TESTIMONY
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Thank you, Mr. Chairman and Members of the Committee, for the opportunity to testify before you regarding the National Oceanic and Atmospheric Administrations (NOAA) activities with tsunamis. I am Brigadier General (ret.) David L. Johnson, Assistant Administrator for Weather Services and Director of NOAA's National Weather Service.

As the world and our Nation mourn the loss of life from the Indian Ocean tsunami tragedy, we recognize the very real threat of tsunamis and ask, "Could it happen here?" We need to be able to answer that question with a high degree of confidence.

We know a tsunami can affect any community along the coast of the United States. This is particularly true for the Pacific coast, where tsunamis have been more frequent. The recent event in Southeast Asia and Africa highlights the need to address the steps we can take to mitigate the potential impact of such an event here at home.

This catastrophic event focuses the spotlight on the threat tsunamis pose to all coastal communities. If there is some good to come from this tragedy, it is the opportunity that we now have to educate United States citizens about the actions they should take if they receive a tsunami warning.

In this testimony, I will describe our existing tsunami warning program, including a brief overview of our work with the International community; specific actions NOAA took during the recent tsunami; and then briefly outline the Administration's plan for developing a global tsunami warning system.

Tsunamis are natural disasters that can form in all of the world's oceans and inland seas, and in any large body of water near seismic activity. Each region of the world appears to have its own cycle of frequency and pattern for generating tsunamis that range in size from small events (no hazards) to the large and highly destructive events. Eighty-five percent of tsunamis occur in the Pacific Ocean and its marginal seas. This is not surprising as the Pacific Basin covers more than one-third of the earth's surface and is

surrounded by a series of mountain chains, deep-ocean trenches and island arcs called the "ring of fire."

Most seismic activity occurs in this ring of fire where the main tectonic plates forming the floor of the Pacific collide against one another or against the continental plates that surround the ocean basin, forming subduction zones. While tsunamis can be generated by any sudden pressure source in the water, such as a meteor, landslide, etc., most are generated from earthquakes. In the tropical Pacific tsunamis tend to be modest in size. While tsunamis in these areas may be locally devastating, their energy decays rapidly with distance. Usually they are not destructive more than a few hundred kilometers away from their sources. That is not the case with tsunamis generated by great earthquakes in the North Pacific or along the Pacific coast of South America. On the average of six times per century, a tsunami caused by an earthquake in one of these regions sweeps across the entire Pacific Ocean, is reflected from distant shores, and sets the entire ocean in motion for days. Although not as frequent, destructive tsunamis have also been generated in the Atlantic and the Indian Oceans, the Mediterranean Sea and even within smaller bodies of water, such as the Sea of Marmara, in Turkey. There have also been tsunamis in the Caribbean, but the lack of any recent tsunami in that area has lowered the level of interest and hindered establishing a warning program in that area.

According to NOAA's National historical tsunami databases, during the 105-year period from 1900 to 2004:

- 923 tsunamis were observed or recorded in the Pacific Ocean.
- 120 tsunamis caused casualties and damage, most near the source. Of these, at least ten caused widespread destruction throughout the Pacific.
- The greatest number of tsunamis during any one year was 23 in 1938. While most were minor, one event did result in 17 deaths.
- There was no single year during this period that was free of tsunamis.
- 19 percent of all tsunamis were generated in or near Japan; 9 percent were generated off Alaska and the west coasts of Canada and the United States; and 3 percent were generated near Hawaii.

The U.S. Tsunami Warning System consists of two warning centers: the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii; and the West Coast/Alaska Tsunami Warning Center (WC/ATWC) in Palmer, Alaska. NOAA conducts research on tsunamis, operates essential ocean buoys and tide gauges to detect tsunamis, and works with other Federal, state, local government agencies and universities as our partners in the tsunami warning mission.

The Richard H. Hagemeyer Pacific Tsunami Warning Center in Hawaii was established in 1949 in response to the unpredicted 1946 Aleutian tsunami, which killed 165 people on the Hawaiian Islands. In 1967, the West Coast/Alaska Tsunami Warning Center in Palmer, Alaska, was created as a result of the 1964 Great Alaska earthquake and tsunami. These centers are responsible for issuing all tsunami warning, watch, advisory, and information messages to emergency management officials and the public throughout their respective areas of responsibility. The Pacific Center covers United States interests and

territories throughout the Pacific, including Hawaii, while the West Coast/Alaska Center covers Alaska, and the west coast of North America from British Columbia in Canada, to California.

About 100 water level gauges are used by the Tsunami Warning Centers and are operated by the Unites States and our international partners. These gauges are along the coasts of islands or continents around the Pacific Rim. NOAA operates many of these stations, including 33 from NOAA's National Water Level Observation Network in the Pacific Ocean basin, which are equipped with software to support the Tsunami Warning System. Water levels from these gauges can be sent directly to NOAA Tsunami Warning Centers and others who want the information. NOAA is working to upgrade the nationwide network with a real-time capability to provide a continuous stream of water level data (minute-by-minute) for integration with tsunami warning systems and research applications. NOAA also helps support many coastal gauges located in other countries around the Pacific.

NOAA operates six Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys. NOAA research activities developed these buoys to measure tsunamis in the deep ocean and to transmit the information back to the Warning Centers in near real time. These instruments accurately calculate the size of the tsunami by measuring the pressure it exerts on the deep ocean floor as the wave passes over. Tsunamis as small as 0.5 cm have been measured. NOAA began placing DART buoys in the Pacific Ocean in 2002 and plans to have a complete coverage of potential Pacific tsunami source zones over the next few years.

In November 2003, the buoys demonstrated their effectiveness. A large earthquake occurred in the Aleutian Islands and generated a tsunami. The two Tsunami Warning Centers evaluated the tsunami using coastal gauge data but didn't "stand down" until a reading arrived from the nearest DART buoy confirming only a small tsunami. During post analysis of the event, DART data were used for a model simulation and the output from the simulation accurately predicted the 2 cm tsunami recorded at Hilo, Hawaii. This NOAA model is still being developed, but an initial version will be transferred to the warning centers for test operations this year. DART data and the forecast model show much promise to help accurately predict tsunami impacts. In the history of Pacific Warning Center, 75 percent of its warnings to Hawaii have been for non-destructive tsunamis. The DART data combined with forecast models promise to significantly reduce false alarm rates as well as provide a better measure of the severity of destructive tsunamis for Hawaii and all other parts of the Pacific. The accurate forecasting of a non-destructive tsunami in November 2003 saved Hawaii an estimated $68M in projected evacuation costs.

The Pacific Center also serves as the operational center for the International Tsunami Warning System of the Pacific, which is comprised of 26 member nations of the Pacific Rim. These members share seismic and water level information with the Pacific Center so the Center can determine whether a tsunami was generated in the Pacific Basin and assess its strength. The Pacific Center's primary responsibility is to issue tsunami

warnings for Pacific Basin teletsunamis -- tsunamis that can cause damage far away from their source. It is not the Center's responsibility to issue local tsunami warnings from seismic events outside of the United States. For example, if an earthquake occurs off the coast of Japan and a local tsunami is generated, it is Japan's responsibility to issue a local tsunami warning. However, it is the Pacific Center's responsibility to warn all participating Nations in the Pacific Basin if the Japanese tsunami will cause damage far from its source.

Only Australia and Indonesia have coastlines bordering both the Pacific and Indian Ocean coasts. None of the other countries impacted by the Indian Ocean tsunami have coasts bordering the Pacific Ocean and therefore they do not receive tsunami bulletins via the automated dissemination network.

Thailand and Indonesia are member states within the International Tsunami Warning System in the Pacific (ITSU), but their participation has been limited. Thailand has no coast along the Pacific, and Indonesia's tsunami threat is primarily outside the Pacific Basin. As a member of the International Coordination Group (ICG) for ITSU, the U.S. has actively encouraged non-member States to become ICG/ITSU members. Under the IGC/ITSU, the U.S. has actively supported the need for global tsunami mitigation actions and will continue to provide support through the development of a Global Earth Observation System of Systems (GEOSS), an effort in which the UNESCO Intergovernmental Oceanographic Commission, the UN International Strategy for Disaster Reduction (ISDR), and a number of other UN agencies and programs participate.

NOAA Tsunami Warning Centers have no authority or responsibility to issue tsunami warnings for the Indian Ocean basin. However, knowing the concern Pacific countries might have about the potential devastating impact a large earthquake and resulting tsunami can inflict, on Sunday, 26 December 2004, at 8:14 p.m. EST, within 15 minutes of the Indonesian earthquake, both centers issued Tsunami Information Bulletins. These bulletins included location and initial magnitude (8.0) information and an assessment that there was no tsunami threat in the Pacific. As the Indian Ocean is outside the NOAA tsunami area of responsibility, NOAA Tsunami Warning Centers have no procedures in place to issue a warning for this region. An hour and 5 minutes after the earthquake, as additional information came in from seismic monitoring stations around the world, another bulletin was issued by both Centers revising the magnitude of the earthquake to 8.5. This time the bulletin contained a statement that the potential existed for a tsunami near the epicenter. Unfortunately, there was no sea-level data or other information available to substantiate or evaluate a tsunami until three and a half hours after the earthquake when news reports began coming indicating casualties in Sri Lanka and Thailand. At about the same time, data from the one sea-level gauge in the Indian Ocean (Cocos I; west of Australia) was received indicating a 45cm peak-to-trough non-destructive tsunami.

Sea-level gauges are essential elements of the current Tsunami Warning System in the Pacific. When strategically located, they are used to quickly confirm the existence or non-existence of tsunami waves following an earthquake, to monitor the tsunami's

progress, and to help estimate the severity of the hazard. There was no data available from the Indian Ocean to help the warning centers know what was occurring.

An effective tsunami warning system requires (1) an assessment of the tsunami hazard, (2) near real-time seismic and oceanographic (sea-level change) data; (3) high-speed data analysis capabilities; (4) a high-speed tsunami warning communication system; and (5) an established local communications infrastructure for timely and effective dissemination of the warning and evacuation requirements. It is also critical that coastal populations are educated and prepared to respond appropriately to tsunami warnings and calls for evacuations. For the Pacific Basin, these tsunami warning requirements are well known. Unfortunately, for the Indian Ocean basin, they were basically non-existent.

There are currently 6 DART buoys in the Pacific operated by NOAA – 3 off the coast of Alaska, 2 off the coast of the western U.S., and one in the eastern Pacific. These first buoys of the currently envisioned 29 buoy array are an example of a successful transition of buoys from research and development into an operational system. Three of the deployed DART buoys are inoperable and will be repaired as soon as the weather permits.

The government of Chile purchased one DART buoys from NOAA and in now operating off the northwest coast of Chile; another buoy is in the process of being purchased at this time. Japan also operates a few cabled deep ocean sensors off its Pacific coasts. The NOAA buoys represent the only current deep ocean capability available to the Tsunami Warning Centers to detect tsunamis. In July of last year, staff from the Pacific Center had discussions with Japanese representatives about the possibility of allowing PTWC access to data from the Japanese cabled buoys.

While technical equipment is required for detection and communication, equally important are continued research and development, and education and outreach to mitigate potential impacts from tsunamis. People must have the knowledge and information to act during potentially life threatening events. Outreach and education efforts, such as NOAA's own StormReady and TsunamiReady programs, are key components of the U.S. National Tsunami Hazard Mitigation Program (NTHMP). These programs foster interaction between emergency managers and their citizens, provide robust communications systems, and establish planning efforts before certification. NOAA also developed multi-hazard risk and vulnerability assessment training and decision support tools using GIS mapping technology to highlight populations, infrastructure and critical facilities at risk for coastal hazards. These tools and other support are critical to land use planning, pre-disaster planning, mitigation efforts, and targeted dissemination of outreach, education and information about high-risk areas.

The International Strategy for Disaster Reduction (ISDR) was launched by the General Assembly of the United Nations to provide a global framework for action to reduce human, social, economic, and environmental losses due to natural and man-made hazards. The ISDR aims at building disaster-resilient communities, highlighting the importance of disaster reduction as an integral component of sustainable development.

ISDR is the focal point within the United Nations system for coordination of strategies and programs for disaster reduction and to ensure synergy between disaster reduction activities and those in the socioeconomic and humanitarian fields. One particularly important role of ISDR is to encourage both policy and awareness activities by promoting national committees dedicated to disaster reduction and by working in close association with regional initiatives. As part of this effort, tsunami hazard maps have been produced for over 300 coastal communities in over 11 countries, including 130 communities throughout the United States.

The United Nation's Education, Scientific, and Cultural Organization's (UNESCO) Intergovernmental Oceanographic Commission (IOC) has developed products to help countries implement tsunami response plans. Road signs and other mitigation products are available through the NTHMP (http://www.pmel.noaa.gov/tsunami-hazard). In summary, Tsunami Response Plans are probably the most cost-effective way to create a tsunami resilient community. To be successful, communities must remain committed to a continuous, long-term education program. Tsunamis are infrequent events and it is important to ensure future generations understand tsunami safety.

Protecting near-shore ecosystems, like coral reefs, is equally important for maintaining disaster–resilient communities. The international media and South Asian officials reported less destruction in locations protected by wave-absorbing healthy coral reefs. NOAA and our federal, state, territorial, and international partners work to protect and preserve coral reef ecosystems.

The United States will continue working closely with the international community to help implement recommended tsunami detection and warning measures for the Indian Ocean Basin and other regions of the world currently without adequate tsunami warning capability. A comprehensive global tsunami warning program requires deploying DART buoys along each of the world's major subduction zones; adding real-time sea-level monitoring/tide gauge stations; establishing Regional Centers for Disaster Reduction, assessing hazards, promoting education and outreach efforts; and conducting research and development.

As recently announced by Vice Admiral Lautenbacher, Undersecretary of Commerce for Oceans and Atmosphere, the Bush Administration has a plan to upgrade the current U.S. Tsunami Warning System. NOAA's contribution to this plan includes procuring and installing 32 new DART buoys, including 25 new buoys in the Pacific and 7 new buoys for the Atlantic and Caribbean. We expect to have the complete network of DART buoys installed and operational by mid-2007; 20 buoys should be operational in FY06, with the final 12 in place in FY07. In addition to the DART buoys, NOAA will procure and install 38 new sea level monitoring/tide gauge stations. The Administration has allocated $24M, over the next two years, to NOAA for this effort, including $18.1M for the Pacific Basin and $5.9M for Atlantic/Caribbean/Gulf.

There were many lessons learned from the Indian Ocean tsunami. A key point to make is that, for all coastal communities, the question is not "if" a tsunami will occur, but

"when." We know what causes a tsunami to develop, and we know a great deal about how to track them and forecast their path. With expansion of the U.S. Tsunami Warning System, NOAA forecasters will be able to detect nearly 100% of tsunamis affecting the United States and will be able to respond and alert communities within minutes of a tsunami-producing event. With expanded education and outreach via NOAA's TsunamiReady program and other efforts, we can rest assured that our coastal communities have the opportunity to learn how to respond to a tsunami event and that we have minimized the threat to American lives.

With global attention on this important matter, we have a great opportunity to help the world better prepare for tsunamis through the development of a Global Earth Observation System of Systems (GEOSS). This system would include a real-time global seismic monitoring network, a real-time DART network, and a near real-time sea level monitoring network. NOAA Administrator, Vice-Admiral Conrad C. Lautenbacher will be a member of the U.S. delegation at the Third Earth Observation Summit (February 16, 2005; Brussels, Belgium) and will work to ensure that the development of a global tsunami warning system is a high priority for the larger Global Earth Observation System of Systems and the Integrated Ocean Observing System.

We look forward to working with Congress and other Nations around the world to help take the pulse of the planet and make our world a safer place. Attached to this written testimony submitted for the record is an article published in the International Tsunami Information Center Tsunami Newsletter, which provides detailed information about NOAA's Pacific Tsunami Warning Center. Much more information about tsunamis can be found at http://wcatwc.arh.noaa.gov, http://www.pmel.noaa.gov/tsunami/, http://www.prh.noaa.gov/ptwc/, and http://www.ngdc.noaa.gov/spotlight/tsunami/tsunami.html.