U.S. Tsunami Programs: A Brief Overview

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Summary

A 9.0 magnitude earthquake struck off Japan's northeast coast near Honshu in the afternoon on Friday, March 11, 2011 (12:46 a.m. eastern time in the United States). The earthquake triggered a tsunami that has caused widespread devastation to parts of the coastal regions in Japan closest to the earthquake. The tsunami traveled across the Pacific Ocean, and the National Oceanic and Atmospheric Administration (NOAA) tsunami warning centers in Hawaii and Alaska issued tsunami warnings for coastal areas of Hawaii, Guam, the Commonwealth of the Northern Marianas, American Samoa, Alaska, and California. Although the tsunami caused widespread damage along the northeast coast of Japan, tsunami warnings issued from the tsunami warning centers gave the above U.S. Pacific territories, Hawaii, and the U.S. West Coast adequate warning to prepare for incoming waves.

NOAA's National Weather Service (NWS) manages the two tsunami warning centers that monitor, detect, and issue warnings for tsunamis generated in the Pacific Ocean. 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 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 goal of NTHMP is to ensure adequate advance warning of tsunamis along all the U.S. coastal areas and appropriate community response to a tsunami event.

The tsunami warning centers monitor and evaluate data from seismic networks and determine if a tsunami is likely based on the location, magnitude, and depth of an earthquake. If the center determines that a tsunami is likely, it transmits a warning message to NOAA's weather forecasting offices and state emergency management centers, as well as to other recipients. The centers monitor coastal water-level data, typically with tide-level gages, and data from NOAA's network of Deep-ocean Assessment and Reporting of Tsunamis (DART) detection buoys to confirm that a tsunami has been generated, and if not, to cancel any warnings. Shortly after the 2004 tsunami in the Indian Ocean, Congress passed the Tsunami Warning and Education Act (P.L. 109-424), to enhance and modernize the existing Pacific Tsunami Warning System to increase coverage, reduce false alarms, and increase the accuracy of forecasts and warnings, among other purposes. As a result, the array was expanded to a total of 39 DART buoys in March 2008.

Funding for the NOAA tsunami program supports three main categories of activities: (1) *warning*, such as the activities of the tsunami warning centers and DART network; (2) *mitigation*, such as the activities of NTHMP; and (3) *research*, including activities conducted by the Pacific Marine Environmental Laboratory and the National Buoy Data Center. The Government Accountability Office (GAO) noted that total funding for all these activities ranged from $5 million to $10 million annually between FY1997 and FY2004, but increased after the 2004 Indian Ocean tsunami from approximately $27 million in FY2005 to $42 million in FY2009. Funding in FY2010 was $41 million.

Currently, 7 of the 39 DART buoys are not operational. Of the 7 buoys that are not working, 5 are deployed in the Pacific Ocean. If more DART buoys fail, and regional forecasting capabilities are impaired, then the NOAA Administrator must notify Congress within 30 days. According to NOAA, the current continuing resolution (P.L. 112-4) does not allow the NWS to allocate FY2011 funding to purchase ship time required to repair the 7 DART buoys that are not working.

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Japan Earthquake and Tsunami

A 9.0 magnitude massive earthquake struck off Japan's northeast coast near Honshu in the afternoon on Friday, March 11, 2011 (12:46 a.m. eastern time in the United States). The earthquake triggered a tsunami[1] that has caused widespread devastation to parts of the coastal regions in Japan closest to the earthquake. The tsunami traveled across the Pacific Ocean, and the National Oceanic and Atmospheric Administration (NOAA) tsunami warning centers in Hawaii and Alaska issued tsunami warnings for coastal areas of Hawaii, Guam, the Commonwealth of the Northern Marianas, American Samoa, Alaska, and California. The first tsunami waves reached Hawaii in the early morning of March 11,[2] and reached the west coast of the United States later in the morning (Pacific time). Although the tsunami caused widespread damage along the northeast coast of Japan, tsunami warnings issued from the tsunami warning centers gave the above U.S. Pacific territories, Hawaii, and the U.S. West Coast adequate warning to prepare for incoming waves.[3] In addition, the long distance traveled across the Pacific from the earthquake epicenter attenuated the energy associated with the tsunami thousands of miles from its source. In contrast, the city of Sendai, Japan, is just 80 miles west of the epicenter.[4]

Tsunami Warning Centers

NOAA's National Weather Service (NWS) manages the two tsunami warning centers that monitor, detect, and issue warnings for tsunamis generated in the Pacific Ocean. 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 magnitude 9.2 earthquake that struck Anchorage, AK, in 1964 and caused major earthquake and localized tsunami damages.[5] 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 also serves as the center for warning U.S. populations located in the western Atlantic.

[1] A tsunami is a large ocean wave typically caused by a subsea earthquake or volcanic eruption that can cause extreme destruction when it strikes land.

[2] CNN U.S., *Tsunami Waves Reach Hawaii, Eye West Coast*, CNN Wire Staff, March 11, 2011, http://www.cnn.com/2011/US/03/11/tsunami/index.html?hpt=T1.

[3] Despite the tsunami warnings, some communities along the West Coast and in Hawaii suffered damages. For example, some boats and harbor facilities were damaged by the tsunami in Crescent City, CA, although most of the fishing fleet headed out to sea to avoid the waves before they reached the harbor, according to the Los Angeles Times. Crescent City has suffered tsunami damage in the past, particularly from the 1964 Good Friday earthquake that struck Alaska. See Maria L. La Ganga, "Crescent City Comes to Grips with Tsunami's Devastation," *Los Angeles Times*, March 13, 2011, http://www.latimes.com/news/local/la-me-japan-quake-crescent-city-20110313,0,5296998.story.

[4] U.S. Geological Survey, Earthquake Hazards Program, http://earthquake.usgs.gov/earthquakes/eqinthenews/2011/usc0001xgp/#details.

[5] See NOAA, NWS, "How *TsunamiReady* Helps Communities and Counties at Risk," http://www.tsunamiready.noaa.gov/.

The National Tsunami Hazards Mitigation Program

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. In 1992, NOAA launched the NTHMP to address the credibility of Pacific tsunami warnings and to reduce the number of "false alarms." The goal of NTHMP is to ensure adequate advance warning of tsunamis along all the U.S. coastal areas and appropriate community response to a tsunami.[6]

Detecting Tsunamis and Issuing Warnings

The tsunami warning centers monitor and evaluate data from seismic networks and determine if a tsunami is likely based on the location, magnitude, and depth of an earthquake.[7] If the center determines that a tsunami is likely, they transmit a warning message to NOAA's weather forecasting offices and state emergency management centers, as well as to other recipients. The centers monitor coastal water-level data, typically with tide-level gages, and data from NOAA's network of Deep-ocean Assessment and Reporting of Tsunamis (DART) detection buoys to confirm that a tsunami has been generated, and if not, to cancel any warnings.[8]

Warnings Triggered by the March 11, 2011, Tsunami

Initial warnings of an impending tsunami were first issued by the PTWC based on seismic information before the network of DART buoys and tide gages actually detected a wave generated by the earthquake.[9] According to NOAA, initial tsunami warnings are normally based only on seismic information to provide the earliest possible alert.[10] Because tsunamis travel more slowly than seismic waves, confirmation of a tsunami may take much longer than confirmation of an earthquake. That was the case for the March 11, 2011, tsunami. The DART network first detected the earthquake-triggered wave 27 minutes after the earthquake struck at 2:46 p.m. local time in Japan,[11] confirming that a tsunami had been generated and could lead to significant widespread inundation around the Pacific Ocean. **Figure 1** shows results from a model depicting the tsunami wave propagation across the Pacific Ocean.

[6] NOAA FY2012 Blue Book, Chapter 5, National Weather Service, p. 691, http://www.corporateservices.noaa.gov/nbo/fy12_presidents_budget/National_Weather_Service_FY12.pdf.

[7] Nearly all tsunamis are triggered by subsea earthquakes, although some may also be caused by underwater volcanic eruptions or landslides.

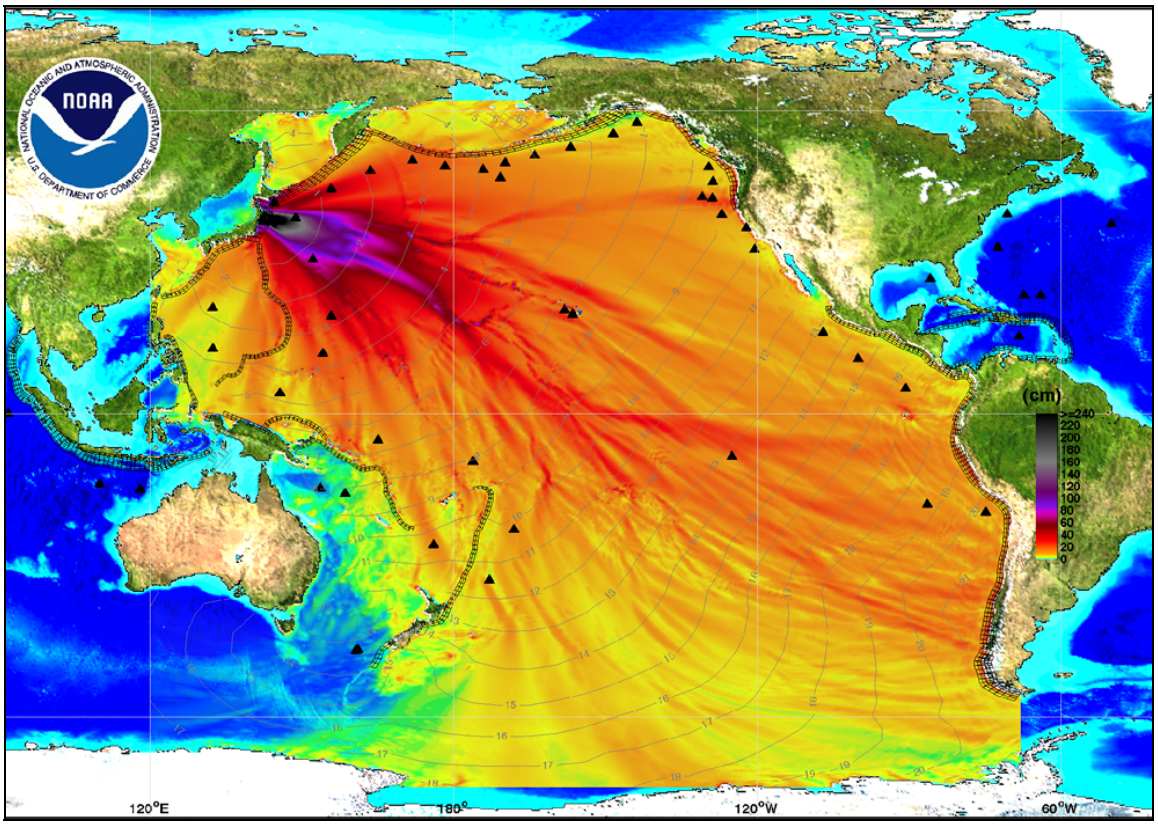
[8] U.S. Government Accountability Office, *U.S. Tsunami Preparedness: NOAA Has Expanded Its Tsunami Programs, but Improved Planning Could Enhance Effectiveness*, GAO-10-490, April 2010, p. 5.

[9] DART buoy 21418; telephone conversation with Laura Furgione, Deputy Director, National Weather Service, March 15, 2011.

[10] NWS, Pacific Tsunami Warning Center, *About PTWC Messages*, http://ptwc.weather.gov/ptwc/about_messages.php.

[11] Telephone conversation with Laura Furgione, March 15, 2011.

Figure 1. Results from NOAA Model Depicting the March 11, 2011 Tsunami Propagating Across the Pacific Ocean



Source: NOAA Center for Tsunami Research, Pacific Marine Environmental Laboratory, http://nctr.pmel.noaa.gov/honshu20110311/.

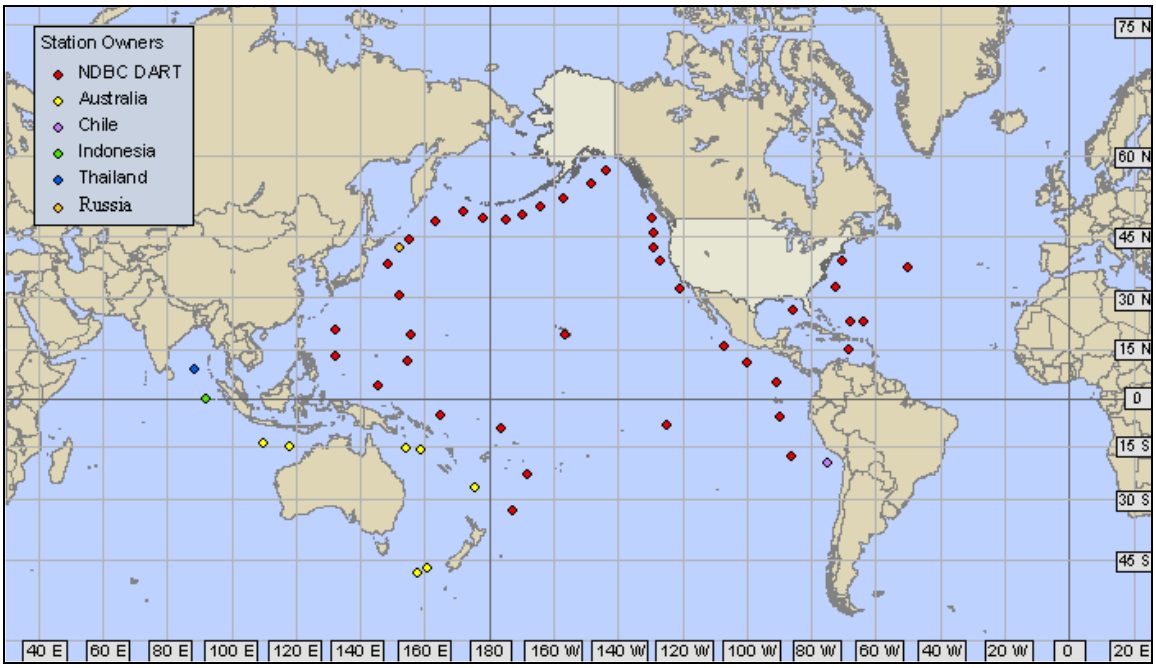
Notes: Colors indicate the wave amplitude in centimeters (see scale bar on right side of figure); contour labels indicate the computed tsunami arrival times. Black triangles indicate location of Deep-ocean Assessment and Reporting of Tsunamis (DART) detection buoys.

The DART Buoy Network

NOAA first completed a six-buoy DART array in 2001 in the Pacific Ocean. Shortly after the 2004 Indian Ocean earthquake and tsunami that killed over 200,000 people, Congress passed H.R. 1674, the Tsunami Warning and Education Act (P.L. 109-424), to enhance and modernize the existing Pacific Tsunami Warning System to increase coverage, reduce false alarms, and increase the accuracy of forecasts and warnings, among other purposes. In part, the 2004 tsunami provided the impetus to expand and upgrade the DART system and to improve the U.S. capability to detect and issue warnings for tsunamis generally. As a result, the array was expanded to a total of 39 DART buoys in March 2008.[12] (See **Figure 2**.)

[12] According to NOAA, 33 of the DART buoys are deployed in the Pacific Ocean, and the rest are deployed in the Atlantic Ocean and Caribbean. NOAA National Data Buoy Center, Deep-ocean Assessment and Reporting of Tsunamis (DART) Description, http://www.ndbc.noaa.gov/dart/dart.shtml.

Figure 2. Locations of DART Buoys



Source: NOAA National Data Buoy Center, http://www.ndbc.noaa.gov/dart.shtml

Notes: The United States owns and operates 39 of the DART Buoys.

Currently, 7 of the 39 buoys are not operational and in need of repair. Of the 7 buoys that are not working, 5 are deployed in the Pacific Ocean. Other countries also operate DART buoys in the Pacific (e.g., Australia and Russia), but if another U.S. DART buoy ceases to function less than 80% of the U.S. DART network would be operational. The Tsunami Warning and Education Act (P.L. 109-424) requires that NWS ensure that maintaining operations of tsunami detection equipment is the highest priority within the tsunami forecasting and warning program at NOAA. Further, P.L. 109-424 requires that the NOAA Administrator notify Congress[13] within 30 days of (1) impaired regional forecasting capabilities due to equipment or system failures; and (2) significant contractor failures or delays in completing work associated with the tsunami forecasting and warning system.[14]

Funding for the Tsunami Program

Funding for the NOAA tsunami program supports three main categories of activities: (1) *warning*, such as the activities of the tsunami warning centers and DART network; (2) *mitigation*, such as

[13] Specifically, P.L. 109-424 requires the NOAA Administrator to notify the Committee on Commerce, Science, and Transportation in the Senate and the Committee on Science (now Science, Space, and Technology) in the House.

[14] The statute does not define what is considered impairment of the forecasting abilities, or what is a threshold for significant contractor failures or delays. However, the committee report accompanying the bill states that NWS is required to notify Congress when the tsunami forecasting capabilities are impaired for more than three months; U.S. Congress, House Science, *United States Tsunami Warning and Education Act*, report to accompany H.R. 1674, 109th Cong., 2nd sess., 2006, H.Rept. 109-698, p. 10. NWS uses an 80% operational threshold as its internal guideline; Telephone conversation with Laura Furgione, March 15, 2011.

the activities of NTHMP; and (3) *research*, including activities conducted by the Pacific Marine Environmental Laboratory and the National Buoy Data Center.[15] In the NOAA budget, these activities are cross-cutting among different activities under the NWS line item.[16] GAO, which analyzed funding data for the three general categories, noted that total funding for all these activities ranged from $5 million to $10 million annually between FY1997 and FY2004, but increased after the 2004 Indian Ocean tsunami from approximately $27 million in FY2005 to $42 million in FY2009. According to GAO, the proportion of funding allocated to warning activities increased from about 40% of the total in FY2004 to approximately 70% of the funding in FY2009.[17] The proportion allocated to mitigation decreased from approximately 50% of the total in FY2004 to about 30% in FY2009, while the proportion for research remained steady between about 6% to 10%.

Funding for the NWS tsunami program for FY2010 was approximately $41 million, allocated as follows:

- $23 million—Strengthen U.S. Tsunami Warning Program;
- $13 million—Spectrum Auction funding;[18]
- $4 million—NWS/Local Warnings and Forecasts; and
- $1 million—Office of Oceanic and Atmospheric Research/Pacific Marine Environmental Laboratory.[19]

In 2010, the Government Accountability Office (GAO) found that NOAA had made progress since 2005 in expanding and strengthening its tsunami warning and mitigation capabilities, including the deployment of the 39 DART buoys. GAO also found that operating and maintaining the buoys has proved difficult and costly, consuming about 28% of the total NOAA Tsunami Warning Program budget in FY2009.[20] GAO noted that NOAA is exploring ways to reduce maintenance costs by improving buoy reliability.

According to NOAA, the current continuing resolution (P.L. 112-4) does not allow the NWS to allocate FY2011 funding to purchase ship time required to repair the seven DART buoys that are not working.[21] As noted above, the delay or failure in completing work associated with the

[15] U.S. Government Accountability Office, *U.S. Tsunami Preparedness: NOAA Has Expanded Its Tsunami Programs, but Improved Planning Could Enhance Effectiveness*, GAO-10-490, p. 7.

[16] For example, the FY2010 enacted budget contains a line item: Strengthen U.S. Tsunami Warning Network—$23.264 million. However, research activities for tsunamis are included in the overall budget for the Pacific Marine Environmental Laboratory and for the National Buoy Data Center.

[17] U.S. Government Accountability Office, *U.S. Tsunami Preparedness: NOAA Has Expanded Its Tsunami Programs, but Improved Planning Could Enhance Effectiveness*, GAO-10-490, p. 8.

[18] Starting in FY2009, the tsunami program received funding from the proceeds of the Federal Communication Commission's auctioning of broadcast frequency spectrum. In FY2012, the program will be augmented by $12.7 million from auction proceeds, according to NOAA. Total funding received from auction proceeds will be approximately $50 million for the tsunami program at the end of FY2012, according to GAO.

[19] E-mail from Lara Hinderstein, NOAA Budget Outreach and Communications, March 11, 2011.

[20] U.S. Government Accountability Office, *U.S. Tsunami Preparedness: NOAA Has Expanded Its Tsunami Programs, but Improved Planning Could Enhance Effectiveness*, GAO-10-490, p. 21.

[21] Approximately $4 million would required, according to NOAA. Telephone conversation with Laura Furgione, March 15, 2011.

tsunami forecasting and warning system by contractors should also trigger notification of Congress by the NOAA Administrator under P.L. 109-424.

Additional Reading

CRS Report RL33861, *Earthquakes: Risk, Detection, Warning, and Research*, by Peter Folger

CRS Report RL33436, *Japan-U.S. Relations: Issues for Congress*, coordinated by Emma Chanlett-Avery

CRS Report R41023, *Haiti Earthquake: Crisis and Response*, by Rhoda Margesson and Maureen Taft-Morales

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