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Report to Congressional Committees

April 2010

U.S. TSUNAMI PREPAREDNESS

NOAA Has Expanded Its Tsunami Programs, but Improved Planning Could Enhance Effectiveness

GAO-10-490

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Highlights

Highlights of GAO-10-490, a report to congressional committees

Why GAO Did This Study

In June 2006, GAO reported a number of concerns about the level of U.S. tsunami preparedness. The National Oceanic and Atmospheric Administration (NOAA) leads U.S. efforts through three key programs: the Tsunami Program, which focuses on detection and warning activities; the National Tsunami Hazard Mitigation Program (NTHMP), which is a partnership with federal and state agencies focusing on hazard assessment and mitigation; and TsunamiReady, which is a partnership with at-risk communities focusing on education and emergency planning. The Tsunami Warning and Education Act of 2006 directed improvements in NOAA's warning and mitigation efforts and mandated GAO to report on its progress. This report addresses (1) the extent to which NOAA developed effective strategic plans for its tsunami programs and (2) the status of NOAA's efforts to strengthen and expand the programs and move tsunami research to application. GAO analyzed NOAA documents and interviewed federal, state, and local officials responsible for tsunami planning and preparedness efforts.

What GAO Recommends

GAO recommends that NOAA revise its tsunami strategic plans to ensure that all plan components are complete and develop a transition plan specifically for tsunami research. NOAA reviewed a draft of this report and agreed with its recommendations.

View GAO-10-490 or key components.
For more information, contact Anu Mittal at (202) 512-3841or mittala@gao.gov.

What GAO Found

NOAA adopted strategic plans for the Tsunami Program in 2008 and NTHMP in 2009, which it developed by following key planning practices and including most of the critical components of strategic plans identified by leading organizations, but some components have not been fully developed. GAO found that NOAA's planning process followed practices critical to creating effective strategic plans, such as involving stakeholders. Both plans also include most of the components of effective strategic plans—such as mission statements and long-term goals—but other necessary components were missing or incomplete. For example, in the Tsunami Program's strategic plan, NOAA identified nine long-term goals but did not identify strategies and performance measures for three of them. Similarly, in the strategic plan for NTHMP, NOAA identified eight long-term goals but did not identify performance measures, milestones, or who is responsible for achieving one of the goals. Although the strategic plan for NTHMP includes a goal for the TsunamiReady program, it does not identify strategies for achieving the goal.

Since 2005, NOAA has made progress in expanding and strengthening its tsunami warning and mitigation capabilities but faces challenges in both areas, as well as in moving its tsunami research to application. To enhance its warning capabilities, NOAA has, among other actions, deployed 39 tsunami detection buoys. Operating and maintaining the buoys, however, has been difficult and costly, consuming about 28 percent of the fiscal year 2009 Tsunami Program budget. NOAA is exploring ways to reduce maintenance costs by improving buoy reliability. To enhance its tsunami hazard mitigation efforts, NOAA expanded NTHMP membership from the 5 Pacific Coast states to all 29 at-risk coastal U.S. states and territories, changed how it funds mitigation projects in states and territories, and restructured NTHMP to better meet its program goals. NOAA's efforts to mitigate tsunami impacts through its TsunamiReady program, however, have been hampered by limited community participation. Although the number of TsunamiReady communities has increased from 27 in 2006 to 74 as of February 2010, overall participation in this voluntary program remains relatively low among the more than 760 communities identified as at risk for a tsunami. In this regard, GAO recommended in 2006 that NOAA conduct an assessment to identify potential barriers to program participation. Although NOAA has not yet conducted this assessment, GAO continues to believe that such an assessment is needed to help inform the agency's strategic planning efforts. Finally, NOAA has not complied with the Tsunami Warning and Education Act's requirement to develop and execute a plan for the transfer of technology from research into the Tsunami Program. Furthermore, NOAA's initial failure to follow its agencywide research transition policy contributed to a 2-year delay in moving the new tsunami forecasting system from research to application in its tsunami warning centers. Only after NOAA developed a transition plan in 2009 that was consistent with the agencywide policy did the transition of the system begin to move forward more efficiently.

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Abbreviations

DART	Deep-ocean Assessment and Reporting of Tsunamis
NOAA	National Oceanic and Atmospheric Administration
NTHMP	National Tsunami Hazard Mitigation Program
PMEL	Pacific Marine Environmental Laboratory
SIFT	Short-term Inundation Forecasting for Tsunamis

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United States Government Accountability Office
Washington, DC 20548

April 28, 2010

The Honorable Maria Cantwell
Chairman
The Honorable Olympia J. Snowe
Ranking Member
Subcommittee on Oceans, Atmosphere,
Fisheries, and Coast Guard
Committee on Commerce, Science, and
Transportation
United States Senate

The Honorable Brian Baird
Chairman
The Honorable Bob Inglis
Ranking Member
Subcommittee on Energy and Environment
Committee on Science and Technology
House of Representatives

On September 29, 2009, the U.S. territory of American Samoa was struck by a tsunami that hit the island within 20 minutes after a strong underwater earthquake, destroying coastal infrastructure and killing over 190 people in the region. Although such damaging tsunamis are relatively rare,[1] the destruction caused by this event—as well as by the December 2004 Indian Ocean tsunami and the February 2010 tsunami that struck Chilean shores after a magnitude 8.8 earthquake—has shown the importance of having a robust system to detect, issue warnings for, and mitigate the impacts of tsunamis. According to the National Oceanic and Atmospheric Administration (NOAA), the Pacific Coast states of Alaska, California, Hawaii, Oregon, and Washington, as well as Puerto Rico and the U.S. Virgin Islands in the Caribbean Sea, face the greatest tsunami hazard in the United States and its territories. In comparison, the U.S. East and Gulf Coasts are relatively low-hazard areas.

[1]Before this event, according to National Oceanic and Atmospheric Administration records, the last tsunami causing significant destruction in the United States and its territories took place at Skagway, Alaska, in November 1994, where a landslide and associated wave killed one person and caused $25 million in damage.

Federal, state, and local government agencies are all involved in efforts to reduce the potential impacts of tsunamis. NOAA's Tsunami Program is primarily responsible for federal tsunami detection and warning activities. Under this program, NOAA's National Weather Service operates two tsunami warning centers, which monitor data from seismic networks operated by NOAA, the U.S. Geological Survey, states, and universities, and issue warnings when tsunamis are likely.[2] NOAA's Tsunami Program also provides leadership and funding for the National Tsunami Hazard Mitigation Program (NTHMP). This program, begun in 1996, is a partnership among NOAA, the U.S. Geological Survey, the Federal Emergency Management Agency, and coastal state emergency management and geological agencies to assess tsunami hazards, improve and coordinate tsunami warning systems, and develop state and local hazard mitigation programs. In addition, NTHMP has taken a lead role in overseeing and making recommendations for improving the TsunamiReady preparedness program. TsunamiReady is a voluntary program that encourages local communities to educate citizens on tsunami hazards, develop tsunami mitigation plans, and establish local warning systems; the program also confers TsunamiReady recognition on communities that meet its guidelines.

In June 2006, we reported that NOAA faced significant challenges in reducing the potential impacts of tsunamis on U.S. coastal communities.[3] Specifically, we reported that NOAA was significantly expanding its tsunami warning, mitigation, and research efforts in the wake of the Indian Ocean event, but the Tsunami Program and NTHMP lacked long-range strategic plans. We also reported that although the two tsunami warning centers could quickly detect and warn of potential tsunamis, false alarms called into question the accuracy and reliability of the warnings. Further, the efforts of at-risk communities to mitigate potential tsunami impacts varied widely, and few communities had chosen to participate in the TsunamiReady preparedness program. We recommended that NOAA take actions to help communities determine the potential impact of tsunamis, reduce the number of false alarms, improve testing of the warning system,

[2]The two centers are the West Coast/Alaska Tsunami Warning Center, located in Palmer, Alaska, and the Richard H. Hagemeyer Pacific Tsunami Warning Center, located in Ewa Beach, Hawaii.

[3]GAO, *U.S. Tsunami Preparedness: Federal and State Partners Collaborate to Help Communities Reduce Potential Impacts, but Significant Challenges Remain*, GAO-06-519 (Washington, D.C.: June 5, 2006).

identify barriers to participation in TsunamiReady, evaluate the NTHMP to assist in strategic planning, and develop comprehensive strategic plans for the Tsunami Program and NTHMP.

Subsequently, in December 2006, Congress passed the Tsunami Warning and Education Act to improve the Tsunami Program's warning, mitigation, and research efforts nationwide.[4] The acts' purposes include enhancing and modernizing the existing detection and warning system for the Pacific Ocean and expanding this system to include other vulnerable states and territories in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico. The act also requires NOAA's National Weather Service to develop and execute a transition plan for moving technology from its research efforts into application within the forecasting and warning program. In addition, the act mandates that we evaluate and report to relevant congressional committees by January 31, 2010, the status of NOAA's efforts. We reported our preliminary findings in a briefing to the staff of the Senate Subcommittee on Oceans, Atmosphere, Fisheries, and Coast Guard, of the Committee on Commerce, Science, and Transportation, and to the staff of the House Subcommittee on Energy and Environment, of the Committee on Science and Technology, on December 11, 2009. We are following up with this report, which provides more detail on the topics covered in the briefing. This report addresses (1) the extent to which NOAA developed effective strategic plans for the Tsunami Program and NTHMP and (2) the status of NOAA's efforts since 2005 to strengthen and expand the programs and move tsunami research to application.

To assess the extent to which NOAA developed effective strategic plans for the Tsunami Program and NTHMP, we reviewed the practices NOAA used to develop the programs' strategic plans and compared them with key practices used by leading organizations we had previously identified.[5] We also compared the strategic plans' components with critical components that should be included in strategic plans as identified by leading organizations and our prior work.[6] In addition, we reviewed

[4]Pub. L. No. 109-424.

[5]GAO, *Executive Guide: Effectively Implementing the Government Performance and Results Act*, GAO/GGD-96-118 (Washington, D.C.: June 1996).

[6]GAO, *Agencies' Strategic Plans under GPRA: Key Questions to Facilitate Congressional Review*, GAO/GGD-10.l.16 (Washington, D.C.: May 1997), and *Managing for Results: Critical Issues for Improving Federal Agencies' Strategic Plans*, GAO/GGD-97-180 (Washington, D.C.: Sept. 16, 1997).

agency documents and interviewed NOAA officials about the processes and components of each plan. To describe the status of efforts since 2005 to improve the tsunami programs and move tsunami research to application, we reviewed program requirements in the Tsunami Warning and Education Act and analyzed NOAA documents to help determine the extent to which the agency has implemented efforts to strengthen the programs' warning and mitigation components. We visited NOAA's tsunami warning centers in Alaska and Hawaii and met with the centers' directors and staff to discuss their tsunami detection and warning efforts. We discussed the status of NOAA's tsunami warning and mitigation efforts with federal, state, and local officials, including NTHMP participants and officials from Alabama, Alaska, California, Hawaii, Maryland, Oregon, and Washington to determine the extent to which services have changed. We also analyzed NOAA's policy and implementation procedures for the transition of research to application and interviewed NOAA officials about how such transitions in the Tsunami Program have been implemented, focusing on the ongoing effort to move tsunami forecasting research to application in the tsunami warning centers. We assessed the reliability of the NOAA data that we used, by reviewing agency documentation and interviewing agency officials about the data's sources and uses, and found them to be sufficiently reliable for the purposes of this report.

We conducted this performance audit from May 2009 to April 2010, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

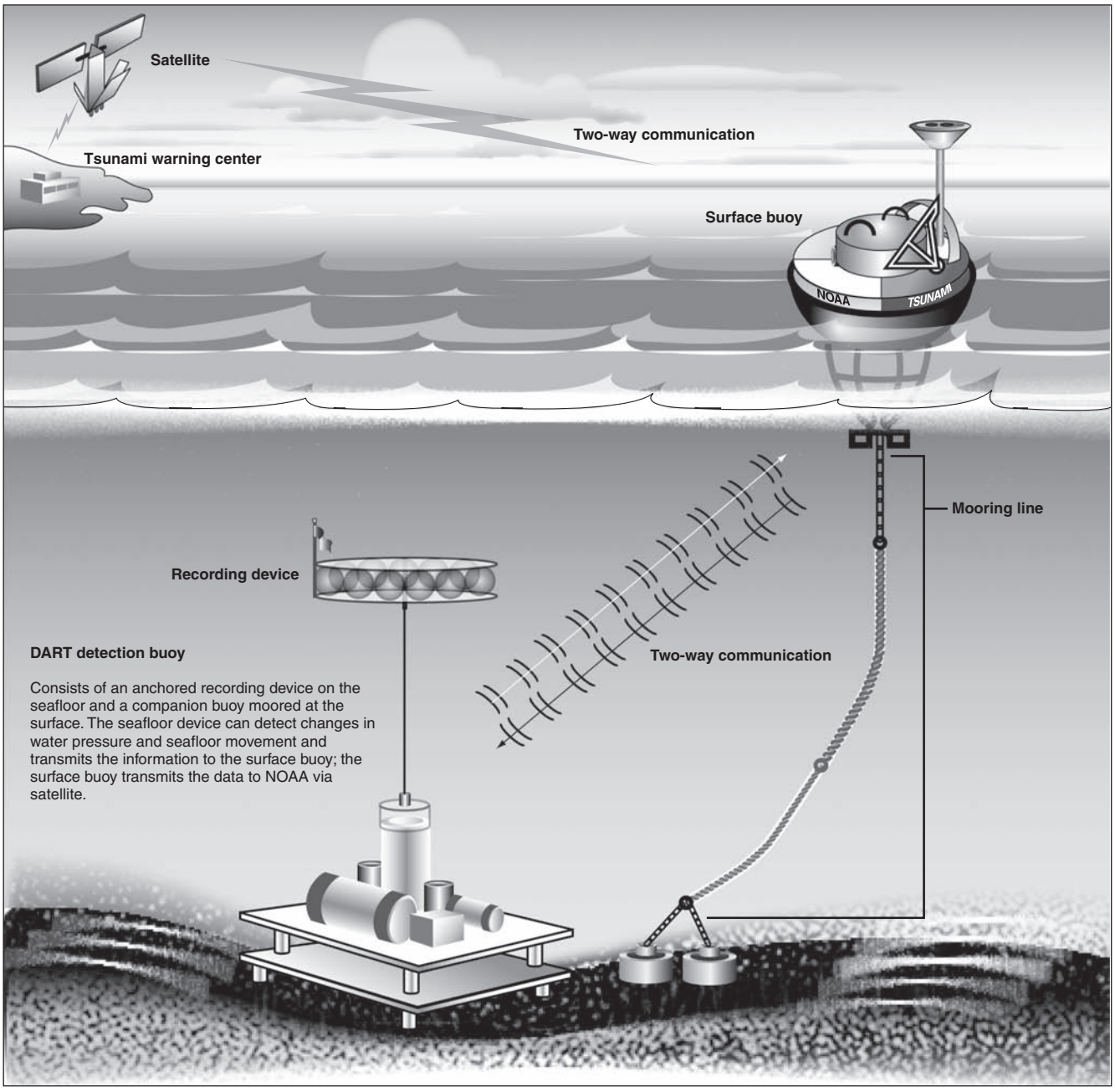
A tsunami is a series of ocean waves typically generated by an underwater earthquake.[7] The size of the resulting tsunami depends on a complex set of factors, including the earthquake's magnitude, its depth below the ocean floor, depth of the overlying water, type and amount of seafloor movement, and energy released. A tsunami wave may be very small in the deep ocean, but as it approaches land, it can increase to tens of feet in height and reach shore as a fast-moving wall of turbulent water. Tsunamis

[7]Landslides, volcanic activity, and meteor strikes are other known, but less common, tsunami sources.

can be classified as local or distant. A tsunami generated by an earthquake off the coast of Alaska would be considered a local tsunami for that state's coastal areas, striking within minutes of the event, while the same event would be considered a distant tsunami for the coast of Washington, which would not likely be hit until 3 or more hours later. Both types of tsunami pose an inundation threat to low-lying coastal communities from multiple destructive waves that can penetrate far inland. Local tsunamis pose particular emergency preparedness challenges because there may not be enough time to sound a warning. In this situation, public education and outreach can save lives by teaching the community to recognize the emergency and move immediately to higher ground.

The process that the tsunami warning centers use to detect potential tsunamis and issue warnings involves several steps. The warning centers first monitor and evaluate data from seismic networks, and if a tsunami is likely, they transmit a tsunami warning message to NOAA's weather-forecasting offices and state emergency management centers, among others. The warning centers also monitor coastal water-level data, as well as data from NOAA's network of Deep-ocean Assessment and Reporting of Tsunamis (DART) detection buoys, to determine if a tsunami has actually been generated and, if not, to cancel any warning (see fig. 1). NOAA's Pacific Marine Environmental Laboratory (PMEL) conducted the research and developed the DART buoys and conducts other research in support of the Tsunami Program, such as the development of tsunami inundation forecast models for at-risk locations. Tsunami forecast models are used by scientists at the warning centers and the research laboratory to help estimate the size of the expected waves and their potential impact on coastal areas. For example, after a massive magnitude 8.8 earthquake off the coast of Chile in February 2010, NOAA scientists initially warned that tsunami waves of about 8 feet could strike Hawaii, but as the tsunami moved across the Pacific, the forecast models helped to more accurately predict the approximately 3-foot tsunami waves that actually struck the islands more than 12 hours after the earthquake.

Figure 1: Configuration of DART Detection Buoy System



Source: GAO and PMEL.

NOAA allocates its annual appropriations and other funds to three main categories of activities in its Tsunami Program:

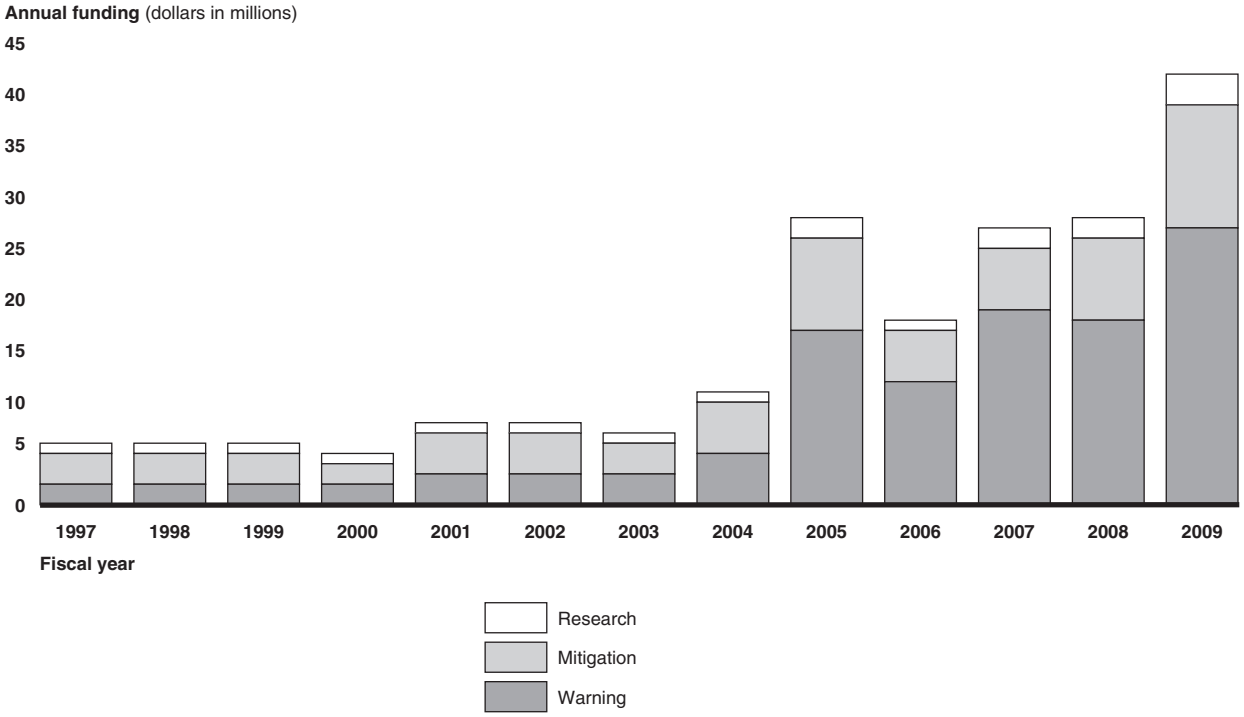
- *warning:* including activities pertaining to tsunami warning centers, DART buoys, seismic and sea-level monitoring networks, and tsunami data management;
- *mitigation:* including activities pertaining to NTHMP, TsunamiReady, and the International Tsunami Information Center;[8] and
- *research:* including activities conducted by PMEL and the National Data Buoy Center.[9]

From fiscal year 1997 through fiscal year 2004, NOAA's allocations to fund tsunami activities remained fairly constant, ranging from about $5 million to $10 million. After the Indian Ocean tsunami, funding increased significantly, from about $27 million in fiscal year 2005 to $42 million in fiscal year 2009 (see fig. 2).

[8]The International Tsunami Information Center was established in 1965 by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization and is funded primarily by NOAA. The center maintains and develops relationships with scientific research and academic organizations, civil defense agencies, and the general public to mitigate the hazards associated with tsunamis by improving tsunami preparedness for all Pacific Ocean nations and helping to develop and implement tsunami warning and mitigation systems globally.

[9]The National Data Buoy Center designs, develops, operates, and maintains a network of data-collecting buoys and coastal monitoring stations.

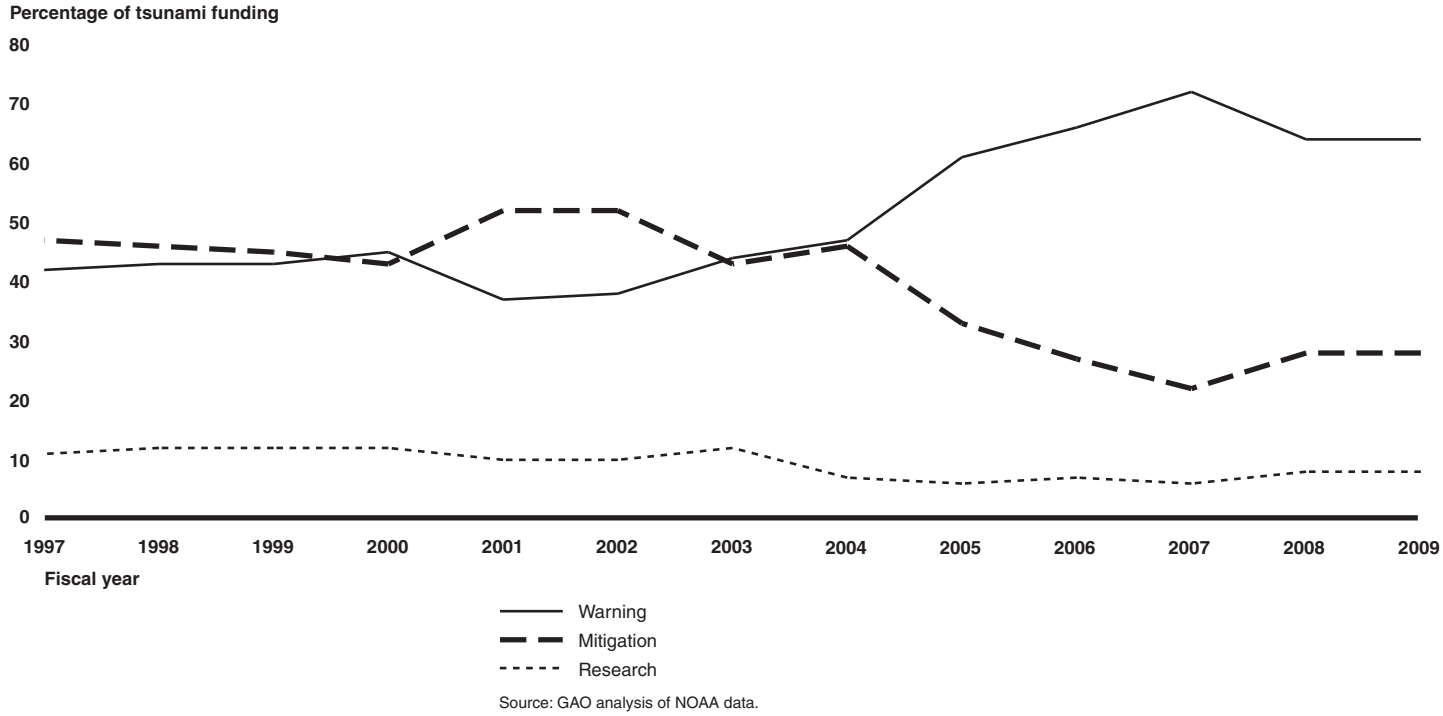
Figure 2: Tsunami Program Funding by Activity, Fiscal Years 1997 through 2009



Source: GAO analysis of NOAA data.

While funding levels generally increased from fiscal year 1997 through fiscal year 2009 for all three categories of tsunami-related activities, according to NOAA officials, the proportion allocated to warning increased from about 40 percent from fiscal year 1997 through fiscal year 2004 to approximately 70 percent of total program funding from fiscal year 2005 through fiscal year 2009 (see fig. 3). In comparison, the proportion allocated to mitigation decreased from about 50 percent from fiscal year 1997 through fiscal year 2004 to approximately 30 percent of total funding from fiscal year 2005 through fiscal year 2009, and the proportion of research funding remained relatively constant, at about 6 to 10 percent of the total.

Figure 3: Tsunami Program Funding Priorities, Fiscal Years 1997 through 2009



Source: GAO analysis of NOAA data.

Starting in fiscal year 2009, funding for the Tsunami Program—including all three categories of tsunami-related activity—received a significant boost from the proceeds of the Federal Communication Commission's auctioning of the broadcast frequency spectrum previously devoted to carrying analog television signals. The auction proceeds are to provide a total of about $50 million to the program through fiscal year 2012, when this funding will expire. In fiscal year 2009, spectrum auction funding provided $13.7 million, which amounted to 32 percent of the $42 million of total Tsunami Program funding for the year. The program also benefits from significant in-kind support and resources, such as data from seismic and water-level monitors operated by other agencies or nations; NOAA has not estimated the monetary value of this support.

NOAA Followed Key Planning Practices and Generally Included Critical Components in Developing Its Tsunami Programs' Strategic Plans

The planning processes NOAA used to develop its Tsunami Program and NTHMP strategic plans followed the three key practices leading organizations use to create effective strategic plans. The plans also generally include the critical components of effective plans—such as mission statements and long-term goals—and are closely linked through their goals and strategies, but some components of the plans have not been fully developed.

NOAA Followed Key Planning Practices to Develop Its Strategic Plans

In our prior work, we identified three key practices that were critical for leading organizations to follow in the creation of effective strategic plans:[10]

- *Involving stakeholders*, such as federal agencies, state governments, or others, in defining the mission and desired outcomes helps ensure that their expectations and interests are met and that resources and efforts are targeted at the program's highest priorities.
- *Assessing external and internal forces* helps managers anticipate future challenges and make adjustments before potential problems become crises. For example, external forces—such as emerging technological trends and new statutory requirements—and internal forces—such as culture, management practices, and business processes—may influence the program's ability to achieve its goals.
- *Aligning program activities to support mission-related outcomes* helps ensure that programs effectively and efficiently produce services that meet customers' needs and stakeholders' interests. Assessing the extent to which a program's activities, processes, and resources contribute to meeting its mission and desired outcomes can identify inadequate or obsolete organizational structures that need to be changed.

NOAA adopted strategic plans in 2008 for the Tsunami Program and in 2009 for NTHMP. We found that NOAA's planning process for developing these plans included the three key practices. Specifically, to develop the

[10]GAO-96-118.

Tsunami Program's strategic plan, NOAA assembled a planning committee of relevant agency officials, who drafted the plan, and then involved stakeholders, including NTHMP members, by giving them the opportunity to review and comment on the draft plan. The planning committee assessed the external and internal forces relevant to the program by analyzing the program's strengths, weaknesses, opportunities, and threats. For example, the planning committee determined that the tsunami warning centers were issuing confusing information statements during events, an internal weakness that threatened its warning mission. In addition, as the planning committee developed the Tsunami Program's strategic plan, NOAA officials aligned the program's structure to meet the purpose of the program as provided in the Tsunami Warning and Education Act and to ensure that its activities supported this mission. For example, the plan identifies four areas of responsibility in the Tsunami Program that align with the main sections of the act: (1) tsunami forecasting and warning, (2) National Tsunami Hazard Mitigation Program, (3) tsunami research, and (4) global tsunami warning and mitigation.

Likewise, when developing the NTHMP's strategic plan, NOAA assembled a planning committee of stakeholders and then shared a draft of the strategic plan with all NTHMP members to incorporate their comments, helping to ensure that their interests and expectations were met. According to NOAA officials, the planning committee assessed the external and internal forces potentially affecting the NTHMP, as was done for the Tsunami Program. For example, the analysis identified certain NTHMP goals that depended on external forces, such as state and local agencies, and were therefore beyond the program's full control. Finally, NTHMP's strategic plan was organized to align its goals and strategies with key components of the program as identified in the Tsunami Warning and Education Act, specifically, to coordinate warning activities, promote and improve community education and mitigation, and improve the quality and extent of inundation modeling and mapping.[11]

[11]Inundation maps identify the expected extent of flooding from tsunamis in specific coastal areas.

NOAA's Tsunami Strategic Plans Generally Include Critical Components, but Some Are Missing or Incomplete

Our past work has shown that effective strategic plans should include six critical components:[12]

- *A comprehensive mission statement* that explains why a program exists and tells what it does.
- *Long-term goals and objectives* that specify how an agency will carry out its mission and explain what results are expected from the program.
- *Strategies to achieve the goals and objectives* that are specific enough to allow an assessment of whether they will help achieve those goals. For example, strategies may describe the processes, skills, technologies, and resources needed to achieve a program's goals and objectives.
- *A description of how performance measures will be used to assess progress toward long-term goals*, including (1) the specific activities within the program that will be assessed for performance and (2) the target level of performance to be achieved for each measure.
- *The identification of external factors that could significantly affect achievement of the strategic goals*, such as economic trends or actions by Congress, state and federal agencies, or other entities. Assessing external factors helps agencies evaluate the likelihood of achieving strategic goals that depend on the actions of others.
- *A description of how program evaluations are to be used to establish or revise strategic goals* and a schedule of future planned evaluations.

We found that the Tsunami Program and NTHMP strategic plans generally include most of the critical components of effective strategic plans. Specifically, for the Tsunami Program's strategic plan, we found that it identifies the program's mission, nine long-term goals for meeting its mission, strategies to achieve most of the goals, activities to implement the strategies, and some performance measures to assess progress. Additionally, during the planning process, the Tsunami Program's strategic planning team identified factors external to the program that could significantly affect achievement of the strategic goals. For example, the planning committee identified current support from the U.S. Geological

[12]GAO-96-118.

Survey, which provides seismic data, as one external factor that, if changed, could affect the program's ability to achieve its goals. Also, the planning committee reviewed relevant program evaluations, such as our 2006 report, to incorporate these findings and recommendations into the strategic plan.

Nevertheless, some key components of the Tsunami Program's strategic plan are not fully developed. For example, although the plan identifies nine long-term goals, it does not identify strategies, performance measures, or the agency offices responsible for achieving the strategies for three of the goals. These three goals are (1) provide technical assistance, training, and capacity development both at global and regional levels, supporting a fully operational tsunami warning system; (2) integrate with other relevant national, regional, and global ocean and coastal observation, warning, mitigation, and risk management systems; and (3) develop effective networks to disseminate tsunami information to the public through partnerships with formal and informal education entities. Furthermore, while the strategic plan lists performance measures for six goals that the program aims to achieve from 2008 to 2017, some are vague or lack a specific date for completion. For example, "reduce the cost for the DART network operation and maintenance" is one of the performance measures. This measure may not be a useful one, however, for the goal of having timely and accurate tsunami forecast and warning products because the measure lacks a specific target for cost reduction and a date for achieving it. The Tsunami Program manager acknowledged these limitations in the strategic plan but said that although the plan did not contain strategies and performance measures for the three goals, the planning committee had developed an action plan, separate from the strategic plan, which identified specific tasks to complete each year to help reach the goals. The program manager also told us that the planning committee was hampered in its efforts to identify performance measures for the three goals because they were very general, and no performance data existed to provide a baseline against which to measure progress.

Similarly, we found that NOAA also used a planning committee to create a strategic plan for the NTHMP that includes nearly all the critical components of an effective plan. For example, to achieve NTHMP's mission "to reduce loss of life and property damage from tsunamis," the strategic plan identifies eight long-term goals. For most of these goals, the plan identifies several strategies and performance measures. For example, for the goal of having "tsunami inundation maps that support informed decision making in tsunami-threatened communities," the strategic plan lists several strategies designed to help achieve the goal, one of which is to

"develop guidelines for tsunami inundation maps." The plan also names NTHMP's Mapping and Modeling Subcommittee as responsible for executing the strategy. Next, the plan identifies a performance measure for this strategy—that "new NTHMP-funded maps…will meet established guidelines by 2012"—so that program officials can assess progress toward implementation. The NTHMP strategic planning committee also considered external factors and reviewed program evaluations as it developed the program's strategic plan, according to NOAA officials. For example, as it developed the plan, the planning committee took into account the recommendations of several reviews, including our 2006 report and a 2005 National Science and Technology Council report on reducing tsunami risk in the United States.[13] We also found that the Tsunami Program and NTHMP strategic plans are closely linked to each other in that some of the Tsunami Program's goals and strategies are actually met through NTHMP's actions. For example, the Tsunami Program identifies NTHMP as one of five key strategies to achieve its own goals.

Nevertheless, as with the Tsunami Program's strategic plan, we found that some of the components of NTHMP's strategic plan are missing or not fully developed. For example, although the plan identifies eight long-term goals, it does not identify performance measures, milestones, or who is responsible for achieving the goal of developing understandable and effective tsunami warning center communications, such as tsunami warning messages for communities. According to the Tsunami Program manager, the NTHMP planning committee did not establish performance measures or milestones because achieving this goal is actually the responsibility of the warning centers, with guidance from NTHMP. In addition, the NTHMP strategic plan contains a goal of establishing more tsunami-resilient communities and establishes a performance measure of increasing the number of TsunamiReady communities to 105 by 2013. The plan does not, however, contain any specific strategies for increasing the number of communities. The TsunamiReady program manager told us that the NTHMP plans to develop goals, strategies, and performance measures for the TsunamiReady program in 2013, after new program recognition guidelines are issued.

[13]National Science and Technology Council, *Tsunami Risk Reduction for the United States: A Framework for Action* (Washington, D.C.: 2005).

Table 1 summarizes our analysis of the extent to which the Tsunami Program and NTHMP plans include the critical components of strategic plans.

Table 1: Status of NOAA's Strategic Plans for the Tsunami Program and NTHMP

Strategic plan components	Tsunami Program strategic plan	NTHMP strategic plan
Mission statement	●	●
Long-term goals and objectives	●	●
Strategies to achieve goals	◉	◉
Performance measures	◉	◉
External factors	●	●
Evaluations	●	●

● = included; ◉ = partially included

Source: GAO analysis.

NOAA Has Expanded and Strengthened Its Tsunami Programs, but Some Challenges Remain

Since our 2006 report, NOAA has made progress in expanding and strengthening its tsunami warning and mitigation capabilities, but maintaining a reliable DART detection buoy network and increasing community participation in the TsunamiReady program have proven to be challenging. In addition, NOAA's initial failure to follow its agencywide research transition policy contributed to about a 2-year delay in moving a new tsunami forecast system from research to application in the warning centers, and NOAA has not complied with the Tsunami Warning and Education Act's requirement that it develop and execute a plan for the transfer of technology from ongoing research into the tsunami forecasting and warning program.

NOAA Has Strengthened Its Tsunami Warning Capabilities While Efforts to Improve Reliability and Reduce the Costs of Its DART Detection Buoy Network Continue

In 2006, NOAA strengthened its tsunami warning capabilities by expanding the operating hours and geographic areas of responsibility for both of its tsunami warning centers. Before the strengthening effort, each of the warning centers operated with staff on site 8 hours a day, 5 days a week, with personnel on standby the remainder of the time. NOAA has since increased staffing levels to operate the warning centers with staff on site 24 hours, 7 days a week. Additionally, NOAA expanded the geographic area for which each warning center is responsible. As shown in figure 4, the West Coast/Alaska Tsunami Warning Center is responsible for warning Alaska and coastal states of the U.S. mainland, as well as Canada, Puerto Rico, and the U.S. Virgin Islands. The Pacific Tsunami Warning Center is

responsible for warning Hawaii and U.S. territories in the Pacific Ocean, as well as over 90 countries across the Pacific,[14] Indian, and Caribbean basins.[15]

[14]The center serves as the operational headquarters for the Pacific Tsunami Warning and Mitigation System, which is part of an international cooperative effort by tsunami-vulnerable countries from across the Pacific ocean, working together to mitigate the potentially destructive impacts of a tsunami.

[15]The center's responsibilities in the Indian Ocean and Caribbean Sea are temporary, until regional tsunami warning centers are developed for these areas.

Figure 4: Areas of Responsibility of U.S. Tsunami Warning Centers

Source: NOAA.

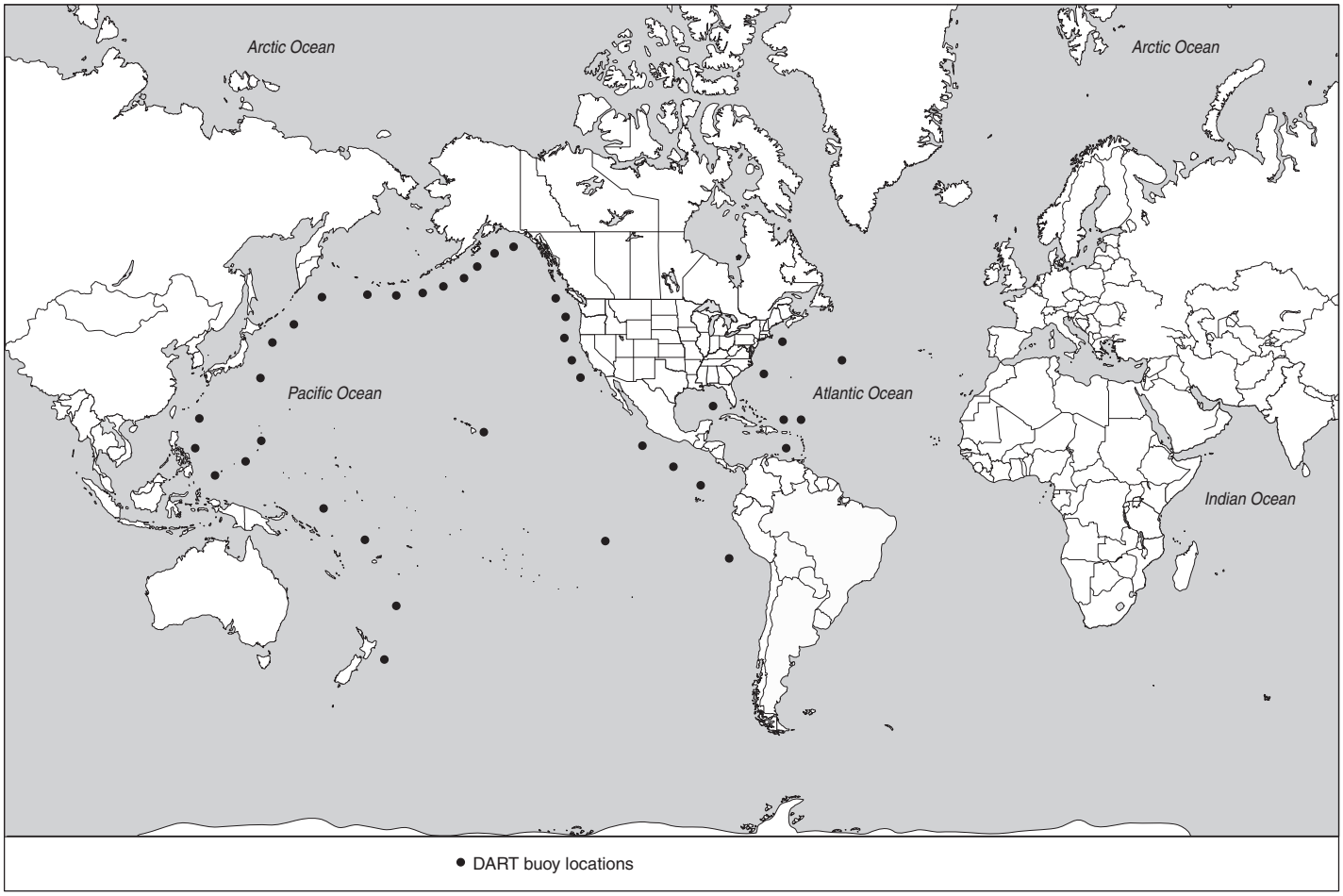
To improve its ability to detect tsunamis, NOAA upgraded and expanded its observational networks for monitoring seismic activity and changes in coastal water levels, and it deployed additional DART buoys to detect deep-ocean tsunami waves far from shore. Since 2005, NOAA has installed new seismic stations in Hawaii and Alaska and integrated its stations with stations maintained by the U.S. Geological Survey, which has installed new stations in the Caribbean. Additional enhancements to other seismic monitoring stations operated by the U.S. Geological Survey in partnership with the National Science Foundation were completed to increase the

number of stations capable of transmitting seismic data during an event.[16] In the Pacific Ocean and Caribbean Sea, NOAA also added 16 new water-level monitoring stations and upgraded 33 existing stations to support tsunami detection.[17] The new and upgraded water-level stations are now capable of providing data on changes in water level to the warning centers faster and more often to confirm whether a seismic event has actually generated a tsunami. Additionally, in March 2008, NOAA completed its 3-year project to expand the network of DART detection buoys from 6 to 39 buoys. These buoys are strategically deployed across the Pacific, Atlantic, and Caribbean basins, as shown in figure 5, in regions with a history of generating tsunamis.

[16]The U.S. Geological Survey also provides data from 15 regional seismic networks that are part of the Advanced National Seismic System. In addition, it operates the National Earthquake Information Center in Golden, Colorado, which has been expanded to operate 24 hours a day, 7 days a week, to monitor seismic data and advise the tsunami warning centers about whether a seismic event could generate a tsunami.

[17]According to agency officials, NOAA also configured 163 water-level stations in the National Water Level Observation Network to support tsunami monitoring. The National Water Level Observation Network is a component of the National Water Level Program, which is managed by NOAA's National Ocean Services through its Center for Operational Oceanographic Products and Services.

Figure 5: U.S. DART Detection Buoy Locations



Source: NOAA.

To enhance its tsunami forecasting capabilities, NOAA began implementing in 2006 a new tsunami forecasting system developed by PMEL, called the Short-term Inundation Forecasting for Tsunamis (SIFT), which uses data from the DART detection buoys. NOAA's tsunami warning centers have been relying on a model that uses location and magnitude data from previous earthquakes in the Pacific Ocean to predict whether a seismic event could generate a tsunami, the potential wave heights, and possible impact areas.[18] The new forecast system will supplement the

[18]The model was originally developed by the West Coast/Alaska Tsunami Warning Center in 1996 and updated in 2002.

existing model by providing estimates of additional tsunami characteristics, such as current velocities and inundation levels, for 75 specific coastal locations.[19] Additionally, the SIFT system uses deep-ocean tsunami wave measurements to produce, before the wave reaches shore, a more precise forecast than the existing model's. DART buoys provide data the SIFT system needs by detecting small changes in deep-ocean waves and quickly transmitting these data to the warning centers. Although warning center officials expressed concerns to us about SIFT's complexity and the staff time needed to operate the system during an event, they acknowledged that it provides a more accurate forecast than the existing model. NOAA is currently testing the SIFT system for use in the tsunami warning centers.

Collectively, NOAA's data indicate that its efforts have enhanced its tsunami detection capabilities and contributed to more accurate and timely warnings. For example, NOAA's data indicate that the tsunami warning centers have a 100 percent detection rate for tsunamis generated within their areas of responsibility since fiscal year 2005. NOAA has also reduced the time needed after a seismic event for the warning centers to issue a warning message. For example, the time needed for the warning centers to issue a message for a distantly generated tsunami has been reduced from an average of 24 minutes in fiscal year 2005 to 15.7 minutes in fiscal year 2009,[20] and the time needed for a local event has been reduced from an average of 9.9 minutes in fiscal year 2005 to 5.8 minutes in fiscal year 2009. The warning centers have likewise made progress reducing false alarms, both in terms of reducing the extent of areas subject to a tsunami warning, as well as shortening the time that areas remain under a warning. For example, in fiscal year 2009, NOAA reduced the average time from initial warning to cancellation to about 90 minutes, surpassing its fiscal year 2013 goal of reducing the time that areas remain under warning from 3 hours to less than 2 hours.

[19]NOAA decided to initially focus on developing site-specific tsunami inundation models for 75 at-risk areas on the basis of population, data availability and quality, and other considerations. As of January 2010, NOAA had completed models for 43 of the selected locations, with plans to develop models for the 32 remaining locations by 2013.

[20]This improved warning capability was recently demonstrated by the Pacific Tsunami Warning Center in its response to the September 2009 American Samoa tsunami, when it issued its initial warning bulletin within 16 minutes of the tsunami-generating earthquake. Similarly, the warning center issued its initial warning bulletin within 12 minutes of the February 2010 Chilean tsunami. NOAA's 2009 fiscal year goal is to issue an initial message within 20 minutes of such seismic events.

While NOAA has improved its tsunami warning capabilities, maintaining the reliability of the DART detection buoys has been challenging and costly. The Tsunami Warning and Education Act requires NOAA, through the National Weather Service, to ensure that maintaining operational tsunami detection equipment is the Tsunami Program's highest priority. When DART buoys are out of service, they cannot detect tsunamis or transmit data to the tsunami warning centers. According to NOAA records on DART buoy performance from July 2006 to August 2009, data were available from the buoys, on average, about 84 percent of the time, and according to officials, about one or two buoy outages occurred per month.[21] In general, data availability goes down and the number of buoy outages goes up during the winter months, when maintenance is virtually impossible because of harsh ocean conditions. The situation reverses during the spring and summer months, when NOAA runs its scheduled buoy maintenance cruise. According to data from NOAA's National Data Buoy Center, which operates and maintains the DART buoy network, failure of mooring lines accounted for almost 60 percent of DART buoy outages from December 2005 to November 2009. Center officials told us that mooring lines fail for a variety of reasons, including ship collisions and vessels that tie up to a buoy. NOAA officials told us they are working to resolve these problems as part of the agency's goal of having data from its three observational networks available at least 90 percent of the time by fiscal year 2013.[22] Meanwhile, the costs of operating and maintaining the DART detection buoy network have been significant. For example, in fiscal year 2009, NOAA allocated nearly $12 million—about 28 percent of NOAA's total tsunami budget—to DART operation and maintenance. NOAA's research program and the National Data Buoy Center are exploring ways to reduce these costs by improving DART buoy reliability—for example, by identifying more durable materials for the mooring line and exploring alternative configurations for anchoring the buoys. Moving some DART stations to less hostile locations with reduced ocean currents and vessel traffic is also being assessed in an effort to improve reliability.

[21]NOAA defines a DART buoy outage as a buoy out of service, with data reporting unavailable for more than 12 hours.

[22]This measure combines average data availability from the seismic, water-level, and DART buoy networks. In fiscal year 2009, data availability from these networks averaged 85 percent.

NOAA Has Expanded and Reorganized Its Hazard Mitigation Program, but Community Participation in TsunamiReady Remains Limited

To improve its mitigation capabilities, NOAA significantly expanded NTHMP's membership and reorganized the program to better focus its activities toward achieving tsunami mitigation goals. In 2005, NOAA expanded NTHMP membership from five Pacific Coast states into a nationwide program including all 29 at-risk coastal U.S. states and territories. NOAA then restructured the NTHMP in 2007 to better meet the needs of the expanded program. As a result of the restructuring, the program consists of an overarching coordinating committee, along with a subcommittee to manage program efforts for key areas of mitigation activity: warning coordination, mapping and modeling, and mitigation and education. Comprising representatives from federal, state, and territory agencies,[23] the coordinating committee assists NOAA in overall program implementation, including recommending how funds are to be allocated and supporting periodic reviews to assess the program's strengths and weaknesses. NOAA also changed the previous annual contracting process for funding mitigation projects—in which the original five member states decided among themselves how to divide the money—to a competitive grant process in 2008. Under the new process, NTHMP members seeking funding must submit proposals for mitigation projects to a panel of subject-matter experts for evaluation, according to an established set of criteria, before recommending to NOAA which projects should be funded. Although the original five member states were initially concerned that NTHMP expansion could divert much-needed mitigation resources away from high-risk areas in those states, officials we spoke with from these states generally agreed that management of the program had improved and available resources had increased for their states.

While NOAA has also taken steps to strengthen its TsunamiReady program, increasing community participation in this voluntary program has been challenging. The number of communities recognized as TsunamiReady has increased from 27 (at the time of our 2006 report) to 74 communities located in 10 states, Puerto Rico, and the Pacific territories,

[23]The coordinating committee comprises two representatives each from NOAA, the U.S. Geological Survey, and the Federal Emergency Management Agency, along with two representatives from each of the following states or territories: Alaska, California, Hawaii, Oregon, Washington, Puerto Rico, and the U.S. Virgin Islands. The remaining states and territories are grouped together for representation, with two representatives each for the following regions: U.S. East Coast states, U.S. Gulf Coast states, and Pacific Islands.

as of February 2010.[24] Despite this progress, overall community participation remains relatively low. For example, the 74 communities that NOAA has recognized as TsunamiReady account for less than 10 percent of the more than 760 communities identified as at risk for a tsunami (see table 2).

Table 2: Number of TsunamiReady Communities and At-Risk Communities as of February 2010

State/territory	TsunamiReady communities	At-risk communities
California	17	158
Oregon	9	50
Washington	9	52
Puerto Rico	9	44
Alaska	7	75
South Carolina	6	9
North Carolina	5	11
Hawaii	4	4
Commonwealth of the Northern Mariana Islands	3	3
Florida	2	37
Virginia	1	26
Georgia	1	6
Guam	1	1
American Samoa	0	1
Texas	0	11
Louisiana	0	11
Mississippi	0	3
Alabama	0	2
Maryland	0	17
Delaware	0	3
New Jersey	0	9
New York	0	9

[24]The program's goal is to recognize 10 new TsunamiReady communities per year and to reach a total of 105 recognized communities by 2013. In fiscal year 2009, 11 new communities were recognized in Alaska, California, Washington, the Northern Mariana Islands, and Puerto Rico. For purposes of the TsunamiReady program, a "community" can be a county, town, borough, small organized rural population, military base, university, corporate complex, tribal nation, or village.

State/territory	TsunamiReady communities	At-risk communities
Connecticut	0	24
Massachusetts	0	64
Rhode Island	0	21
New Hampshire	0	8
Maine	0	105
U.S. Virgin Islands	0	3
Total	**74**	**767**

Source: GAO analysis of NOAA data.

Communities along the Pacific Coast and in the Caribbean, where tsunami hazard is highest, have been the most active in seeking TsunamiReady recognition, while those in other areas, such as the East and Gulf Coasts, have been less active in participating in the program.[25] For example, only 2 of 64 at-risk Gulf Coast communities and only 13 of 312 at-risk East Coast communities have been recognized as TsunamiReady. NOAA program staff and state and local emergency management officials offered a number of reasons for this apparent lack of interest in TsunamiReady recognition by the East and Gulf Coast communities, including limited information on the extent of the tsunami hazard; competing priorities for time and resources to plan for and respond to more common events, such as hurricanes; and costs to meet the recognition requirements. Additionally, some officials told us that some communities have been reluctant to pursue the designation because they believe it might draw undue attention to the tsunami hazard and potentially deter tourists from visiting their communities.

NOAA has not conducted a formal assessment to identify barriers to or possible incentives for participating in the TsunamiReady program, as we recommended in 2006. Instead, in part on the basis of recommendations from a 2007 NTHMP review of the program and feedback from a series of NTHMP meetings and local community workshops, NOAA decided to focus its efforts on revising the program's recognition guidelines. Existing TsunamiReady guidelines have emphasized warning and preparedness efforts. These guidelines require TsunamiReady communities to establish a 24-hour warning point and emergency operations center and have more

[25]While NOAA has generally assessed the relative tsunami hazard level for each coastal region, the list of at-risk communities is not further prioritized by relative risk because the agency currently lacks the information needed to conduct a comprehensive tsunami risk assessment for each coastal community.

than one means of receiving tsunami warnings and alerting the public; to promote public readiness through community education; and to develop a formal tsunami plan, including plans for emergency exercises. According to a program official, revised guidelines under development are intended to take a more comprehensive approach and to address all aspects of emergency management planning: mitigation, preparedness, warning, response, and recovery. NOAA officials told us that over the next 2 years, they plan to work with social scientists to conduct a survey to establish a baseline of tsunami preparedness in at-risk coastal communities, to conduct pilot projects in selected communities to obtain feedback on and test implementation of the revised guidelines, and to conduct internal and external reviews of the revised guidelines. NOAA then plans to further revise the guidelines to address issues identified through these efforts before submitting them to the NTHMP coordinating committee for its approval. NOAA anticipates implementing the new TsunamiReady recognition guidelines nationwide sometime in 2012. Although developing new guidelines may help strengthen the TsunamiReady program, we continue to believe that it does not substitute for a comprehensive assessment to determine what potential barriers may be inhibiting community participation and that NOAA should conduct such an assessment.

NOAA's Failure to Follow Its Research Transition Policy Contributed to Delays in Implementing a New Tsunami Forecasting System

Since 2006, NOAA has been transitioning the SIFT tsunami forecasting system from its developer, PMEL, to application at the tsunami warning centers. In large part because the laboratory and Tsunami Program officials did not follow NOAA's agencywide policy and implementation procedures for the transition of new technologies from research to application, numerous modifications were needed to make the system usable by the warning centers, leading to about a 2-year delay in implementation.[26] The agency's policy and procedures describe a four-step process for systematically reviewing all research projects and, if appropriate, moving them to application. This process includes checkpoints for NOAA officials to ensure that all activities have been successfully completed before a research project can proceed to the next step (see fig. 6).

[26]NOAA first issued its Policy on Transition of Research to Application (NAO 216-105) in May 2005 and the corresponding implementation procedures in December 2005; the policy and implementation procedures were updated in July 2008 and November 2008, respectively.

Figure 6: NOAA's Process for Moving Research to Application

Source: NOAA.

When PMEL began the SIFT transition, it prepared an initial transition plan in 2006. This plan did not follow NOAA's transition policy, however, and as a result, did not undergo checkpoint reviews or contain all of the plan elements required by NOAA's policy and implementation procedures. Tsunami Program and PMEL officials told us they did not realize that this policy applied to the transition of relatively small research efforts like the SIFT system, which the officials said accounted for their failure to follow NOAA's transition policy. Although a transition team consisting of officials

from the warning centers and PMEL was assembled, the warning center officials were not actively involved in developing the transition plan, which should identify requirements for the new technology and criteria it must meet to be implemented, among other things. Thus, the 2006 transition plan did not identify requirements for the SIFT system or performance measures to enable PMEL and the warning centers to test and evaluate the system. These shortcomings left the warning centers with no formal mechanism to provide input into the transition process or to evaluate the SIFT system before accepting it for implementation. As a result, numerous modifications to the system were needed to make it practical for use after the warning centers received it.

In 2008, however, to revise the transition plan and accelerate the system's implementation, NOAA's Tsunami Program manager collaborated with staff from PMEL and the warning centers and established a SIFT transition team with more involvement from the warning centers. According to NOAA officials, the transition team completed a revised plan in June 2009 that meets the requirements of NOAA's research transition policy and implementation procedures, such as defining system requirements and performance measures. Additionally, NOAA officials performed a checkpoint review of the transition. As a result of these changes, according to officials at PMEL and the warning centers, communication between them has improved, and NOAA is closer to implementing the SIFT system in the centers.

Moreover, NOAA has not complied with the Tsunami Warning and Education Act's requirement that it, through the National Weather Service, develop and execute a plan for the transfer of technology from ongoing research into the tsunami forecasting and warning program.[27] Although NOAA has developed a specific transition plan for the SIFT system, this transition plan does not meet the act's requirement because it does not generally address how other research should undergo transition. In response, NOAA officials told us they believe that NOAA's general transition policy and implementation procedures, along with individual

[27]The Tsunami Warning and Education Act does not impose a deadline for NOAA to create the plan. By December 2009, however, NOAA was required to submit a report to Congress on how technology is being transferred into the Tsunami Program. The report discusses various research transitions but not the required plan.

transition plans for selected projects,[28] satisfy its planning obligations under the act. But when we first asked program officials about the required tsunami research transition plan, they told us they did not have one and that they were unfamiliar with the act's requirement. Because NOAA's existing policy and procedures, which predated the act, do not provide a plan specifically for the transfer of tsunami research into the Tsunami Program, and because NOAA has not created a separate plan for the transfer of tsunami research, we believe that NOAA has not fully complied with the act's requirement for a transition plan for tsunami research.

Conclusions

NOAA and its partners have taken important initial steps toward implementing effective, results-oriented management by creating strategic plans for the Tsunami Program and NTHMP. By following the key practices we and leading organizations have identified for developing strategic plans and generally including the critical components of effective plans—such as long-term goals and strategies to achieve them—NOAA has established a solid foundation for managing its programs. Nevertheless, because NOAA has not identified strategies or performance measures for some goals, it is not clear how the agency intends to pursue these goals or how it will measure its progress toward achieving them. In this regard, identifying barriers to participation, as we previously recommended, and developing strategies for achieving the goal of expanding TsunamiReady program participation could help address the low participation rate in this community preparedness program. In addition, both the warning and mitigation components of NOAA's programs can benefit greatly from the results of tsunami-related research. As demonstrated by the transition of SIFT from research to application in the warning centers, however, the failure to plan properly can result in the need for multiple modifications to a system to make it usable, leading to delays in implementing a promising new technology. Until NOAA develops a plan specifically for the transition of technology from research to application in the Tsunami Program, it will not be in compliance with the requirement of the Tsunami Warning and Education Act, and the potential persists for delays like those experienced in the SIFT transition.

[28]Since the passage of the Tsunami Warning and Education Act in December 2006, NOAA has prepared a transition plan for only one tsunami project—the SIFT system as described above.

Recommendations for Executive Action

To improve national tsunami preparedness and ensure that NOAA fulfills its responsibilities under the Tsunami Warning and Education Act, we are recommending that the Secretary of Commerce direct the Administrator of NOAA to take the following two actions:

- Revise the Tsunami Program's and NTHMP's strategic plans to ensure that all the components are fully developed, in particular, that they include effective strategies and performance measures for all goals, including those for the TsunamiReady program.
- Develop a transition plan for tsunami research, as required by the Tsunami Warning and Education Act. The plan should incorporate lessons learned from the transition of the SIFT tsunami forecasting system.

Agency Comments and Our Evaluation

We provided a copy of our draft report to the Department of Commerce for review and comment. The Department provided us NOAA's comments on the draft report, in which NOAA said that the report captures and addresses the major elements of the Tsunami Program and acknowledges the involvement and roles of all levels of government. NOAA also agreed with our two recommendations. NOAA said that it will initiate revisions to the Tsunami Program's and NTHMP's strategic plans upon receipt of the National Academy of Sciences' report on the Tsunami Program expected in the summer of 2010. NOAA also said that it will initiate the development of a Tsunami Program transition plan for tsunami research in the summer of 2010 in coordination with its research partners. NOAA also provided technical comments that we incorporated into the report as appropriate. NOAA's comments are presented in appendix I.

We are sending copies of this report to the appropriate congressional committees, Secretary of Commerce, Administrator of NOAA, and other interested parties. In addition, this report will be available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or mittala@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix II.

Anu K. Mittal
Director, Natural Resources and Environment

Appendix I: Comments from the Department of Commerce

UNITED STATES DEPARTMENT OF COMMERCE
The Secretary of Commerce
Washington, D.C. 20230

April 15, 2010

Ms. Anu K. Mittal
Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Ms. Mittal:

Thank you for the opportunity to review and comment on the Government Accountability Office's draft report entitled "U.S. Tsunami Preparedness: NOAA Has Expanded Its Tsunami Programs, but Improved Planning Could Enhance Effectiveness" (GAO-10-490). On behalf of the Department of Commerce, I have enclosed the National Oceanic and Atmospheric Administration's programmatic comments on the draft report.

Sincerely,

Gary Locke

Enclosure

Department of Commerce
National Oceanic and Atmospheric Administration
Comments on the Draft GAO Report Entitled
"U.S. Tsunami Preparedness: NOAA Has Expanded Its Tsunami Programs, but Improved Planning Could Enhance Effectiveness"
(GAO-10-490, April 2010)

General Comments

The Department of Commerce and the National Oceanic and Atmospheric Administration (NOAA) appreciate the opportunity to review this Government Accountability Office (GAO) report on tsunami preparedness. The report captures and addresses the major elements of the tsunami program and acknowledges the involvement and roles of all levels of government.

NOAA Response to GAO Recommendations

The draft GAO report states, "To improve national preparedness and ensure that NOAA fulfills its responsibilities under the Tsunami Warning and Education Act, we are recommending that the Secretary of Commerce direct NOAA to take the following two actions:"

Recommendation 1: "Revise the Tsunami Program's and National Tsunami Hazard Mitigation Program's (NTHMP) strategic plans to ensure that all of the components are fully developed, in particular, that they include effective strategies and performance measures for all goals, including those for the TsunamiReady program."

NOAA Response: NOAA agrees with this recommendation. NOAA will initiate the revisions to the Tsunami Program and NTHMP's strategic plans upon receipt of the National Academy of Sciences Report on the Tsunami Program. This report is expected in the summer of 2010 and will provide additional recommendations for NOAA's Tsunami Program. These recommendations will be addressed within the revised Tsunami Program and NTHMP strategic plans.

Recommendation 2: "Develop a transition plan for tsunami research, as required by the Tsunami Warning and Education Act. The plan should incorporate lessons learned from the transition of the SIFT [Short-term Inundation Forecasting for Tsunamis] tsunami forecasting system."

NOAA Response: NOAA agrees with this recommendation. NOAA will initiate the development of a Tsunami Program Transition Plan for Tsunami Research in the summer of 2010 in coordination with its research partners.

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contact

Anu K. Mittal (202) 512-3841 or mittala@gao.gov

Staff Acknowledgments

In addition to the contact named above, Stephen D. Secrist, Assistant Director; Elizabeth R. Beardsley; Ellen W. Chu; Brad C. Dobbins; Wyatt R. Hundrup; Katherine Killebrew; Michael J. Meleady; and Katherine M. Raheb made key contributions to this report.

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