warning capabilities. Billed as "an excellent example of science serving society," Lautenbacher has indicated that GEOSS's infrastructure will be built upon extant environmental data collection platforms, telecommunication capabilities, environmental observation systems, and communication lines operating around the world.<sup>14</sup> Through planned interoperability of GEOSS and other systems, the United States would assist other IOC members in developing a tsunami early warning capacity in the Indian Ocean and eventually a more expansive global network.<sup>15</sup> (See also "Tsunami Detection Operations.") With respect to domestic and international discussions on developing new generation state-of-the-art deep water tsunami detection instrumentation, the U.S. Congress has urged that whatever technologies are adopted to upgrade the U.S. tsunami warning network

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<sup>13</sup> U.S. Congress, Senate Committee on Science, Commerce and Transportation, *United States Tsunami Preparedness*, hearing, Feb. 2, 2005. Oral testimony of Brig. Gen. Jack Kelly, Jr., former NWS Director, and present Deputy Administrator for NOAA on behalf of Vice Admiral Conrad Lautenbacher, Jr. (U.S. Navy, Ret.) Undersecretary of Commerce for Oceans and Atmosphere and NOAA Administrator, National Oceanic and Atmospheric Administration, Department of Commerce.

<sup>14</sup> U.S. Dept. of Commerce, NOAA, Office of the Federal Coordinator for Meteorology, "World Weather Program: The Global Observing System: Its Impacts and Future," by BGEN John J. Kelly Jr., (USAF, Ret.), *The Federal Plan for Meteorological Services and Supporting Research: Fiscal Year 2006*, Report FCM P1-2005, Appendix B: 237-243 (Washington, DC: October 2005). Other examples of international communications networks are included.

<sup>15</sup> For example, one of the international observation networks currently being developed and proposed to be a major component of GEOSS is the International Global Ocean Observing System (IGOOS). Another is a potential network of thousands of ARGO floats that monitor global climate variability in the equatorial Pacific, known collectively as the ARGO Array. For more information on ocean observing systems, see U.S. Congress, House Resources Subcommittee on Fisheries, Conservation, and Wildlife, *Status of Ocean Observing Systems in the United States*, Oversight Hearing, serial no. 108-102, July 13, 2004 (Washington, DC: GPO, 2005).



also serve multiple purposes to enhance future global environmental observations of systems such as GEOSS.

Most international science agencies and non-governmental organizations representing Indian Ocean nations generally support the developing GEOSS as the infrastructure for a future global tsunami early warning network. Many other nations praised President Bush's January 2005 proposal and then his July 2005 "action plan" for a U.S. tsunami warning system as "a good start," and a model for a global system.

**U.S. DART Buoys for the Indian Ocean.** At a May 2006 meeting in Melbourne, Australia, the United States laid out plans for lending two "surplus" state-of-the-art Deep Ocean Assessment and Reporting of Tsunamis (DART II) buoys for "operational detection of tsunami and verification of non-events in the Indian Ocean."<sup>16</sup> U.S. contributions, and similar contributions from other developed countries such as Germany, are helping to establish a limited archetypical IOTWS in the near-term. NOAA selected two sites to deploy the Dart buoys:<sup>17</sup> (1) near the Andaman Islands off Sumatra, Indonesia at, 0°N and (2) between Colombo, Sri Lanka, and Phuket, Thailand, at 9°N. NOAA deployed the first buoy in December 2006 to commemorate the anniversary of the 2004 disaster. The second deployment is scheduled for May 2007. NOAA officials say that they would provide technical assistance and some funding for operation and maintenance (O&M) through whatever entity is established to manage the IOTWS. The IOC is also discussing mechanisms to fund a "tsunami watch capacity" that would include long-term O&M of the entire IOTWS. Many IOC members have agreed that the development and deployment of the IOTWS provides opportunities and platforms for hosting other environmental sensors. They also have suggested joint uses of international fleets to assist in deployment and maintenance of the buoys.<sup>18</sup>

## Tsunami Protection for the United States

In January 2005, Representative Pallone of New Jersey called for establishing a tsunami detection and warning network for the U.S. Atlantic coast, Gulf of Mexico, and Caribbean Sea.<sup>19</sup> Other lawmakers questioned whether the risk of a tsunami for

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<sup>16</sup> ICG/IOTWS Working Group 2 on Sea Level Data Collection and Exchange, Including Deep Ocean Tsunami Detection Instruments, *Draft Minutes: Annex IV, Proposal by U.S. for Contribution of Two DART Buoys to the IOTWS*, in Inter-session Meeting, 1-2, May 2006, Melbourne, Australia, pp. 16-25, [41 p.], available at [<http://ioc3.unesco.org/indotsunami/documents/wgfiles/WG2%20Interseasonal%20meeting%20report%20Melbourne.pdf>].

<sup>17</sup> Their placement is outside the limits of any single nation's Exclusive Enterprise Zone (EEZ).

<sup>18</sup> IGO/PTWS Coordination Group, Article 4.9, p. 8.

<sup>19</sup> Statement of Representative Frank Pallone, *Congressional Record*, Jan. 4, 2005: H40. "There has been a lot of discussion and I think there is a need to expand the tsunami early warning system that exists in the Pacific not only to the Indian Ocean but also possibly to (continued...)

the east coast justified such expenditures. At January 2005 congressional briefings, NOAA scientists pointed out the potential dangers related to the Puerto Rican Trench — the deepest point in the western Atlantic Ocean — to assure that the risks were real.<sup>20</sup> They cited massive landslides and sloughing that have occurred historically along the North American continental shelf and strong underwater earthquakes that occurred off the coast of Puerto Rico, which, in some cases, generated tsunamis that caused loss of life in the thousands and widespread property damage.<sup>21</sup>

New Hampshire, among other states, has had a contingency plan for tsunami emergencies and has managed a clearinghouse of information about historical tsunami disasters that have affected the northeast United States.<sup>22</sup> In 2005, two U.S. communities in the western Atlantic basin became the first of NWS *TsunamiReady* communities outside the Pacific Basin. One of these was in Florida on the Gulf of Mexico and the other was Norfolk, VA, on the mid-Atlantic Coast.<sup>23</sup> Since then, five other Atlantic coast states and Puerto Rico have been declared *TsunamiReady* by NWS. In contrast, some areas potentially at risk for tsunamis in the eastern Pacific Ocean, including the U.S. mainland, Alaska, and Hawaii have had tsunami emergency evacuation plans in place for over 40 years.

## Bush Administration Actions

On January 14, 2005, the White House Office of Science and Technology Policy (OSTP) announced a proposal for an improved tsunami warning and detection system for the United States.<sup>24</sup> The President’s plan stated that 32 dedicated tsunami warning and detection DART buoys would be procured and deployed by mid-2007. The President’s stated goal was to improve tsunami detection for the far Pacific and Atlantic Oceans, Gulf of Mexico, and Caribbean Sea.

**President Bush’s Tsunami Action Plan.** In December 2005, President Bush released *Tsunami Risk Reduction for the United States: A Framework for*

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<sup>19</sup> (...continued)

the Atlantic Ocean and throughout the world.”

<sup>20</sup> USGS, Woods Hole Science Center, “Caribbean Tsunami and Earthquake Hazards Studies Program,” available at [[http://woodshole.er.usgs.gov/projects/project\\_get.php?proj=29210EQ&style=html](http://woodshole.er.usgs.gov/projects/project_get.php?proj=29210EQ&style=html)].

<sup>21</sup> See “The Puerto Rico Trench: Implications for Plate Tectonics: Earthquake and Tsunami Hazards” at [<http://oceanexplorer.noaa.gov/explorations/03trench/trench/trench.html>] and also, University of Puerto Rico at Mayaguez, The Puerto Rico Warning and Mitigation Program at [<http://poseidon.uprm.edu>].

<sup>22</sup> State of New Hampshire, “Disaster Plan 409,” Sect. II, Geological Hazards, Seismic Hazards, at [[http://www.nhoem.state.nh.us/mitigation/state\\_of\\_new\\_hampshire.asp](http://www.nhoem.state.nh.us/mitigation/state_of_new_hampshire.asp)]. See also NOAA, National Weather Service *TsunamiReady* Program, “Is your Community Ready for the Next Tsunami?,” at [<http://tsunami.gov>].

<sup>23</sup> NOAA, National Weather Service, “*TsunamiReady* Communities,” available at [<http://www.tsunamiready.noaa.gov/ts-communities.htm>].

<sup>24</sup> U.S. EOP, OSTP, Press release, Jan. 14, 2005.

*Action* (dated July 2005).<sup>25</sup> This plan outlined steps to be taken to reduce tsunami risk on the U.S. mainland, Hawaii, and U.S. territories in the far Pacific Ocean and Caribbean Sea.<sup>26</sup> To implement recommendations in his plan, President Bush proposed \$20.4 million for the NWS for FY2007. He also requested \$3.95 million for USGS's Global Seismic Network (GSN) upgrades, about \$35,000 more than FY2006-enacted funding. That funding would enable real-time telemetry for 20% of 127 global seismic sensing platforms which lack that capability. (See "**Appendix B,**" **Table 1.**)

To complement the President's plan, some social scientists argued for "institutionalizing" a public education component in implementing legislation that might serve to protect the United States from tsunamis.<sup>27</sup> They envisioned training of local authorities as resident developers and deliverers of disaster education and local tsunami emergency planning, in addition to interagency resource sharing at all levels of government and a visible federal agency-presence within the community.<sup>28</sup> Finally, they recommend adaptation as an alternative means of disaster management, such as using low-tech, high-impact solutions for disseminating public evacuation orders.<sup>29</sup> (See **Appendix A**, S. 50, 109<sup>th</sup> Cong.)

## National Weather Service Tsunami Programs

NOAA's National Weather Service (NWS) has managed the U.S. operational program for tsunami warnings in U.S. Pacific coastal areas and has played a role in international tsunami protection. The National Tsunami Warning Program (NTWP) consists of two U.S. tsunami warning centers that monitor, detect, and warn for possible tsunamis generated in the Pacific Ocean.

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<sup>25</sup> Executive Office of the President, National Science and Technology Council, *Tsunami Risk Reduction For the United States: A Framework for Action*, A Joint Report of the Subcommittee on Disaster Reduction and the United States Group on Earth Observations, July 2005 (released December 2005).

<sup>26</sup> *Ibid.*, Ch. 4, "International Cooperation."

<sup>27</sup> Eileen Shea, Project Coordinator, East West Center, Honolulu, HI, "Testimony," Senate Commerce Tsunami Preparedness hearing, Feb. 2, 2005, available at [[http://commerce.senate.gov/hearings/testimony.cfm?id=1361&wit\\_id=3955](http://commerce.senate.gov/hearings/testimony.cfm?id=1361&wit_id=3955)].

<sup>28</sup> See Government Accountability Office (GAO), "State and Local Tsunami Hazard Mitigation Activities Are Under Way although Implementation Varies Considerably among Locations," in *U.S. Tsunami Preparedness: Federal and State Partners Collaborate to Help Communities Reduce Potential Impacts, but Significant Challenges Remain*, GAO Report GAO-06-519, June 2006, p. 29. Prepared for Congressional Committees and Senator Diane Feinstein.

<sup>29</sup> See Eileen Shea, Project Coordinator, East West Center, Honolulu, HI, "Testimony," Senate Commerce Tsunami Preparedness hearing, Feb. 2, 2005, available at [[http://commerce.senate.gov/hearings/testimony.cfm?id=1361&wit\\_id=3955](http://commerce.senate.gov/hearings/testimony.cfm?id=1361&wit_id=3955)].

An associated program under the NTWP concentrates on reducing the rate of false tsunami alarms issued for the Pacific Ocean. The National Tsunami Hazards Mitigation Program (NTHMP) assists states in emergency planning and in developing maps of potential coastal inundation for a tsunami of a given intensity. The NTHMP also operates tsunami disaster outreach and education programs through NOAA's *TsunamiReady* program.

**Tsunami Warning Centers.** The NWS operates the Pacific Tsunami Warning Center (PTWC) at Ewa Beach, HI, and the West Coast/Alaska Tsunami Warning Center (WC/AKTWC) at Palmer, AK. The PTWC monitors for tsunamis and issues warnings for the Hawaiian Islands, the U.S. Pacific territories, and other U.S. and international interests in the Pacific Basin. The center was established in 1949, after a strong earthquake and massive landslides off the coast of southwest Alaska caused a disastrous tsunami for the Hawaiian Islands only hours later. The WC/AKTWC was established in 1967, following a devastating earthquake of  $M_w$  9.2 that struck Anchorage, AK, in 1964 and caused major earthquake and localized tsunami damages.<sup>30</sup> The WC/AKTWC is responsible for issuing tsunami warnings to emergency management officials in Alaska, British Columbia (Canada), Washington State, Oregon, and California. The WC/AKTWC now also serves as the center for warning U.S. populations located in the western Atlantic Ocean and is linked by telemetry with seven deep ocean DART buoys currently deployed off U.S. Atlantic, Caribbean, and Gulf of Mexico shores. (See **Figure 1**).

**National Tsunami Hazard Mitigation Program (NTHMP).** In 1992, NOAA launched the NTHMP to address the credibility of Pacific tsunami warnings. At that time, there had been a 75% false-alarm rate for tsunamis. Local officials in Hawaii became concerned about significant social upheaval and economic disruption being caused by false alarms and whether the public would continue to heed future tsunami warnings. Through technological progress and iterative improvements, the false-alarm error rate has improved significantly since then. In addition, periodic drills are conducted by the Hawaiian government to familiarize the public with proper emergency procedures to be followed in the event of an actual disaster.

Another major research effort at NTHMP considers the potential for a sizable earthquake in the Pacific Northwest Cascadia Region which USGS scientists and others believe would generate tsunamis that could severely damage several U.S. Pacific coastal regions.<sup>31</sup> The NTHMP has worked with five Pacific states — Alaska, California, Hawaii, Oregon, and Washington — and is now working with five Atlantic states and Puerto Rico in developing local tsunami emergency preparedness plans for “communities-at-risk” as part of NOAA's *TsunamiReady* program.<sup>32</sup>

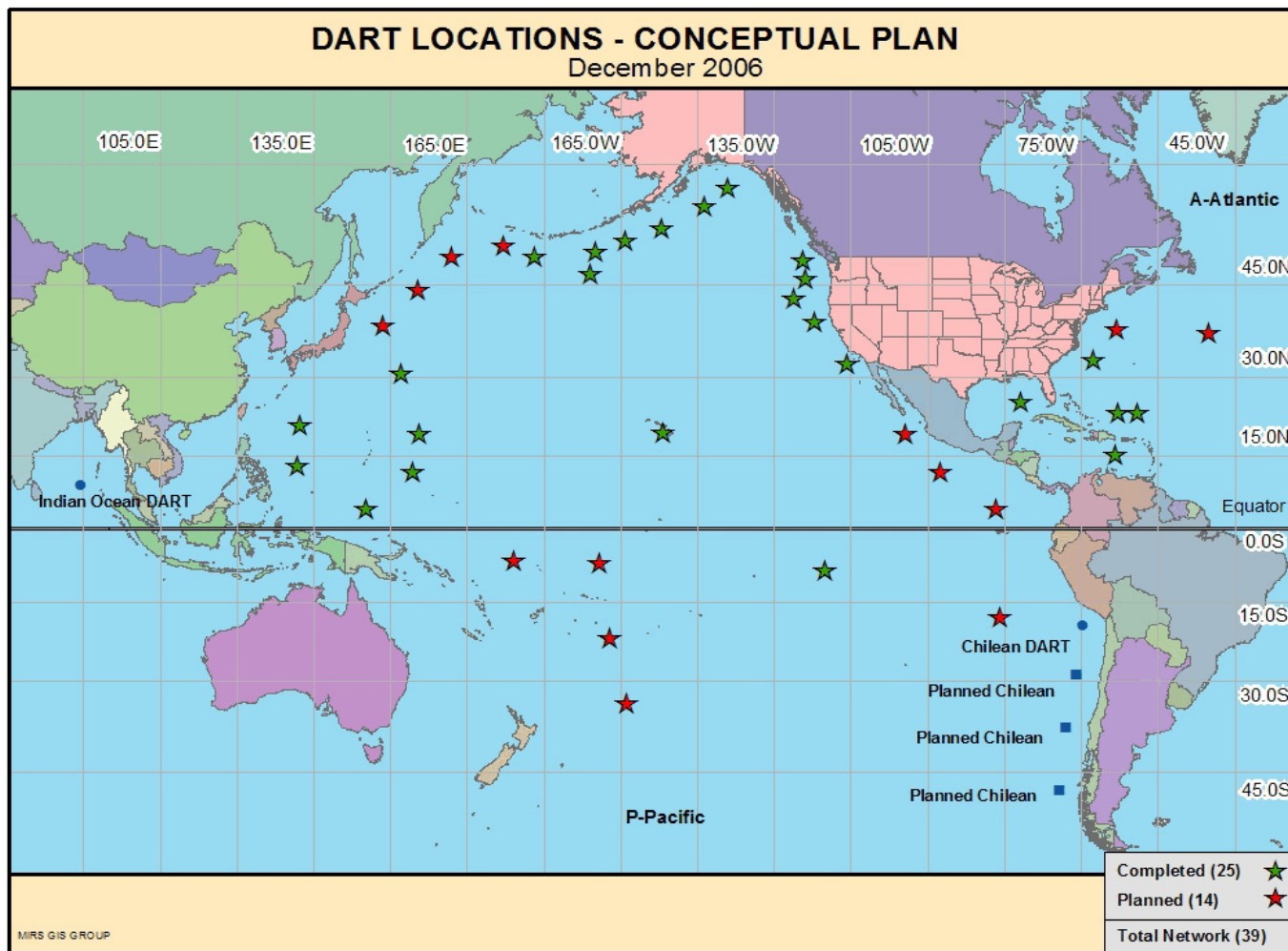
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<sup>30</sup> See NOAA, NWS, “How *TsunamiReady* Helps Communities and Counties at Risk,” available at [<http://www.stormready.noaa.gov/tsunamiready/>].

<sup>31</sup> USGS, “Local Tsunami Hazards in the Pacific Northwest from Cascadia Subduction Zone Earthquakes,” by Eric L. Geist, at [<http://pubs.usgs.gov/pp/pp1661b/pp1661b.pdf>].

<sup>32</sup> NOAA, NWS, *TsunamiReady*, at [<http://www.stormready.noaa.gov/tsunamiready/ts-communities.htm>].

Figure 1. Proposed U.S. DART Buoy Network



**Source:** National Oceanic and Atmospheric Administration. "NOAA Increases Tsunami Warning Capability for the Most Threatened Parts of the United States," December 22, 2006. Available at [<http://www.noaaneews.noaa.gov/stories2006/s2765.htm>].

NTHMP research and development has resulted in technology transferred to assist tsunami warning operations. An example is a tsunami disaster model which — with the requisite seismic data and knowledge of location of where a tsunami is triggered — can project the trajectory and intensity of ensuing waves. The NTHMP also assists states on behalf of coastal communities in producing maps of potential tsunami inundation.

**Tsunami Detection Operations.** NOAA currently operates a network of 20 dedicated tsunami detection and relay stations as part of the NWS DART Program. NWS will deploy a total of 39 stations as the backbone of the U.S. tsunami early warning network.<sup>33</sup> (See **Figure 1** for DART buoy locations and **Figure 2** for the technical components.) In April 2006, seven DART buoys were added to the U.S. network and deployed in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico.<sup>34</sup> Eventually, 32 U.S. DART buoys will operate in the Pacific Ocean, including the current three off the Alaskan Peninsula and three in the mid-Pacific Ocean. Another DART buoy was developed for the Chilean government and is deployed in the eastern South Pacific Ocean off Chile’s coast. Although the United States and partnering nations that rely on the network may have the capability for early detection of tsunamis, NOAA officials have cautioned that subsequent warnings are only effective if national emergency officials can receive those communications and, in turn, alert the public to take the necessary precautions or actions.

**Other Supporting Technologies.** In addition to a planned 39 operating DART buoys, the NWS operates hundreds of marine weather buoys around U.S. coasts. These buoys provide data for telecommunications-capable, meteorological-instrumented platforms which have figured into the overall plans for an expanded U.S. tsunami early warning network.<sup>35</sup> Also, tide gages off all U.S. coasts and in the Great Lakes can detect sudden surges and other disturbances such as changes in submarine pressures which may be indicative of a possible approaching tsunami.<sup>36</sup>

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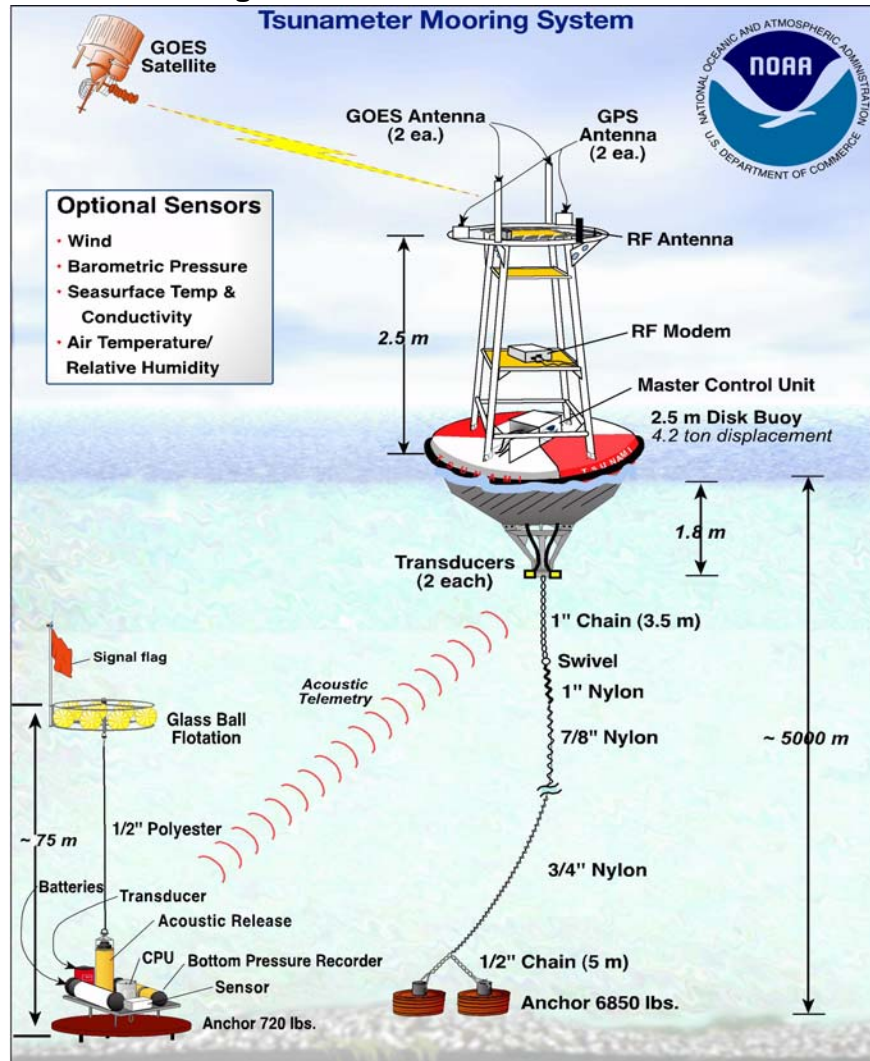
<sup>33</sup> Hugh B. Milburn et al., “Real-Time Tsunami Reporting from the Deep Ocean,” NOAA Pacific Marine Environmental Laboratory (1996), at [[http://www.ndbc.noaa.gov/Dart/milburn\\_1996.shtml](http://www.ndbc.noaa.gov/Dart/milburn_1996.shtml)].

<sup>34</sup> NOAA FY07 Budget Briefing, National Press Club, Washington, DC, Feb. 9, 2006. See also **Figure 1**.

<sup>35</sup> For example, NWS weather buoys record data, such as temperature, wind speed and direction, and atmospheric pressure at a fixed location. Other “drifting” marine data buoys measure the speed of ocean currents, changes in salinity (or density) of the ocean, and changes in sea surface from the “mean height.” Sea surface height data can also be collected by sensors on U.S. satellites. In all cases, those data are relayed to ground receiving stations.

<sup>36</sup> The National Ocean Service (NOS) operates the National Water Level Observation Network of tide-gages off *all* U.S. coasts and in the Great Lakes (NWLON). In major U.S. harbors the NOS PORTS program, in addition to operating tide gages, assesses the physical conditions of shipping channels which may bear on how a tsunami might impact that particular location. National tide gage operations are also found in other countries.

Figure 2. NOAA DART Platform



**Source:** National Oceanic and Atmospheric Administration, from “U.S. Announces Plans for an Improved Tsunami Warning and Detection System.” See [<http://www.noaanews.noaa.gov/stories2005/s2369.htm>], accessed January 18, 2005.

In addition to weather and marine navigational buoys, about 1,000 of a planned array of 3,000 ARGO “drifter” floats currently operate in the equatorial Pacific Ocean. These are used for monitoring short-term climate variability and operate primarily to detect ocean conditions associated with El Niños and La Niñas (periodic climate adjustments in the ocean that affect global weather). NOAA officials have advocated using ARGO floats as platforms for situating tsunami detection instrumentation as well as other instrumentation to build a Global Ocean Observation System, calling the ARGO Array the “next step in global observations.”<sup>37</sup> As early as in the 108<sup>th</sup> Congress, prior to the Indian Ocean disaster,

<sup>37</sup> NOAA/Woods Hole Oceanographic Institution, *Observing the Ocean in Real-Time: Argo, a Global Array of Profiling Floats to Understand and Forecast Climate*, ed. Stan Wilson (1996). Funded in part by private academic institutions.

legislation had been introduced to consider the auxiliary technologies that might enhance a U.S. tsunami detection and warning network.<sup>38</sup>

For the eastern United States, NOAA officials have suggested other platforms for tsunami monitoring and detection in the Atlantic Ocean such as regional coastal and ocean observation networks currently operating or being developed for the eastern seaboard of Canada, U.S. coastal waters, and the Great Lakes. In support of U.S. interests in the Gulf of Mexico coasts, in the Caribbean Sea, and Atlantic coasts of the Greater Antilles, the University of Puerto Rico at Mayaguez developed and now operates a regional tsunami warning system and communications network.<sup>39</sup>

## Related and Contributing U.S. Programs

The U.S. Geological Survey (USGS) is improving the earthquake monitoring and warning capabilities of the Global Seismic Network (GSN) by upgrading stations that have not had real-time data communication ability. USGS has also increased coverage of seismic alerts at the National Earthquake Information Center (NEIC) in Golden, CO. Other alternatives for broadcasting tsunami warnings may include radios, cellular phone networks, and the Internet to reach local officials or rural populations. International telecommunications networks, such as the Global Telecommunication System (GTS) (with common data transmission protocols) provide a capability for emergency communications among worldwide government institutions (i.e., weather bureaus).<sup>40</sup>

**The U.S. Geological Survey (USGS).** The USGS is also integral to the NWS National Tsunami Warning Program. USGS operation of the Global Seismic Network has been critical in identifying the potential for and issuing early warning of tsunamis. The GSN is a network of 127 global seismic monitoring stations, some of which are situated in the Indian Ocean. The GSN network is managed by the Incorporated Research Institutions for Seismology (IRIS), which is a consortium of academic institutions involved in earthquake monitoring, detection, and modeling.<sup>41</sup>

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<sup>38</sup> On Jan. 5, 2005, Representative Curt Weldon circulated a “Dear Colleague” letter advocating the reintroduction of H.R. 5001 (108<sup>th</sup> Congress), the Ocean and Coastal Observation System Act, in the 109<sup>th</sup> Congress. This legislation promoted development of an “Integrated Ocean Observation System,” to protect U.S. citizens in coastal communities from tsunamis. For further information on U.S. ocean observation systems, see U.S. House Resources Subcommittee on Fisheries, Conservation, and Oceans, *Status of Ocean Observing Systems in the United States*, Oversight Hearing, serial no. 108-102, July 13, 2004 (Washington, DC: GPO 2005).

<sup>39</sup> University of Puerto Rico at Mayaguez, *Puerto Rico Tsunami Warning and Mitigation Program*, available at [<http://poseidon.uprm.edu/>].

<sup>40</sup> Kenneth B. Allen, Director of the Partnership for Public Warning, “Letter to President Bush,” Jan. 3, 2005, at [<http://www.partnershipforpublicwarning.org/ppw/>]. See also, Joab Jackson, “Cisco, IBM Propose Internet-Based Disaster Alert System,” *Government Computer News*, Feb. 11, 2005, available at [<http://www.gcn.com/>].

<sup>41</sup> Incorporated Research Institutions for Seismology (IRIS), “Global Seismic Network (GSN) at [<http://www.iris.edu/about/GSN/>].



Although the USGS does not monitor directly for *tsunamigenesis*,<sup>42</sup> the GSN measures intensity of land-based and submarine earthquakes around the globe in real-time. Depending on where they occur and their magnitude, the USGS determines whether to alert NOAA (NWS) of the possible onset of a tsunami.

At the time of the tsunami disaster in the Indian Ocean, USGS officials indicated that only about 80% of GSN instruments had capability for real-time data telemetry.<sup>43</sup> In FY2005, P.L. 109-13 funded President Bush's request to upgrade the GSN network for 100% real-time communication capability. The 109<sup>th</sup> Congress appropriated \$8.1 million in emergency supplemental appropriations for that purpose. Of the \$8.1 million provided, a part of the funding was to increase the number of seismic monitoring stations around the globe.<sup>44</sup> Another part of the funding was to increase the number of staff at the NEIC to monitor GSN data. Conferees on the emergency funding bill noted that resources recommended for GSN upgrades might enable USGS and NWS to exchange more comprehensive data and information for tsunami modeling exercises in a more timely manner.

USGS scientists at the NEIC collect and analyze data on crustal deformation and ocean floor displacement from earthquakes and determine which events may be precursors to the generation of tsunamis. USGS topographical mapping data and digital elevation models (DEM) have been used to develop more spatially accurate tsunami inundation maps for potential communities-at-risk. The inundation maps have assisted emergency managers in developing tsunami evacuation plans and have also guided decisions of local government authorities in land-use planning and private development by considering the possible impacts of tsunamis. USGS primarily monitors for seismic activity on land, but its geologists have asserted that land-based operations can be as important for tsunami detection and warning as deep ocean buoys.<sup>45</sup> In coastal areas of the United States, and especially along the Pacific coast, earthquakes have generated landslides, some of which have resulted in abrupt mass wasting of land into the ocean and displacing large volumes of water locally. Large submarine landslides occur beneath the ocean and off the continental shelf occasionally generating tsunamis. Other research has been conducted at USGS to consider the potential effects on the U.S. Atlantic coast from a "super tsunami" that may be caused by the collapse of a volcano in the Canary Islands off west Africa.<sup>46</sup>

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<sup>42</sup> The formation of a tsunami.

<sup>43</sup> Dr. Charles Groat, Director of the USGS, presentation on the USGS FY2006 budget held at the Dept. of the Interior, Washington, D.C., Feb. 7, 2005. Congress appropriated \$8.1 million in emergency supplemental appropriations for FY2005 in P.L. 109-13.

<sup>44</sup> Dr. Charles Groat, Director of the USGS, presentation on USGS FY2007 budget held at the Dept. of the Interior, Washington, D.C., Feb. 6, 2006.

<sup>45</sup> These include the USGS Advanced National Seismic System (ANSS), the Global Seismic Network (GSN), National Strong-motion Program, and other U.S. regional networks and cooperators. See [<http://earthquake.usgs.gov/research/index.php?areaID=12>].

<sup>46</sup> Rossella Lorenzi, "Top World Tsunami Hotspots Detailed," *Discovery News (online)*, Jan. 11, 2005, available at [<http://dsc.discovery.com/news/briefs/20050110/tsunamidanger.html>]. "According to Simon Day, Benfield Greig Hazard Research Center at University College (continued...)"

**World Weather Watch.** The U.N. World Weather Watch (WWW) is a cooperative program organized and administered by the U.N. World Meteorological Organization (WMO). The mission of the WWW is to ensure that people no matter where they are around the globe are adequately warned about possible severe weather or dangerous ocean-related conditions.<sup>47</sup> NOAA officials regard the global reach of WWW networks and associated World Weather Program (WWP) data centers<sup>48</sup> as an important tool for communicating tsunami warnings and tsunami-related data and information to international governments and scientific institutions respectively.

NOAA also has a leadership role in the WWW with respect to meteorological data collection, management, and archiving.<sup>49</sup> The Department of State negotiates on behalf of the United States to achieve and maintain international agreements that sustain WWW operations globally. WWW members, including the United States and its Far Pacific trust territories, use established international telecommunications protocols (GTS) for receiving and disseminating weather data, forecasts, and warnings.

**National All Hazards Weather Radio (NAHWR).** The NWS has operated NOAA Weather Radio (NWR) for decades to warn individuals in their homes or at public institutions such as schools and hospitals of the potential of severe weather and to take appropriate action.<sup>50</sup> In 2003, the Department of Homeland Security

<sup>46</sup> (...continued)

London, U.K., geological evidence suggests that during a future eruption, Cumbre Vieja Volcano on the island of La Palma in the Canary Islands, off West Africa, could experience a catastrophic failure of the western flank.”

<sup>47</sup> NOAA officials stress that, “The exchange and sharing of data on a worldwide basis is a critical part of developing descriptions and the understanding of our global environment.” U.S. Dept. of Commerce, NOAA, Office of the Federal Coordinator for Meteorology, “World Weather Program,” *The Federal Plan for Meteorological Services and Supporting Research: Fiscal Year 2005*, Report FCM P1-2004, Appendix B: 223-228 (Washington, DC: Oct. 2004). Examples of international communications networks are included.

<sup>48</sup> NOAA, NESDIS, “About the World Data Center System.” Two of three WMO World Weather Program (WWP) data centers are housed in NOAA’s Environmental Satellite and Data and Information Service (NESDIS) National Geophysical Data Center (NGDC). (See, [<http://www.ngdc.noaa.gov/wdc/wdcmain.html>]). These data centers archive global weather data and analysis, and are telecommunication enabled portals used for exchanging meteorological and climatological data and scientific research around the globe. WWP data archives provided valuable information for post-disaster assessment of the 2004 Indian Ocean tsunami. See, for example, “NOAA Scientists Able to Measure Tsunami Height from Space,” available at [<http://www.noaanews.noaa.gov/stories2005/s2365.htm>]. The U.S. Global Earth Observation (GEO) Workplan for 2006 “identifies the WDCs as one of the archives for data collected over coastal regions subject to tsunami risk.” See [[http://www.ngdc.noaa.gov/products/news\\_archive\\_2005.html](http://www.ngdc.noaa.gov/products/news_archive_2005.html)].

<sup>49</sup> NESDIS’s National Oceanic Data Center (NODC) maintains the NOAA/IOC long-term archive of global tsunami events, including inundation, and damage data.

<sup>50</sup> Over time, Congress has expanded the reach of NOAA NWR by authorizing funds to construct more NWR transmission towers or adding repeaters that can be mounted on (continued...)

(DHS) initiated discussions with NWS to collaborate and modify NWR to enable dissemination of public warnings for *all* disasters, natural or otherwise.<sup>51</sup> An agreement between the two agencies paved the way for a DHS National All Hazards Weather Radio Network (NAHWR) that would broadcast warnings and hazard-related information over the existing NWR communications spectrum, now coined the Public Alert network.<sup>52</sup> NOAA has retained management of the NWR network.

DHS envisions NAHWR disseminating warnings of earthquakes, tsunamis, volcanoes, floods, other natural disasters, and terrorist or industrial-related disasters. In 2003, Congress provided \$10 million in the Emergency Wartime Supplemental Appropriations Act, 2003 (P.L. 108-11), to develop the architecture of the NAHWR network.<sup>53</sup> NOAA received appropriations of about \$2.3 million for NWR in base funding for local weather forecasts and warnings in FY2006 and the same amount for FY2007 (P.L. 110-5). President Bush requested \$2.3 million for NWR for FY2008. However, some observers have argued that about \$150 million is needed to develop a broadband network capable of integrating multiple federal agency emergency communications.

Despite progress with NAHWR, the NWR network still stands on its own. NOAA officials have asserted that NWR can help to safeguard some people living in coastal areas of the United States with early warning of an approaching tsunami, possible coastal flooding from storm surges, and other hazardous marine conditions such as rough waters or unusually high tides. They add that NWR can also serve to notify coastal populations of tsunami false alarms, which may alleviate some resulting panic and economic disruption. Many emergency management experts believe that an expansive NAHWR network will materialize in the future; however,

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<sup>50</sup> (...continued)

existing structures in some localities to extend the range of existing NWR emergency transmissions. The battery operated receiver is the critical component for receiving emergency warnings. An audible alarm is generated and the device activated by a NWS transmission of a severe weather warning. The instrument also generates a flashing light for the hard of hearing. NWR receivers are made available to the public at a modest cost for individuals, and at no cost to public schools applying for grant assistance. The NWS has attempted to target rural areas so as many potentially affected communities as possible have an opportunity to receive severe weather-related warnings or other emergency communications from their nearest NWS Weather Service Office (WSO). Also, because of significant advances in weather forecast technologies the lead time for emergency warnings in most cases has increased giving people more time to take appropriate action.

<sup>51</sup> National emergency management communications for the United States became the responsibility of the Department of Homeland Security (DHS) in March 2003, when FEMA was transferred to the newly established DHS.

<sup>52</sup> See NOAA All Hazards Weather Radio (NWR) at [<http://www.nws.noaa.gov/nwr/>].

<sup>53</sup> Congress approved \$156 million in §3010 of the Deficit Reduction Act of FY2005 (P.L. 109-171). (See H.Rept. 109-362, p. 204). The funding would “provide for an *all hazards* alert system to [issue] alerts in response to natural disasters, man-made accidents, and terror incidents.” Of that amount, \$50,000,000 would be used to implement a tsunami warning and coastal vulnerability program that would be funded by proceeds from a Federal Communications Commission (FCC) spectrum auction. The measure passed Congress on Feb. 6, 2006 (H.Rept. 109-366) and was signed by the President on February 8, 2006.

that depends on a number of factors which include available federal resources, standardization of telecommunications (communication protocol), and system interoperability among the various U.S. agencies responsible for disasters.

**Cooperative Protection for the Pacific Basin.** NOAA's Director of the NWS leads the UNESCO International Coordinating Group (ICG) for the International Tsunami Warning System in the Pacific (ITSU). ITSU was created in 1968 and has operated out of the Pacific Tsunami Warning Center (PTWC) until recently when a separate international warning center for the Pacific was dedicated. In October 2005, ICG/ITSU was renamed ICG/Pacific Tsunami Warning and Mitigation System (ICG/PTWMS), a change made to align the new center with tsunami warning and mitigation programs operated under UNESCO's Intergovernmental Oceanographic Commission (IOC) and to distinguish it from the U.S. PTWC. The PTWMS currently serves 28 member nations that are vulnerable to tsunamis generated around the Pacific Basin. Three member states — Australia, Thailand, and Indonesia (in part) — are unique in that they are also threatened by tsunamis generated in the Indian Ocean.<sup>54</sup> (For more information on U.S. participation in international efforts to develop regional tsunami protection, see “International Proposals.”)

## Conclusion

Decisions about whether and how to proceed with establishing an international tsunami early warning system for the Indian Ocean (and elsewhere) are considered complicated for a number of reasons, which include the following:

- the cross section and needs of different international users;
- uniform standards required for communications and interoperability of systems that collect and analyze data or receive or disseminate tsunami warnings.
- financial resources needed for operations and maintenance to sustain regional tsunami warning systems over the long-term; and
- proprietary rights of some nations in the Indian Ocean and elsewhere to charge for real-time access to satellite data that might be critical for detection and tracking tsunamis or conducting post-disaster assessments.

Some Members of Congress have contended that the costs of acquiring those data could be well worth it in terms of lives saved. Others have asserted that licensing requirements and the costs of acquiring real-time proprietary data from some international agencies could be prohibitive. Still others are of the opinion that global environmental data should be accessible and available at the minimum cost of reproduction, especially when countries like the United States have provided relief to those affected by the December 2004 tsunami disaster, or are underwriting tsunami

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<sup>54</sup> See “International Tsunami Information Center: ITSU Master Plan,” the International Coordination Group for the Tsunami Warning System in the Pacific (IGC/ITSU), UNESCO/IG, at [<http://www.tsunamiwave.info/>].

detection and warning efforts for the Indian Ocean.<sup>55</sup> Finally, concerns have been raised about (inter)national security and compromise of intelligence-gathering operations if “open” access to multinational data and telecommunications is availed.

Some U.S. lawmakers had questioned the risk of a tsunami hitting the U.S. Atlantic coast.<sup>56</sup> They argued that because the probability is low, the risk factor should guide the scale of development and investment in a cooperative tsunami early warning system for the U.S. eastern seaboard. NOAA scientists rebutted that notion, asserting that the risks were real and could be disastrous for the U.S. Atlantic Basin.<sup>57</sup>

Since February 2005, the United States has taken important strides to define its role and responsibilities for tsunami protection in the global context. It has supported international efforts through the U.S. Intergovernmental Oceanographic Committee (IOC) including financial resources and technological advice. It has also participated in international planning for and development of a global tsunami warning network, including the development of an international warning system for the Indian Ocean. This work has proceeded along with the U.S. domestic effort. Recently, the United States deployed the first of two second generation DART buoys (DART II) as a contribution to an incipient but growing IOTWS network for the northeastern Indian Ocean. That action demonstrated expanding involvement by the United States in tsunami protection outside the Pacific Basin.

IOC members eagerly anticipate the launch of the Global Earth Observation System of Systems (GEOSS), a U.S. initiative that is led by NOAA. Some countries propose to “piggy back” on GEOSS as part of developing their own regional tsunami early warning capabilities. The IOC indicates that in the future, short of financial support, some countries may contribute in their own capacity through *in-kind* services. One example presented by IOC included pledging national fleets to assist in deploying, repairing, and decommissioning tsunami monitoring and detection equipment. A second example called for lesser developed nations with fewer resources to provide manpower to an international “corps” responsible for maintenance-related activities necessary to sustain the long-term multinational effort for tsunami protection. Such a model, IOC indicated, works not only for global tsunami detection and warning systems but also would serve in building, operating, and maintaining other observation networks of global scope (e.g., IGOOS). That notwithstanding, NOAA officials are concerned that if GEOSS is not deployed, a “truly global” tsunami warning system may never be realized.

International scientists and engineers considered the Bush Administration action plan for a U.S. tsunami early warning network as a viable model for other regions of the globe. Countries who have come to rely on the United States for their tsunami

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<sup>55</sup> Gregg Withee, Assistant Director for NOAA Satellite Data and Information Services, January 5, 2005, House briefing.

<sup>56</sup> USGS, Earthquake Hazards Program, “Off W Coast of Northern Sumatra, Can It Happen in the United States?” at [<http://earthquake.usgs.gov/eqinthenews/2004/usslav/canit.html>].

<sup>57</sup> University of Southern California, Viterbi, School of Engineering, Tsunami Research Group [<http://www.usc.edu/dept/tsunamis/caribbean/webpages/1918prindex.html>] and [<http://www.usc.edu/dept/tsunamis/caribbean/webpages/index.html>].

warnings have supported plans to expand and upgrade U.S. tsunami detection and warning capabilities. Members of Congress who have backed the President's plan have introduced and acted on funding and legislation to implement actions necessary for protection of U.S. mainland coastlines, those of Hawaii, and of the Far Pacific trust territories. Initially, this included providing emergency and later regular appropriations to procure the necessary equipment for an expanded U.S. tsunami early detection and warning network.

The President's plan suggested that nearly \$30 million would be required for FY2005-FY2006 to upgrade U.S. tsunami early warning capabilities. The 109<sup>th</sup> Congress approved \$25.4 million for that effort in H.R. 1268, the FY2005 Emergency Supplemental Appropriations Act (P.L. 109-13), and in regular appropriation for FY2006 (P.L. 109-108). The 109<sup>th</sup> Congress passed H.R. 1674 (enacted as P.L. 109-424) which, in addition to supporting efforts to strengthen the U.S. Tsunami Early Warning Network, called for research initiatives to study U.S. mitigation options and to enhance public education of the dangers of tsunamis. The act also authorized U.S. involvement in supporting "in country" sociological needs (i.e., in those nations affected by the December 2004 tsunami), to include educating indigenous populations and visitors about tsunamis and adaptation strategies that can complement detection and warning.

For FY2007, the President requested \$12.5 million to complete procurement of DART buoys for expansion and technology upgrades of the U.S. network. P.L. 110-5 — the Revised Continuing Appropriation Resolution, 2007 — essentially funded NWS tsunami-related activities at the FY2006 appropriation level. In FY2008 the President has requested \$20.4 million, including \$1.8 million in new funding for deploying the remaining DART buoys and for conducting network-associated operations and maintenance. If Congress approves the FY2008 request, the federal government will have committed about \$40 million to improve tsunami early warnings for the U.S. mainland, Hawaii, and territorial waters.

Finally, with the enactment of P.L. 109-424, the U.S. Tsunami Warning and Education Act, \$27 million would be authorized over the next five years to continue upgrading and servicing the U.S. tsunami early warning network as well as expanding social components of the NWS National Tsunami Hazard Mitigation Program. (See **Appendix A.**) If funded at those levels, NOAA officials have stated that there would be sufficient resources to finish deployment of DART buoys in U.S. waters; strengthen the National Tsunami Warning and the National Tsunami Mitigation Program; and expand partnerships between NOAA's NWS, U.S. states, and communities-at-risk through the *TsunamiReady* program. Others are more optimistic and believe that funding could go a long way towards long-term maintenance of the U.S. network and to help to cover costs of U.S. advice in developing the IOTWS network. However, NWS officials have insisted that U.S. contributions alone cannot ensure success or longevity of global operations.

## Appendix A: Tsunami-Related Legislation

In the 108<sup>th</sup> Congress, even before the Indian Ocean tsunami disaster, legislation had been introduced to expand tsunami early warning networks globally.<sup>58</sup> After the Indian Ocean disaster, at the beginning of the 109<sup>th</sup> Congress in January 2005, no fewer than 14 bills were introduced for similar purposes. Most of the post-disaster legislation sought to expedite tsunami protection for the United States and its trust territories. Some bills called for a more globally oriented approach for tsunami protection to include populations outside of the United States. The bills that supported U.S. involvement in a global effort encouraged U.S. representation at any international negotiations that might define national roles and responsibilities for operating and maintaining a global tsunami early warning network, adding that such negotiations be conducted through established international diplomatic channels, which were cited as the U.N. UNESCO IOC, the ISDR, and WMO.

In the 109<sup>th</sup> Congress, a number of provisions of various lawmakers' legislation were enacted indirectly rather than as stand alone legislation. Some proposals to authorize programs were funded in emergency appropriations bills, such as P.L. 109-13, or later in regular appropriations bills. For example, such funding bills had directed the United States to incorporate tsunami preparedness and response, public education and awareness, and risk adaptation in domestic disaster planning as part of U.S. emergency management and recovery and advisory efforts abroad.

Similar to the Administration's January 2005 proposal and the President's July 2005 *Action Plan*, most of the legislation introduced had called for domestic needs to be met before international commitments were made. As of December 2006, 20 out of a total 39 DART-II buoys had been deployed, with 19 of those operating in U.S. waters. The United State has loaned two U.S. DART buoys for siting in international waters in the Indian Ocean to protect indigenous populations.

### Legislation in the 109<sup>th</sup> Congress

In the 109<sup>th</sup> Congress, S. 50 and H.R. 1674 addressed sociological needs in post-tsunami disaster planning, and included safeguards for communities-at-risk on U.S. coasts as well as those countries affected by the 2004 Indian Ocean tsunami disaster. The House bill adopted many of the provisions of S. 50, but in some cases H.R. 1674 was more definitive about funding allocations for specific proposals of the legislation (e.g., technology, research, and mitigation). Each proposed similar programs, but what was expected of NOAA in terms of outcomes differed. The Senate, for example, considered a longer time frame with respect to authorizing appropriations to implement provisions of S. 50. However, both bills sought domestic action first to protect the United States and its trust territories from future tsunami disasters before commitments were made for international efforts.

**S. 50 (Inouye).** The Tsunami Preparedness Act of 2005 (S. 50) introduced by Senator Inouye on January 24, 2005, directly supported the Bush Administration's

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<sup>58</sup> Representative Curt Weldon sponsored an original bill, H.R. 5001, in the 108<sup>th</sup> Congress. H.R. 1584 in the 109<sup>th</sup> Congress was a reintroduction of that measure. See footnote 38.

strategy for an expanded U.S. tsunami early warning system. Similarly, it proposed that the United States and other nations act together to build a global detection and warning capacity. In contrast to the President's proposal however, S. 50 would have required that U.S.-produced tsunami-related information and scientific research findings be disseminated internationally, and that transfer of technology to assist in global tsunami hazard mitigation efforts be facilitated by the United States. Toward that end, S. 50 proposed a U.S. multi-agency task force to include NOAA, the Federal Emergency Management Agency (FEMA), the USGS, and the National Science Foundation (NSF). NOAA would lead U.S. global tsunami warning efforts as part of developing a multi-purpose, international earth observation system (GEOSS). The bill also called for \$35 million to be authorized for FY2006-FY2012.

The Senate Commerce Subcommittee on Disaster Preparedness held hearings on S. 50, on February 2, 2005 (S.Hrg. 109-93). At the hearing, Ranking Member Inouye, referring to potential tsunami disasters around the globe, noted that the subcommittee could be effective in educating populations at risk. Inouye stated that S.50 considered sociological needs associated with tsunami disasters in addition to detection and warning, thus requiring NSF's contribution. He also noted a proviso that NOAA would be authorized to receive reimbursement of cash or services "in-kind" from international agencies it assisted in the development of a global tsunami early warning network.

On March 10, 2005, the full Commerce, Science, and Transportation Committee marked up S. 50, and ordered the measure reported with an amendment in the nature of a substitute. Senator Stevens stated that if S. 50 were to be enacted, NOAA would be required to notify Congress if a DART buoy malfunctioned so that arrangement for a replacement could be made expeditiously. Also, \$5 million was authorized annually for an "integrated coastal vulnerability and adaption program." On April 19, 2005, Senator Stevens, Chair of the Committee, issued a written report (S.Rept. 109-59). On July 1, S. 50, the Tsunami Preparedness Act (amended), was laid before the Senate. S.Amdt. 1101 was offered on behalf of Senator Steven in the nature of a substitute bill. The amended bill proposed to authorize funding for the Administrator of NOAA to strengthen its tsunami detection, forecast, warning, and mitigation program. It also would have authorized establishing an International Tsunami Warning Center for the Pacific (ITWCP) to monitor tsunamis and issue warnings for U.S. trust territories in the far Pacific, as well as ITWCP-associated countries. Further, it proposed a clearinghouse for U.S. tsunami-related information accessible to the IOC Tsunami Unit (ITSU) member states. As amended, the bill passed the Senate by unanimous consent and was referred to the House. However, there was no further legislative action on S. 50. Instead, the Senate acted on a related bill. (See "H.R. 1674.")

**H.R. 1674 (Boehlert).** Introduced on April 18, 2005, H.R. 1674, the United States Tsunami Warning Education Act of 2005, directed the National Weather Service to strengthen tsunami detection, forecasts, and warnings, and to increase support for related disaster mitigation activities. H.R. 1674 provided for upgrade and expansion of the U.S. tsunami warning network for the Pacific (to include U.S. territories), the Atlantic Ocean, the Gulf of Mexico, and the Caribbean Sea. The bill also addressed sociological issues related to tsunami disasters.



The measure was referred to the House Committee on Science Subcommittee on Environment, Technology, and Standards which marked it up on April 20, 2005. A full Science Committee markup was held on May 4, 2005. The bill was reported by the House Science Committee on September 28, 2006 (H.Rept. 109-698), and passed the House (amended) on December 6, 2006, by voice vote. The Senate passed H.R. 1674 by unanimous consent on December 9, 2006. The President signed H.R. 1674 into law as P.L. 109-424 on December 20, 2006.

P.L. 109-424 strengthens the National Weather Services's National Tsunami Hazards Mitigation Program (NTHMP) by enhancing U.S. tsunami detection and warning capabilities and incorporating tsunami awareness and preparedness in disaster plans. It also confers on Congress the responsibility to oversee development and operations of the U.S. network. Two reports to Congress are required. The National Academy of Sciences (NAS) was directed to report on U.S. capacity for tsunami protection and to recommend changes if needed. The Government Accountability Office (GAO) was directed to report on U.S. operations through 2010.

P.L. 109-424 also encouraged cooperation between NOAA, the USGS, and the NSF, in establishing an international tsunami research program. In addition, it would (1) improve coordination for tsunami and other coastal hazards warnings at federal, state, and international government levels; (2) educate for public preparedness; and (3) aid in establishing a multinational regional tsunami warning network for countries bounded on the Indian Ocean. The act also encourages mutual sharing of tsunami-related data among countries that would become members of a "Global Tsunami and Warning Mitigation Network." Finally, it provides for developing educational and outreach activities for U.S. populations-at-risk and a mechanism for advising other countries on such matters. To carry out the act, \$30 million was authorized annually for FY2006 through FY2008, with 70% of spending allocated to upgrade operations and management of the U.S. network, 20% for mitigation programs, and 10% for international tsunami research.

## Appendix B: U.S. Tsunami Warning Program Funding

NOAA officials provided an original estimate of \$30 million for implementing the President's January 2005 U.S. Tsunami Response and Protection plan. NWS had suggested more modest funding to mount tsunami detection instrumentation on existing Atlantic Ocean platforms, such as weather buoys. However, the President decided that a number of DART platforms would be deployed instead (See **Figure 2** for illustration of a DART buoy). NOAA had estimated that costs could vary depending upon the scale of the project, for example, the number of DART buoys, and supporting instruments that would be deployed and obligation for operation and maintenance (O&M) in the out-years.<sup>59</sup> Other related federal expenditures to boost U.S. protection from tsunamis would have included funding for scientific research, disaster mitigation grants, public outreach and education, and, at the time, partnering with six U.S. states with communities-at-risk bordering on the Pacific Ocean through the NWS *TsunamiReady* program. It was also determined that telecommunication upgrades were needed for the USGS Global Seismic Network (GSN) upon which the United States depends for earthquake detection and to determine the potential for tsunamis. (See "Related and Contributing U.S. Programs.")

**Table 1** includes funding for U.S. tsunami-related programs since FY2001. Prior to FY2004, all tsunami-related activities were funded by NOAA's Office of Oceanic and Atmospheric Research (OAR) and obligated out of NOAA's Operations, Research, and Facilities (ORF) account. In FY2004, NOAA's National Weather Service assumed responsibility for administering these activities. After the December 2004 tsunami disaster, funds were obligated out of the NWS ORF and a Procurement, Acquisition, and Construction (PAC) account, the latter used mainly to procure capital intensive tsunami detection hardware and associated supporting technologies. Congress has provided funding for U.S. tsunami monitoring and detection operations, early warning capabilities, research, outreach and education, and mitigation. Such appropriations have been found under Title II, Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service in Science, Justice, and Commerce Appropriations Acts.

Thus far, President Bush has requested almost \$40 million for FY2005-FY2008 to implement his July 2005 action plan (**Table 1**). (See also, "President Bush's Tsunami Action Plan.") Upon release of the administration proposal in February 2005, the Director of OSTP, John Marburger, noted that protection from the U.S.

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<sup>59</sup>U.S. Congress, House Committee on Science, "Tsunamis: Is the U.S. Prepared?," Hearing, January 26, 2005, p.41, [Serial No. 109-1], prepared statement of Rep. Sheila Jackson Lee. See [http://commdocs.house.gov/committees/science/hsy98395.000/hsy98395\_0.htm]. "DART stations cost about \$250,000 to purchase and around \$125,000 per year to maintain. Stations are now located off the coasts of Alaska, the Pacific Northwest, and Chile, but we need to consider how this system can be expanded to other parts of the world. Reliability of the DART system needs to be understood as we consider its deployment worldwide."

system would “ultimately include the Indian Ocean,” with respect to tsunami warning benefits.<sup>60</sup>

**Table 1. NOAA U.S. Tsunami Program Funding: FY2001-FY2008**  
(\$millions)

| U.S. Tsunami Warning Program <sup>a</sup> |           | NTHMP <sup>b</sup> | TWEAK <sup>c</sup> | Strengthen Tsunami Warnings <sup>d,e</sup> | Annual Total  |
|---|-----------|--------------------|--------------------|--|---------------|
| <b>FY2008</b>                             | Approp.   | —                  | —                  | —  | —             |
|   | Requested | 0.0                | 0.0                | 23.2                                       | <b>\$23.2</b> |
| <b>FY2007<sup>f</sup></b>                 | Approp.   | 2.3                | 2.0                | 9.4  | <b>\$13.7</b> |
|   | Requested | 0.0                | 0.0                | 20.4                                       | <b>\$20.4</b> |
| <b>FY2006<sup>g</sup></b>                 | Approp.   | 2.3                | 2.0                | 9.4  | <b>\$13.7</b> |
|   | Requested | 0.0                | 0.0                | 9.5  | <b>\$9.5</b>  |
| <b>FY2005 Suppl.<sup>h</sup></b>          |           | 7.1                | 0.0                | 10.2                                       | <b>\$17.3</b> |
| <b>FY2005</b>                             | Approp.   | 4.3                | 2.0                | —  | <b>\$6.3</b>  |
|   | Requested | 0.0                | 0.0                | —  | <b>\$0.0</b>  |
| <b>FY2004</b>                             | Approp.   | 4.3                | 2.0                | 0.6  | <b>\$6.9</b>  |
|   | Requested | 0.0                | 0.0                | —  | <b>\$0.0</b>  |
| <b>FY2003</b>                             | Approp.   | 4.3                | —                  | —  | <b>\$4.3</b>  |
|   | Requested | 0.0                | —                  | —  | <b>\$0.0</b>  |
| <b>FY2002</b>                             | Approp.   | 3.3                | —                  | —  | <b>\$3.3</b>  |
|   | Requested | 2.3                | —                  | —  | <b>\$2.3</b>  |
| <b>FY2001</b>                             | Approp.   | 3.3                | —                  | —  | <b>\$3.3</b>  |
|   | Requested | 0.0                | —                  | —  | <b>\$0.0</b>  |

**Source:** Funding data compiled by CRS from annual Commerce, Justice, State, Judiciary and Related Agency annual appropriations reports, and NOAA’s *FY2008 Budget Summary*, February 5, 2007.

**Notes:**

- a. Funding for NOAA tsunami programs is not authorized by legislation. The last NOAA authorization to fund NWS/NOAA Research programs occurred on October 29, 1992 in the 102<sup>nd</sup> Congress (P.L. 102-567).
- b. The Tsunami Hazard Mitigation Program is operated out of the Pacific Tsunami Warning Center, HI, and has been funded since FY2004 by NWS. A major portion of the funding for the NTHMP is divided among each of five Pacific states (AK, HI, WA, OR, and CA). The NTHMP administers the NOAA’s *TsunamiReady* program and provides assistance for developing local warning capacity, emergency plans, and tsunami inundation maps.

<sup>60</sup> John H. Marburger, Director of the White House Office of Science and Technology Policy, “Testimony,” Hearing, Feb. 2, 2005.

- c. Prior to FY2004, the Tsunami Warning and Environmental (Observation Center), AK conducted experimental tsunami warning system programs, but had no budget line. In FY2004, TWEAK was transferred to NWS, along with all other U.S. tsunami-related programs. Funding has not been requested by the Administration since; Congress has appropriated \$2.0 million annually.
- d. Funding proposed by the President and authorized by Congress in P.L. 109-13 was allocated as SSJC appropriations for NOAA in FY2006.
- e. Includes funding for PAC account to (1) procure DART buoys, (2) upgrade tsunami warning communications network capabilities and (3) assist in developing a global telecommunications infrastructure for tsunami warning. (A separate request of \$8.1 million in P.L. 109-13 was for USGS's Global Seismic Network (GSN) to upgrade GSN telecommunications and an increase in the number of seismic monitoring staff at the USGS National Earthquake information Center.)
- f. For FY2007 P.L. 110-5, *Revised Continuing Resolution on FY2007 Appropriations*, funds most NOAA programs at appropriation levels authorized for FY2006 whose funding was carried forth to FY2007, resulting in a net increase of \$0.0 for FY2007.
- g. FY2006 appropriations include a rescission of 1.28% in P.L. 109-148 and P.L. 109-108, Div. B, Title II-Department of Commerce, §638.
- h. Emergency Supplemental Appropriations Act, 2005 (P.L. 109-13), first authorized funding to the NOAA subactivity, "Strengthen U.S. Tsunami Warning Network," after the December 24, 2004 tsunami disaster in the Indian Ocean. Congress provided funding for the NWS Procurement, Acquisition, and Construction (PAC) account from FY2005 emergency supplemental appropriations. This funding was used to procure replacement DART buoys (only three out of six were operating in the Pacific Ocean at the time of the tsunami disaster) and to expand the U.S. tsunami warning network into the far Pacific and Atlantic Oceans, the Gulf of Mexico, and the Caribbean Sea.

Other funding obligations include the U.S. contribution to international tsunami warning efforts, including the IOTWS. NOAA officials assert that future U.S. support for a "global" tsunami warning network will be facilitated through development of the NOAA-led Global Earth Observing System of Systems (GEOSS) whose implementation is being managed by the "US GEO" team.<sup>61</sup> In addition, two U.S. second generation deep-water tsunami detection buoys (DART II) are currently on loan and are being sited in the Indian Ocean for tsunami warnings.

***P.L. 109-13, Emergency Supplemental Appropriations for FY2005.***

The first round of funding to upgrade and expand U.S. tsunami detection and warning capabilities was authorized by P.L. 109-13,<sup>62</sup> and was reported as H.Rept. 109-72, Div. A, which accompanied the Emergency Supplemental Appropriations Act for Defense, the Global War on Terror, and Tsunami Relief, 2005. Congress approved \$17.3 million for FY2005-FY2006 for the NWS National Tsunami Warning Program and \$8.1 million was for related USGS activities. Of the NWS total, \$7.1 million was for coastal inundation mapping and to expand outreach and preparedness programs for U.S. communities-at-risk as part of the *TsunamiReady* Program under NOAA's Operations, Research, and Facilities account. Congress also directed that a portion of total NWS tsunami-related funding be provided to the West

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<sup>61</sup> The United States Group on Earth Observations (US GEO), Interagency Working Group on Earth Observations is a standing subcommittee under the Committee on Environment and Natural Resources, the United States Group on Earth Observations (US GEO)." See [<http://www.sdr.gov/Tsunami%20Risk%20Reduction%20for%20the%20US%20-%20A%20Framework%20for%20Action%202005-12-22.pdf>].

<sup>62</sup> U.S. Congress, House Committee on Appropriations, "Communication from the President of the United States Transmitting a Request for Supplemental Appropriations ... Including Tsunami Relief and Reconstruction," H.Doc. 109-9, Feb. 15, 2005 (Washington, DC, GPO: 2005).

Coast/Alaska Tsunami Warning Center (WC/AKTWC) to upgrade and expand services. Congress authorized the NWS to hire an additional 43 full-time equivalents at U.S. tsunami warning centers to monitor USGS seismic alerts and tsunami detection instruments around the clock, so that tsunami warnings could be issued in near real-time and false alarms retracted in a timely manner. Still other funding was provided to develop an international warning center for the Pacific, in Hawaii, to serve IOC ITSU members.

Further, Congress approved \$10.2 million for NOAA's PAC account to procure 32 new generation, DART II buoys for deployment in the Far Pacific and Atlantic Oceans, the Gulf of Mexico, and the Caribbean Sea. The NWS indicated that their deployment would add several new data points observations of ocean conditions and sea-floor displacement at depth. (See "National Weather Service Tsunami Programs.") With respect to the U.S. GEOSS initiative, conferees also encouraged NOAA "to develop buoys with capabilities beyond the single purpose of tsunami reporting."<sup>63</sup>

Finally, Congress approved \$8.1 million for the USGS National Earthquake Information Center (NEIC) in Golden, CO, to upgrade the Global Seismic Network (GSN) and to increase the number of GSN instruments capable of relaying real-time seismic data. Funding was also included to hire additional staff for the NEIC to interpret GSN data around the clock. At that time, only 80% of the 127 instruments in the GSN had real-time telemetry capability. Conferees noted that GSN seismic data are critical for NWS tsunami warning centers in making a determination whether there is potential for a tsunami to be generated (*tsunamigenesis*) after an underwater earthquake or other geological disturbance. In that respect, the WC/AKTWS has responsibility for modeling the tracking and potential intensity of tsunamis and, in turn, warn national and international emergency management officials.

House and Senate Appropriations Committees bill reports for FY2007 indicated that lawmakers would have provided appropriations requested by President Bush (\$20.4 million) to procure the remaining DART buoys needed to complete the U.S. tsunami network and to deploy them. The Revised Continuing Appropriations Resolution, 2007 (P.L. 110-5) funded NOAA at FY2006 appropriation levels and, thus, authorized nothing new for FY2007 or beyond.

Accordingly, for FY2008, President Bush has requested \$23.2 million to procure and deploy the remaining buoys (including two spares) as well as to bring the entire U.S. tsunami early detection and warning network online by the end of calendar year 2007. **Table 2** shows the Administration's estimates to complete implementation of the U.S. tsunami early warning network and associated tsunami mitigation efforts.

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<sup>63</sup> U.S. Congress, Senate Committee on Appropriations, *Departments of Commerce and Justice, Science, and Related Agencies Appropriations Bill, 2006* (S.Rept. 109-88 on H.R. 2862), p. 78, "Tsunami Preparedness, Warnings, and Forecasts," June 23, 2005.

**Table 2. Strengthening the U.S. Tsunami Warning Program:  
Details of the President's FY2008 Request**  
(\$millions)

| <b>Proposed Actions</b>   | <b>[Subset]</b> | <b>Requested</b> |
|---|-----------------|------------------|
| Deploy final 10 DART buoys  |                 | 3.3              |
| O&M for an expanded network of 29 buoys                           |                 | 10.0             |
| DART operations & maintenance costs                               | [4.6]           |                  |
| DART ship-time costs  | [4.6]           |                  |
| Emergency DART repair   | [0.5]           |                  |
| Natl. Data Buoy Center, DART Program Management                   | [0.2]           |                  |
| DART R&D  |                 | 0.5              |
| Expanded "tsunami reporting" sea-level monitoring (O&M)           |                 | 0.8              |
| Alaska sea-level monitoring network                               | [0.1]           |                  |
| O&M expanded seismic networks for PTWC & WC/ATWC                  |                 | 0.5              |
| State of Alaska seismic monitoring network                        | [0.3]           |                  |
| Maintain 24/7 operations at the PTWC & WC/ATWC                    |                 | 2.0              |
| Maintain expanded International Tsunami Information Clearinghouse |                 | 0.2              |
| Tsunami inundation forecast modeling of U.S. communities at risk  |                 | 2.4              |
| State of Alaska inundation mapping & modeling                     | [0.4]           |                  |
| Tsunami education/outreach activities ( <i>TsunamiReady</i> )     |                 | 0.6              |
| State of Alaska community readiness programs                      | [0.3]           |                  |
| Research/modeling for effective warning and mitigation measures   |                 | 0.5              |
| Archive tsunami data at National Geophysical Data Center          |                 | 0.2              |
| Puerto Rico Seismic Network for Caribbean tsunami warnings        |                 | 0.3              |
| National Tsunami Hazard Mitigation Program (NTHMP)                |                 | 2.1              |
| <b>Total Funding Requested</b>                                    |                 | <b>\$23.4</b>    |

**Source:** U.S. Department of Commerce, NOAA, *Budget Estimates, Fiscal Year 2008: Congressional Submission*

Remaining authorized funding for U.S. tsunami protection programs is now in the purview of the 110<sup>th</sup> Congress whose Commerce, Justice, Science and Related Agencies Appropriation Subcommittees would review the President's FY2008 request. The possibility exists that the 110<sup>th</sup> Congress may also hold oversight hearings to consider progress in implementing provisions of P.L. 109-424, long-term operations and maintenance of the U.S. network, and the U.S. role and responsibilities in international efforts to establish the IOTWS network.