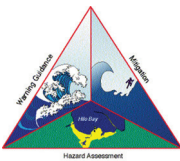
The background features a large, stylized blue wave graphic that curves across the top and bottom of the page. The wave is composed of several layers of different shades of blue, from a deep cerulean to a light sky blue, creating a sense of movement and depth. The main title is positioned in the upper left quadrant, with the subtitle below it. The overall design is clean and modern, with a focus on the blue color palette.

National Media Tsunami Guidebook

**National Tsunami Hazard
Mitigation Program
(NTHMP)**



NTHMP | January, 2010

The NTHMP includes all 29 U.S. coastal States, Territories and Commonwealths, the United States Geological Survey, the Federal Emergency Management Agency, and National Oceanic and Atmospheric Administration (NOAA). This strong and active partnership enables all levels of government to work toward the common goal of saving the lives of all people at risk for a tsunami at our nation's coastlines, and reducing damage to property and the economy.

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Introduction

Intended Audience

This guidebook provides a concise overview of the notification process used to send tsunami alerts to national public information broadcasters, local jurisdictions, and the public. It includes a Tsunami Warning Flow Chart that shows how information from NOAA's Tsunami Warning Centers is sent to broadcasters, a contact list of experts who can provide credible tsunami information during an event, and graphics that can be used to provide the public with information on tsunami generation, detection equipment, and safety messages.

What is a Tsunami?

A tsunami:

- is a *series* of ocean or sea waves caused by a sudden, large displacement of water most often caused by earthquakes, but also by landslides, volcanic eruptions, and comet or meteorite impacts in the ocean.
- is like a fast rising flood tide, storm surge or an advancing wall of water and strikes with devastating force.
- may move faster than you can run.
- will continue for many hours. The first wave is often not the largest nor the most dangerous, and surges may arrive 10 hours or more after the initial wave.

Who is at Risk?

All U.S. ocean coasts can be impacted by tsunamis, though based on proximity to tsunami sources and sea floor configurations, some areas are at much greater risk than others. Within the last 150 years, destructive and deadly tsunamis have struck Hawaii, Alaska, California, Oregon, Washington, American Samoa, Puerto Rico, and the U.S. Virgin Islands.

How Are Tsunamis Generated?

Tsunamis are generated when geologic events cause large, rapid movements of the sea that displace the water column. This swift change creates a series of high energy waves that radiate outward from the source. Locations nearest to the source will be impacted within minutes. Locations farther away may not see impacts for hours. Any coast can be impacted by a tsunami. Some areas are at a much greater risk than others due to the proximity to tsunami sources and sea floor. Impacts vary from site to site depending on a location's unique bathymetric and topographical characteristics.

Why Are Tsunamis Dangerous?

As the tsunami crosses the deep ocean, it may be only a few feet or less in height. Unlike wind-generated waves that affect the surface of the ocean, tsunamis move the entire water column. As the waves enter shallower water, they are compressed, their speed slows, they build in height, and associated currents intensify becoming a threat to life and property (see Figure 1).

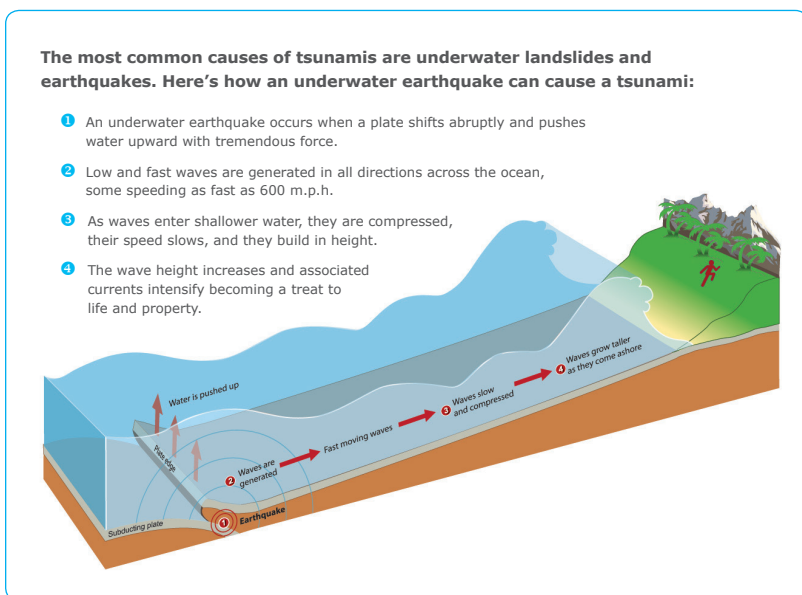


Figure 1. How Tsunamis are generated (Credit: University of Alaska, modified by NOAA/NWS)

A tsunami's travel time is on the order of minutes (for local events) to hours (for distant events). For local events, there will not be enough time to assess the potential severity of the tsunami before it inundates the coast.

What are the Signs that a Tsunami is Coming?

Natural Warning

Strong ground shaking, a loud roar from the ocean, the water receding from the shore unusually far and exposing the sea floor, or the water level rising rapidly are all nature's warning signs that a tsunami may be coming. If you observe any of these signs, immediately move to higher ground or inland. A tsunami may arrive within minutes.

DO NOT WAIT for an official warning. The earthquake or changes in the water at the shore may be your only warning, and you may have only minutes to get to high ground. Stay away from low areas until told by officials that the danger has passed. Waves may impact the coast at irregular intervals for 10 hours or longer.

Official Warning

You may learn a tsunami alert has been issued by a Tsunami Warning Center through TV and radio station broadcasts, NOAA All Hazards Weather Radio, or in some cases by announcements from emergency officials, aircraft, outdoor sirens, Emergency Managers Weather Information Network (EMWIN), or mobile devices. Immediately move away from beaches, harbors, or low-lying areas and follow instructions from emergency personnel.

Both natural warnings and official alerts are equally important. Respond to whatever you hear or observe first!

Tsunami Warning Centers in the U.S.

When an earthquake that might generate a tsunami for the U.S. coast is detected, the West Coast/Alaska Tsunami Warning Center (WC/ATWC) and Pacific Tsunami Warning Center (PTWC) assess the potential for danger to coastal locations within their respective Areas of Responsibility (AOR).

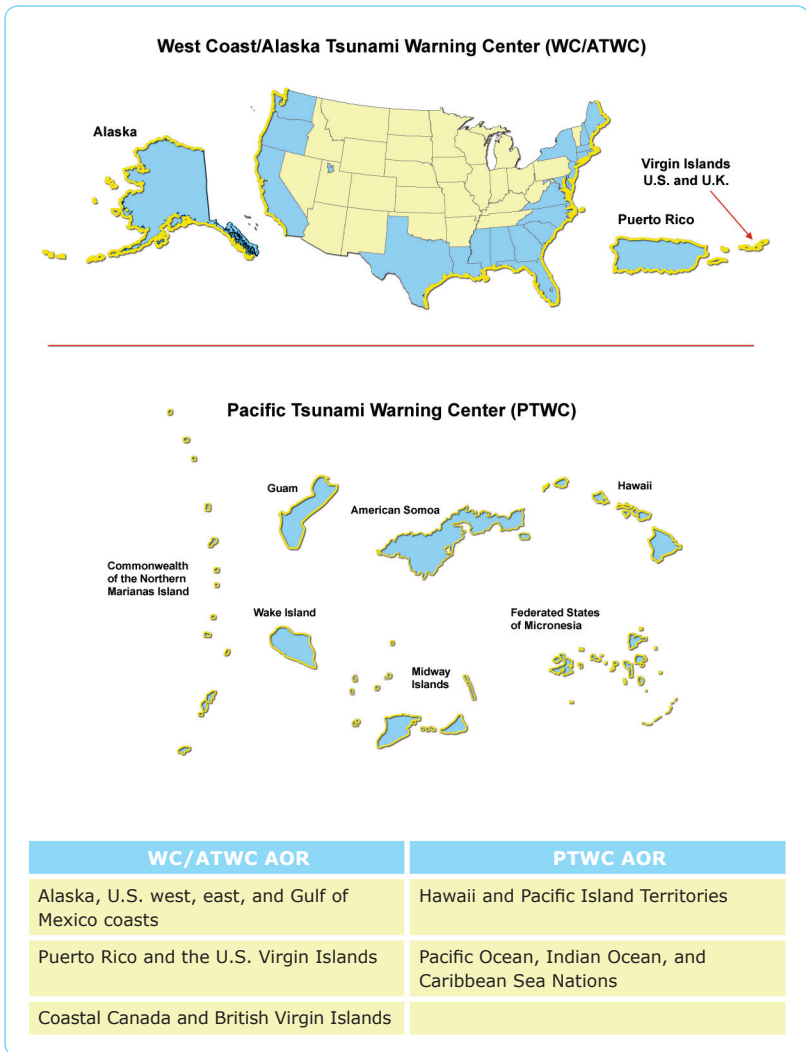


Figure 2. Domestic Areas of Responsibility (AOR) for U.S. Tsunami Warning Centers
(Credit: NOAA/NWS)

The Tsunami Warning Centers are responsible for providing tsunami warnings, advisories, watches, and information statements to their areas of responsibility as reflected in Figure 2 (page 4).

Both centers will issue messages for their respective areas of responsibility in response to potentially tsunamigenic events. The two U.S. Tsunami Warning Centers collaborate to provide warning services and mutual backup. It is important to respond to the products specific to the area where you are located. Figures 2 and 3 show the Tsunami Warning Centers' Domestic and international areas of responsibility.

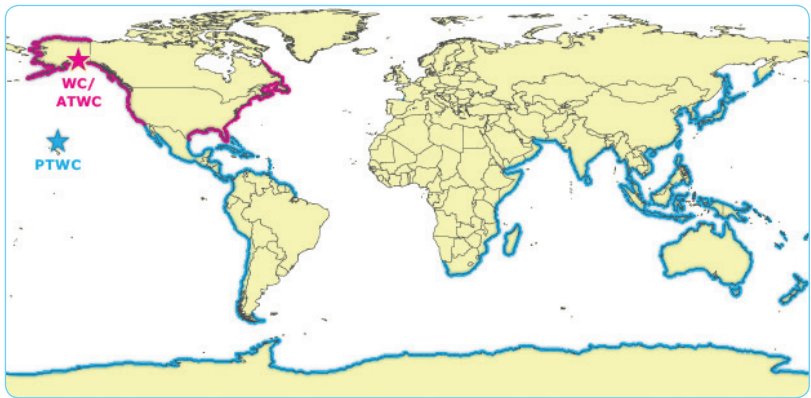


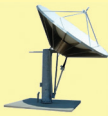
Figure 3. International areas of responsibility for U.S. Tsunami Warning Centers. The WC/ATWC area of responsibility shown in pink and the PTWC area of responsibility shown in blue. (Credit: NOAA/NWS)

National Weather Service Forecast Offices in the U.S.

WFOs serve an important link in disseminating tsunami information and in working with emergency management agencies prior to, during, and after an event. When a Tsunami Watch/Warning/Statement is issued, National Weather Service Forecast Offices (WFOs) relay the messages on NOAA All Hazards Weather Radio and are responsible for activating the Emergency Alert System (EAS) in accordance with emergency management agency directions. In addition to forwarding tsunami information over NOAA All Hazards Weather Radio and EAS, WFOs may issue local statements to supplement information contained in the tsunami messages. WFOs also support the tsunami warning system by providing outreach and educational services to partners and the general public.

Tsunami Warning Center Product Flow Chart

How the U.S. Tsunami Warning System Works



Step 1

Pacific Tsunami Warning Center and/or West Coast/Alaska Warning Center issue a Tsunami warning/advisory/watch/information message.



Step 2

This message is received by the National Weather Service (NWS) Forecast Offices, state/provincial, county, local emergency services offices, broadcasters, Emergency Alert System, other federal agencies, international partners, and the public.



Step 3

County/Local officials issue county/local tsunami or evacuation (when needed) message.



Step 4

This message is received by local jurisdictions, broadcasters and the public.

Figure 4. Tsunami Warning System Message Flow Chart. (Credit: NOAA/NWS)

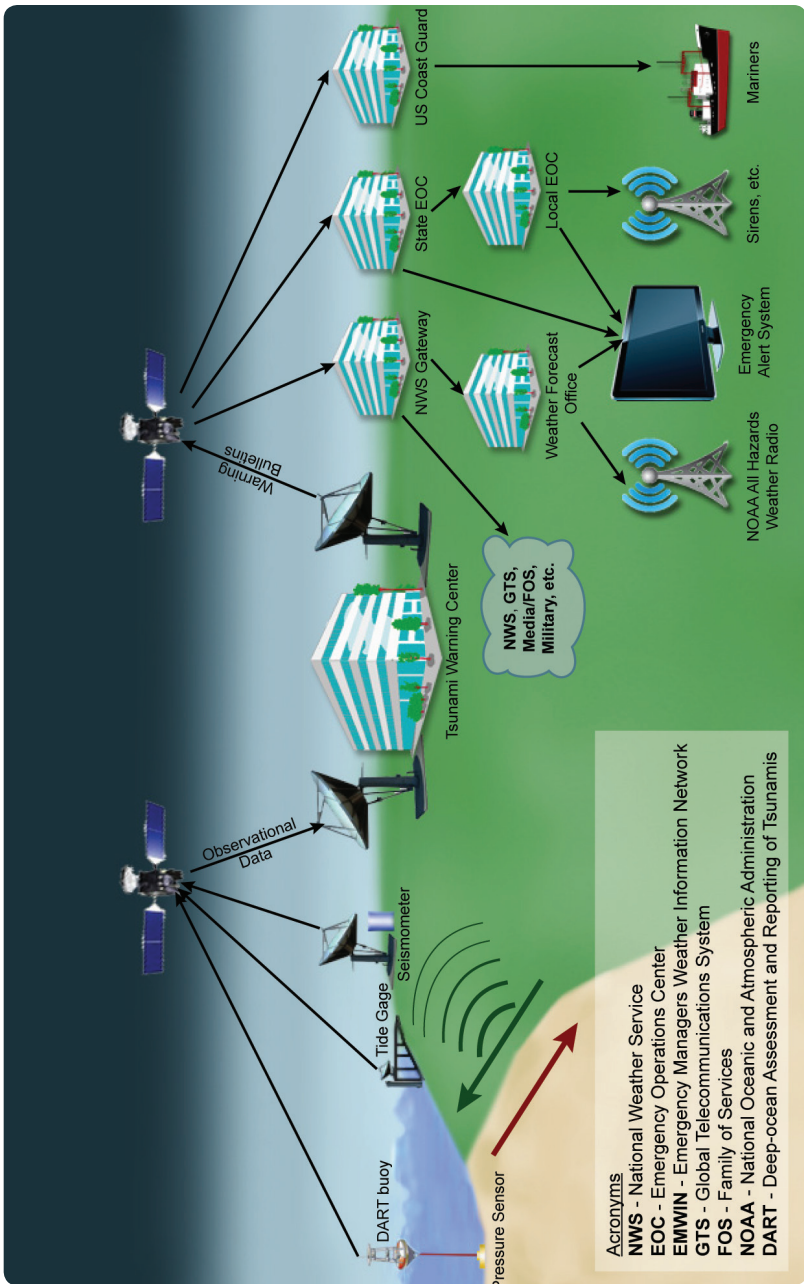


Figure 5. Tsunami Warning System Diagram. (Credit: NOAA/NWS)

Levels of Tsunami Alert

U.S. Tsunami Warning System Four Levels of Messaging



1 Warning

Danger! Run for high ground and follow emergency instructions.



2 Advisory

Possibly dangerous local currents. Move off the beach and stay out of the water.



3 Watch

Potential Danger. Stay tuned for more information.



4 Information Statement

Relax. No local danger, but a distant ocean basin may be in danger.

Warning

A tsunami warning is issued when a tsunami with the potential to generate widespread inundation is imminent or expected. Warnings alert the public that dangerous coastal flooding accompanied by powerful currents is possible and may continue for several hours after initial arrival. Warnings alert emergency management officials to take action for the entire tsunami hazard zone. Appropriate actions to be taken by local officials may include the evacuation of low-lying coastal areas, and the repositioning of ships to deep waters when there is time to safely do so. Warnings may be updated, adjusted geographically, downgraded, or canceled. To provide the earliest possible alert, initial warnings are normally based only on seismic information.

Advisory

A tsunami advisory is issued when a tsunami with the potential to generate strong currents or waves dangerous to those in or very near the water is imminent or expected. The threat may continue for several hours after initial arrival, but significant inundation is not expected for areas under an advisory. Appropriate actions to be taken by local officials may include closing beaches, evacuating harbors and marinas, and the repositioning of ships to deep waters when there is time to safely do so. Advisories are normally updated to continue the advisory, expand/contract affected areas, upgrade to a warning, or cancel the advisory.

Watch

A tsunami watch is issued to alert emergency management officials and the public of an event which may later impact the watch area. The watch area may be upgraded to a warning or advisory - or canceled - based on updated information and analysis. Therefore, emergency management officials and the public should prepare to take action. Watches are normally issued based on seismic information without confirmation that a destructive tsunami is underway.

Information Statement

A tsunami information statement is issued to inform emergency management officials and the public that an earthquake has occurred, or that a tsunami warning, watch or advisory has been issued for another section of the ocean. In most cases, information statements are issued to indicate there is no threat of a destructive tsunami and to prevent unnecessary evacuations as the earthquake may have been felt in coastal areas. An information statement may, in appropriate situations, caution about the possibility of destructive local tsunamis. Information statements may be re-issued with additional information, though normally these messages are not updated. However, a watch, advisory or warning may be issued for the area, if necessary, after analysis and/or updated information becomes available.

Jurisdictions should continue to monitor tsunami alerts coming out of their respective Tsunami Warning Center in case the alert level changes.

NOTE: This list is in order of highest to lowest tsunami alert and pertains to tsunami alerts for the U.S. and Canada. International products may have different definitions based on agreements with the Intergovernmental Oceanographic Commission (IOC).

Tsunami Safety

Be Aware of Nature's Warnings



- Drop, cover, and hold until the earthquake shaking stops.
- If you are on the coast and the earthquake shaking is hard or lasts over 20 seconds, the sea begins to recede, the water level rises rapidly or there is a loud roar from the sea, IMMEDIATELY move to higher ground or inland—preferably to 100 feet in elevation or a mile from the coast—or to the highest floor of a sturdy building, and STAY there.
- Follow instructions for Tsunami Warning (below).

What to do During a Tsunami Warning for Your Area



- Keep calm.
- Immediately move to your local tsunami shelter area using defined tsunami evacuation routes.
If there are no evacuation routes defined, move to higher ground that is at least 100 feet in elevation, a mile inland, or to the highest floor of a sturdy building and STAY there.
- If you are already in a safe location, STAY there.
- Move on foot when possible - Do not drive - keep roads open and clear for emergency vehicles.
- Pay attention to NOAA All Hazards Weather Radio and/or local broadcasts for changes and/or updates in tsunami alerts.
- Stay away from the coast and low-lying areas until local officials say it's safe to return to the warned area.

What to do during a Tsunami Advisory for Your Area



- Keep calm.
- Move out of beach areas, marinas, and harbors.
- Stay away from beach areas, marinas, and harbors until local officials say it's safe to return to the area under an advisory.
- Pay attention to NOAA All Hazards Weather Radio and/or local broadcasts for changes in tsunami alerts.

What to do during a Tsunami Watch for Your Area



- Keep calm, you are not under immediate threat from a tsunami.
- Pay attention to NOAA All Hazards Weather Radio and/or local broadcasts to be alerted should your location be upgraded to a Tsunami Warning or Advisory.

What To Do during a Tsunami Information Statement for Your Area



- Keep calm, you are not under immediate threat from a tsunami, and the likelihood of being upgraded to an advisory or warning is low.
- Pay attention to NOAA All Hazards Weather Radio and/or local broadcasts to be alerted should your location be upgraded to a Tsunami Warning or Advisory.

Be Prepared before a Tsunami strikes



- Know which areas are safe and which are not.
- Know the hazard zones, evacuation route(s), and locations of the nearest high ground, tsunami shelter and/or assembly area where you live, work, and visit by contacting your local or state emergency management agency.
- Learn and practice the safe walking route to shelter and assembly areas.
- Create and practice a family emergency plan.
- Have a portable disaster supplies kit with a three-day supply of food, water, and medication. Keep the kit in a location where you can access it quickly.
- Be sure you understand the evacuation plans of your child's school.
- Purchase a NOAA All Hazards Weather Radio to receive all tsunami, weather and water warnings.
- Sign up to receive Tsunami Warning Center email or text messages at [weather.gov/ptwc/subscribe.php](https://www.weather.gov/ptwc/subscribe.php) or [wcatwc.arh.noaa.gov/watcher/tsunamiwatcher.php](https://www.wcatwc.arh.noaa.gov/watcher/tsunamiwatcher.php)

Tsunami Bulletin Samples

From the West Coast/Alaska Tsunami Warning Center (pertinent media information highlighted)

BULLETIN
PUBLIC TSUNAMI MESSAGE NUMBER 2
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
600 AM AST SUN JAN 13 2008

Date and time of message in local time

...THIS MESSAGE IS FOR TEST PURPOSES TO SHOW AN EXAMPLE
WEXX30 MESSAGE...

...A TEST TSUNAMI WARNING IS IN EFFECT FOR **PUERTO RICO AND THE VIRGIN ISLANDS...**

Identifies that a Tsunami Warning is in effect for specific locations

Identifies that a Tsunami Advisory is in effect for specific locations

...A TEST **TSUNAMI ADVISORY** IS IN EFFECT FOR THE NORTH CAROLINA - VIRGINIA - MARYLAND - DELAWARE - NEW JERSEY - NEW YORK - CONNECTICUT - RHODE ISLAND - MASSACHUSETTS - NEW HAMPSHIRE - MAINE - NEW BRUNSWICK - NOVA SCOTIA AND NEWFOUNDLAND COASTAL AREAS FROM DUCK NORTH CAROLINA TO LA MANCHE NEWFOUNDLAND...

Identifies areas that are not under a Tsunami Warning, Advisory or Watch

...**THIS MESSAGE IS INFORMATION ONLY** FOR U.S. AND CANADIAN ATLANTIC AND GULF OF MEXICO COASTAL REGIONS NOT INCLUDED IN THE AREAS LISTED ABOVE...

Tsunami Warning definition and recommended action for affected areas

A TSUNAMI WARNING MEANS... ALL COASTAL RESIDENTS IN THE WARNING AREA WHO ARE NEAR THE BEACH OR IN LOW-LYING REGIONS SHOULD MOVE IMMEDIATELY INLAND TO HIGHER GROUND AND AWAY FROM ALL HARBORS AND INLETS INCLUDING THOSE SHELTERED DIRECTLY FROM THE SEA. THOSE

FEELING THE EARTH SHAKE... SEEING UNUSUAL WAVE ACTION... OR THE WATER LEVEL RISING OR RECEDING MAY HAVE ONLY A FEW MINUTES BEFORE THE TSUNAMI ARRIVAL AND SHOULD EVACUATE IMMEDIATELY. HOMES AND SMALL BUILDINGS ARE NOT DESIGNED TO WITHSTAND TSUNAMI IMPACTS. DO NOT STAY IN THESE STRUCTURES.

ALL RESIDENTS WITHIN THE WARNED AREA SHOULD BE ALERT FOR INSTRUCTIONS BROADCAST FROM THEIR LOCAL CIVIL AUTHORITIES. A TSUNAMI HAS BEEN RECORDED.

Tsunami Advisory definition and recommended action for effected areas

A TSUNAMI ADVISORY MEANS THAT A TSUNAMI CAPABLE OF PRODUCING STRONG CURRENTS OR WAVES DANGEROUS TO PERSONS IN OR VERY NEAR THE WATER IS IMMINENT OR EXPECTED. SIGNIFICANT WIDESPREAD INUNDATION IS NOT EXPECTED FOR AREAS UNDER AN ADVISORY. CURRENTS MAY BE HAZARDOUS TO SWIMMERS... BOATS... AND COASTAL STRUCTURES AND MAY CONTINUE FOR SEVERAL HOURS AFTER THE INITIAL WAVE ARRIVAL.

Event information including earthquake location, magnitude, and any tsunami observations

AT 555 AM ATLANTIC STANDARD TIME ON JANUARY 13 AN EARTHQUAKE WITH PRELIMINARY MAGNITUDE 8.2 OCCURRED 130 MILES/209 KM NORTHWEST OF MAYAGUEZ PUERTO RICO. THIS EARTHQUAKE HAS GENERATED A TSUNAMI WHICH COULD CAUSE DAMAGE TO REGIONS IN A WARNING OR ADVISORY. THE WAVES WILL FIRST REACH SAN JUAN PUERTO RICO AT 620 AM AST ON JANUARY 13. ESTIMATED TSUNAMI ARRIVAL TIMES AND MAPS ALONG WITH SAFETY RULES AND OTHER INFORMATION CAN BE FOUND ON THE WEB SITE WCATWC.ARH.NOAA.GOV.

A TSUNAMI HAS BEEN OBSERVED AT THE FOLLOWING SITES

LOCATION	LAT	LON	TIME	AMPL
SAN JUAN - PR	18.5N	66.1W	1045UTC	2.0M/6.6FT

TIME - TIME OF MEASUREMENT

AMPL - TSUNAMI AMPLITUDES ARE MEASURED RELATIVE TO NORMAL SEA LEVEL.

IT IS ...NOT... CREST-TO-TROUGH WAVE HEIGHT.

VALUES ARE GIVEN IN BOTH METERS(M) AND FEET(FT).

Information on tsunami behavior and safety

TSUNAMIS CAN BE DANGEROUS WAVES THAT ARE NOT SURVIVABLE. WAVE HEIGHTS ARE AMPLIFIED BY IRREGULAR SHORELINE AND ARE DIFFICULT TO FORECAST. TSUNAMIS OFTEN APPEAR AS A STRONG SURGE AND MAY BE PRECEDED BY A RECEDING WATER LEVEL. MARINERS IN WATER DEEPER THAN 600 FEET SHOULD NOT BE AFFECTED BY A TSUNAMI. WAVE HEIGHTS WILL INCREASE RAPIDLY AS WATER SHALLOWS. TSUNAMIS ARE A SERIES OF OCEAN WAVES WHICH CAN BE DANGEROUS FOR SEVERAL HOURS AFTER THE INITIAL WAVE ARRIVAL. DO NOT RETURN TO EVACUATED AREAS UNTIL AN ALL CLEAR IS GIVEN BY LOCAL CIVIL AUTHORITIES.

PTWC responsibilities for this event

THE PACIFIC TSUNAMI WARNING CENTER IN EWA BEACH HAWAII WILL ISSUE MESSAGES FOR AREAS IN THE CARIBBEAN OUTSIDE PUERTO RICO AND THE VIRGIN ISLANDS.

Frequency of updates from WC/ATWC and where to find timely information

MESSAGES WILL BE ISSUED EVERY 30 MINUTES OR MORE FREQUENTLY IF THE SITUATION WARRANTS. THE TSUNAMI ALERT WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE. FOR FURTHER INFORMATION STAY TUNED TO NOAA WEATHER RADIO... YOUR LOCAL TV OR RADIO STATIONS... OR SEE THE WEB SITE WCATWC.ARH.NOAA.GOV.

THIS IS A TEST MESSAGE. DO NOT TAKE ACTION BASED ON THIS TEST MESSAGE.

From the Pacific Tsunami Warning Center (pertinent media information highlighted)

BULLETIN
TSUNAMI MESSAGE NUMBER 4
NWS PACIFIC TSUNAMI WARNING CENTER EWA BEACH HI
718 AM HST MON JUN 02 2008

Date and time of message in local time

TO - CIVIL DEFENSE IN THE STATE OF HAWAII

SUBJECT - TSUNAMI WARNING

Identifies that a Tsunami Warning is in effect for specific locations

A TSUNAMI WARNING IS ISSUED FOR THE STATE OF HAWAII EFFECTIVE AT 0718 AM HST.

Event information including earthquake location, magnitude, and any tsunami observations

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 0415 AM HST 02 JUN 2008
COORDINATES - 38.5 NORTH 143.1 EAST
LOCATION - OFF EAST COAST OF HONSHU JAPAN
MAGNITUDE - 8.1 MOMENT
MAGNITUDE - 8.3 RICHTER (MS)

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

GAUGE LOCATION	LAT	LON	TIME	AMPL	PER
OFUNATO JP	39.0N	141.7E	1520Z	2.23M/7.2FT	26MIN

LAT – LATITUDE (N-NORTH, S-SOUTH)
 LON – LONGITUDE (E-EAST, W-WEST)
 TIME – TIME OF THE MEASUREMENT (Z IS UTC IS GREENWICH TIME)
 AMPL – TSUNAMI AMPLITUDE MEASURED RELATIVE TO NORMAL SEA LEVEL.
 IT IS ...NOT...CREST-TO-TROUGH WAVE HEIGHT.
 VALUES ARE GIVEN IN BOTH METERS(M) AND FEET(FT).
 PER – PERIOD OF TIME IN MINUTES(MIN) FROM ONE WAVE TO THE NEXT.

Information on the tsunami event and tsunami behavior

EVALUATION

A TSUNAMI HAS BEEN GENERATED THAT COULD CAUSE DAMAGE ALONG COASTLINES OF ALL ISLANDS IN THE STATE OF HAWAII. URGENT ACTION SHOULD BE TAKEN TO PROTECT LIVES AND PROPERTY.

A TSUNAMI IS A SERIES OF LONG OCEAN WAVES. EACH INDIVIDUAL WAVE CREST CAN LAST 5 TO 15 MINUTES OR MORE AND EXTENSIVELY FLOOD COASTAL AREAS. THE DANGER CAN CONTINUE FOR MANY HOURS AFTER THE INITIAL WAVE AS SUBSEQUENT WAVES ARRIVE. TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND THE FIRST WAVE MAY NOT BE THE LARGEST. TSUNAMI WAVES EFFICIENTLY WRAP AROUND ISLANDS. ALL SHORES ARE AT RISK NO MATTER WHICH DIRECTION THEY FACE. THE TROUGH OF A TSUNAMI WAVE MAY TEMPORARILY EXPOSE THE SEAFLOOR BUT THE AREA WILL QUICKLY FLOOD AGAIN. EXTREMELY STRONG AND UNUSUAL NEARSHORE CURRENTS CAN ACCOMPANY A TSUNAMI. DEBRIS PICKED UP AND CARRIED BY A TSUNAMI AMPLIFIES ITS DESTRUCTIVE POWER. SIMULTANEOUS HIGH TIDES OR HIGH SURF CAN SIGNIFICANTLY INCREASE THE TSUNAMI HAZARD.

THE ESTIMATED ARRIVAL TIME IN HAWAII OF THE FIRST TSUNAMI WAVE IS

1122 AM HST 02 JUN 2008

MESSAGES WILL BE ISSUED HOURLY OR SOONER AS CONDITIONS WARRANT.

Frequency of updates from PTWC

Federal Media Contacts

Tsunami Websites

Current Tsunami Information

tsunami.gov

Additional graphics, animations and reference information

nthmp.tsunami.gov

West Coast/Alaska Tsunami Warning Center

wcatwc.arh.noaa.gov

Pacific Tsunami Warning Center

weather.gov/ptwc

Subject Matter Experts

For media interviews with federal tsunami subject matter experts, please contact the Public Affairs Offices of each agency listed below.

NOAA

NOAA Public Affairs

NOAA Public Information Officer (PIO)

Silver Spring, Maryland

Phone: 1-301-713-0622 - Monday thru Friday, 8-5pm

1-202-834-5235 - after business hours

West Coast/Alaska Tsunami Warning Center (WC/ATWC)

Palmer, Alaska

Phone: 1-907-745-4212

Pacific Tsunami Warning Center (PTWC)

Ewa Beach, Hawaii

Phone: 1-808-689-8207

Caribbean Tsunami Warning Program (CTWP)

English and Spanish Resources

Mayaguez, Puerto Rico

Phone: 1-787-249-8307

Tsunami Numerical Modeling and Inundation Mapping

NOAA Office of Atmospheric Research

Silver Spring, Maryland

Phone: 1-301-734-1123

U.S. Geological Survey (USGS)

USGS Public Information Officer (PIO)

Menlo Park, California

Phone: 1-650-329-4006

National Earthquake Information Center (NEIC)

Golden, Colorado

Phone: 1-303-273-8500

Federal Emergency Management Agency (FEMA)

FEMA News Desk

Washington, D.C.

Phone: 1-202-646-3272 - answered 24 hours a day every day

Email: fema-news-desk@dhs.gov

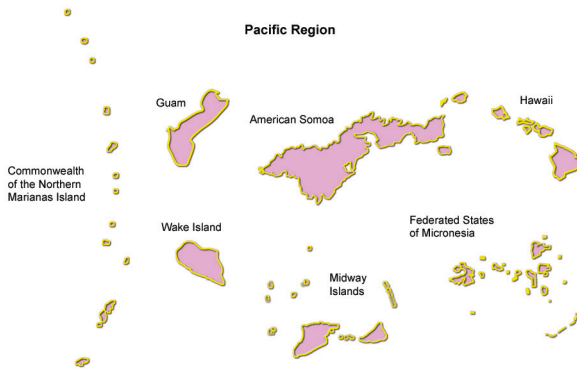
Local and State Government and NWS Weather Forecast Offices

For local and state government and NWS Weather Forecast Office media contacts, please refer to the NTHMP Media Website from nthmp.tsunami.gov.

National Weather Service Regions



Pacific Region



NWS Alaska Region PIO

Anchorage, Alaska
Phone: 1-907-271-4767

NWS Southern Region PIO

Fort Worth, Texas
Phone: 1-817-978-1111 x 140

NWS Pacific Region PIO

Honolulu, Hawaii
Phone: 1-808-532-6411

NWS Eastern Region PIO

Bohemia, New York
Phone: 1-631-244-0149

NWS Western Region PIO

Salt Lake City, Utah
Phone: 1-801-524-5692

Figure 6. The National Weather Service Regional areas of responsibilities, locations of the Regional Headquarters offices, and Public Information Office contact information. (Credit: NOAA/NWS)

Tsunami Detection and Forecasting

How Tsunamis are Detected and Observed

NOAA's Tsunami Warning Centers monitor the earth 24 hours a day, 7 days per week through a tsunami detection system consisting of seismic, coastal sea-level, and Deep-ocean Assessment and Reporting of Tsunamis (DART®) networks.

Seismic Networks

Most damaging tsunamis are caused by earthquakes. Seismic data are collected from hundreds of seismic sensors, called seismometers, from around the world. The scientists at the Tsunami Warning Centers use seismic data to determine the location and magnitude of earthquakes. The location and magnitude of an earthquake determine whether or not scientists will issue a tsunami warning, advisory, or watch.

Coastal Sea-Level Networks

These networks consist of sea-level gauges that measure the ocean height at specific coastal locations. When a tsunami arrives at a gauge, the water level will vary from its normal tide cycle. The scientists use data from these gauges to detect a tsunami and estimate its impact at the coast.

DART Network

DART stations detect water pressure changes in the deep ocean resulting from the formation and propagation of tsunamis. A DART station consists of a pressure sensor located on the sea floor and a data transmission buoy located on the surface. As a tsunami passes, the depth of the water changes as does the pressure on the sensor. This pressure change is transmitted acoustically to the surface buoy and then via satellite to the Tsunami Warning Centers.

Tsunami Warning Centers

Once an earthquake or tsunami is detected and the information is received at the Tsunami Warning Center, earthquake and tsunami analysis begins.

The Tsunami Warning Center will:

- Locate and determine the magnitude of the earthquake through automated processes;
- Analyze the earthquake or tsunami data;
- Analyze the sea-level data to verify the existence of a tsunami and to calibrate models; and
- Send the appropriate warning, watch, advisory or information message.

A tsunami may have been generated if the source of the earthquake is under or near the ocean, not too deep within the earth, and if the magnitude is sufficiently large. On the basis of this seismic evidence, the appropriate Tsunami Warning Center issues a tsunami warning, advisory, or watch to threatened areas near the epicenter. The warning, advisory, or watch may be extended to areas located further from the epicenter if the magnitude of the earthquake is very large and there is a possibility of a long-range destructive tsunami. All remaining areas will be notified that an event has occurred.

Tsunami bulletins are initially issued based solely on earthquake parameters – magnitude, location, and depth. Initial messages are issued as soon as this information has been determined.

After the initial message has been issued, the Tsunami Warning Center monitors the nearest tide gauges and DARTs to confirm the existence or nonexistence of a tsunami and its degree of severity and issues supplementary information or cancels the initial message. Tsunami history, forecast models, and observed tsunami amplitudes are taken into account when determining the extent of danger for the area of responsibility.

The time it takes for a Tsunami Warning Center to issue an alert depends on the seismic network density and distribution around the epicenter. In regions of high seismic network density, the Tsunami Warning Centers can provide alerts within 5 minutes. In areas of lower seismic network density, response time increases to 10-15 minutes.

If a tsunami that is potentially destructive at great distances is detected, the Tsunami Warning Center will issue an ocean-wide tsunami warning to advise designated national authorities. Such a warning alerts all warning system participants to the approach of a potentially destructive tsunami

and provides estimated tsunami arrival times for key locations. Tsunami forecasts or estimated wave heights may be included in the tsunami warning if there is enough available data and the model results are judged by Tsunami Warning Center staff to be reliable.

Typically, during a tsunami, bulletins containing updated information are issued at least hourly, until the tsunami has crossed the entire ocean or additional data is received to indicate there is no further threat. Tsunami warnings are canceled when the Tsunami Warning Center determines that the tsunami is no longer dangerous.

Even when the warning is canceled, it does not mean it is safe for the public to return to any evacuated coastline areas. Due to structural damage, debris, and other safety concerns, the “all-clear” may not be issued by the local authorities for hours or even days after the event. Therefore, it is important to heed local officials’ instructions concerning whether or not it is safe to return to the affected area.

How Tsunamis are Forecast

Forecasting Impacts

Tsunami Warning Centers use tsunami forecast models, including the Alaska Tsunami Forecast Model (ATFM) and the Short-term Inundation Forecasting for Tsunamis (SIFT) to provide wave height, arrival time, and inundation forecasts for coastal areas potentially impacted by the tsunami. These models use the seismic and sea-level data provided by detection networks to forecast impacts at specific locations throughout the ocean basin.

Forecast models help scientists at the Tsunami Warning Centers determine and refine the level of alert (warning, advisory, watch, or information statement) to issue for specific areas of the coast. The forecasts issued during tsunami events assist local emergency management officials in determining whether or not to issue evacuation orders.

This determination is critical as emergency managers not only want to ensure that communities that will experience inundation during a tsunami are evacuated, but also to ensure that communities that are not threatened during a tsunami event do not have to undergo needless evacuation.

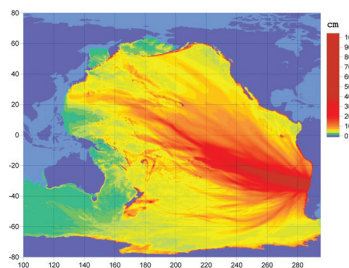


Figure 7. Alaska Tsunami Forecast Model for the February 27, 2010 Chilean Tsunami (Credit: NOAA)

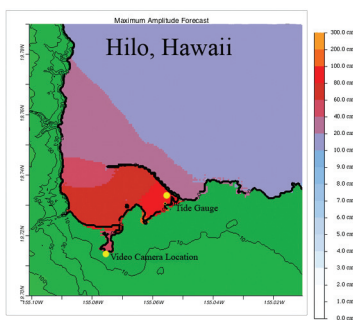


Figure 8. The SIFT tsunami inundation forecast for Hilo, Hawaii from the February 2010 Chilean earthquake. (Credit: NOAA)

Roles and Responsibilities

Roles and Responsibilities of Federal, State, and Local Governments

Federal agencies

National Oceanic and Atmospheric Administration (NOAA)

NOAA's role is to provide tsunami detection, forecasting and warnings for the Pacific Ocean, Arctic Ocean regions, the Northwestern Atlantic Ocean, Caribbean Sea, and Gulf of Mexico [The Tsunami Warning and Education Act of 2007, 33 U.S.C. § 3201, et seq., (P.L. 109-479)]. The mission of NOAA's National Weather Service is to protect lives and property from tsunami hazards by providing timely, accurate, reliable, and effective tsunami information to coastal populations and emergency management within its area of responsibility; and by advancing other aspects of tsunami hazard mitigation such as community preparedness and public education. This is accomplished through NOAA's Tsunami Warning Centers, National Weather Service Forecast Offices, TsunamiReady™, and the Caribbean Tsunami Warning Program.

U.S. Geological Survey (USGS)

USGS' role is to provide seismic data to NOAA's Tsunami Warning Centers, conduct tsunami research and risk assessments, and conduct independent seismic analyses of potential tsunamigenic earthquakes at its National Earthquake Information Center (NEIC). The USGS, along with other partners, supports the Global Seismic Network (GSN). The GSN provides high-quality seismic data to assist earthquake detection (including tsunamigenic earthquakes).

Federal Emergency Management Agency (FEMA)

FEMA becomes the lead Federal agency in managing emergency response efforts once a tsunami has caused damage to a U.S. community and a Presidential Disaster Declaration has been issued. FEMA's mission is to support our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards.

Other

National Tsunami Hazard Mitigation Program (NTHMP)

The National Tsunami Hazard Mitigation Program (NTHMP) is a partnership between Federal and State agency representatives designed to reduce the impact of tsunamis on U.S. coastal communities. Led by the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS), the NTHMP is the nation's community-focused program to improve tsunami mitigation and preparedness of at-risk areas within the United States and its territories.

International Tsunami Information Centre (ITIC)

The International Tsunami Information Centre (ITIC) maintains and develops relationships with scientific research and academic organizations, civil defense agencies, and the general public in order to carry out its mission to mitigate the hazards associated with tsunamis by improving tsunami preparedness for all Pacific Ocean nations. ITIC is also assisting in the development and implementation of tsunami warning and mitigation systems globally. ITIC was established in November 1965 by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO).

State governments

State governments, typically through coordinated efforts between emergency management agencies and geological surveys, play a pivotal role in facilitating tsunami preparedness, warning reception and dissemination, and response activities at both the state and local levels. This is achieved through creation of state-level tsunami risk reduction programs that in cooperation with the U.S. National Tsunami Hazard Mitigation Program and other federal, state and local agencies, and tribal nations, promote tsunami planning, public education, and hazard mitigation among coastal communities with an aim towards improving public safety by achieving TsunamiReady™ recognition for each local jurisdiction.

The role of local governments is to implement public education and awareness programs within the community, develop tsunami response and evacuation plans, identify appropriate evacuation routes, and implement effective warning reception and dissemination systems that can notify residents, visitors, and the business community when tsunami bulletins are issued by NOAA's Tsunami Warning Centers. Local governments are responsible for issuing official evacuation orders and all-clear notifications within their jurisdictions.

Visiting the U.S. Tsunami Warning Centers

You are welcome to visit the U.S. Tsunami Warning Centers. Appointments and advance arrangements are encouraged. Please follow the guidance provided below to arrange your visit.

Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC)

Media and Foreign Nationals

Please contact the NOAA Public Relations Officer at 1-(808)-532-6411.

Local Citizens and Other Visitors

Please contact PTWC at 1-808-689-8207.

NOTE: Due to the limited size of PTWC's facilities, visitor groups should be limited to 15 or fewer persons.



Figure 9. Pacific Tsunami Warning Center (PTWC) (Credit: NOAA/NWS/PTWC)

West Coast/Alaska Tsunami Warning Center (WC/ATWC)

Public Tours

The West Coast and Alaska Tsunami Warning Center is open to the public for tours every Friday afternoon at 1, 2, and 3 pm.

Contact

Phone: 907-745-4212

NOTE: It is a good idea for groups of more than six people to call ahead so that special arrangements can be made if needed.



Figure 10. West Coast/Alaska Tsunami Warning Center (WC/ATWC) (Credit: NOAA/NWS/WCATWC)

Visits During Unfolding Tsunami Events

Visits to the TWCs during tsunami events can not be accommodated. Please contact the local NOAA Public Relations Office or State Government Emergency Management for information during tsunami events.

TsunamiReady™

Information

What is TsunamiReady™?

A National Weather Service (NWS) program conducted in close coordination with state emergency management agencies, which promotes tsunami hazard preparedness as an active collaboration among federal, state, and local emergency management agencies, the public, and the NOAA tsunami warning system.

TsunamiReady™ is based on the NWS StormReady™ program.

The program's main goal is to increase public safety during tsunami emergencies.

Who is TsunamiReady™ for?

TsunamiReady™ is for coastal communities and counties with a tsunami hazard.

What are the benefits of being TsunamiReady™?

- The community is better prepared to save lives in a tsunami emergency.
- As tsunamis are highly dangerous but rare events, the program helps communities keep their tsunami response plans current.
- The program increases a community's contact with experts and warning dissemination personnel.
- The program enhances core emergency response infrastructure, which also supports response to other hazards.

What makes a community TsunamiReady™?

Several guidelines must be met for a community or county to attain TsunamiReady™ status.

Among these are:

- Multiple methods of receiving NWS tsunami warning information.
- The ability to disseminate a tsunami warning to the local populations.
- An established warning point and emergency operations center.
- A community tsunami awareness program.
- Designated tsunami hazard zones.
- Evacuation and response plans.

For more information on TsunamiReady™ go to tsunamiready.noaa.gov.

Tsunami Facts

What is a Tsunami?

A tsunami:

- is a *series* of ocean or sea waves caused by a sudden, large displacement of water most often caused by earthquakes, but also by landslides, volcanic eruptions, and comet or meteorite impacts in the ocean.
- is like a fast rising flood tide, storm surge or an advancing wall of water and strikes with devastating force.
- may move faster than you can run.
- will continue for many hours. The first wave is often not the largest nor the most dangerous, and surges may arrive 10 hours or more after the initial wave.

Other tsunami facts:

- A small tsunami at one beach may be a giant tsunami a few miles away.
- A tsunami can strike anywhere along an ocean coast.
- There is no season for tsunamis; they can strike at any time of year and any time of the day or night.
- Tsunamis can reach the coast within minutes of an earthquake.
- Tsunamis disturb the entire water column while storms only disturb the uppermost section.

Why are Tsunamis dangerous?

As a tsunami crosses the deep ocean, it may be only a few feet or less in height. Unlike wind-generated waves that affect the surface of the ocean, tsunamis move the entire water column. As the waves enter shallower water, they are compressed, their speed slows, they build in height, and associated currents intensify becoming a threat to life and property.

There is usually little time to forecast the severity of a tsunami after one is generated and entire coastlines can be inundated by a large tsunami.

How often do tsunamis occur?

On average, two tsunamis occur per year throughout the world that inflict damage near the source. Approximately every 15 years, a destructive ocean-wide tsunami occurs somewhere in the world.

Historic Tsunamis



Figure 11. Destruction in Phuket, Thailand from the 2004 Indian Ocean Tsunami
(Credit: NOAA/NWS/WCATWC)



Figure 12. Destruction in Phuket, Thailand from the 2004 Indian Ocean Tsunami
(Credit: NOAA/NWS/WCATWC)



Figure 13. Three sequential pictures which show the arrival of a major wave at Laie Point, Oahu, Hawaii on March 9, 1957. (Credit: NOAA/NESDIS/NGDC)

Most Deadly U.S. Tsunamis

Date	Deaths	Magnitude	Location*
Feb. 27 - 28, 2010	124	8.8	Chile
Sept. 29 - 30, 2009	192	8.0	Samoa Islands
Dec. 26, 2004	227,898	9.0	Indian Ocean
March 27, 1964	124 <i>(4 in Oregon, 107 in Alaska, and 13 in California)</i>	9.2	Prince William Sound, Alaska
May 22, 1960	1223 <i>(61 in Hawaii)</i>	9.5	Chile
Aug. 4, 1946	1790	8.1	Dominican Republic
April 1, 1946	165	8.6	Unimak Island, Alaska
Nov. 18, 1929	29	7.2	Grand Banks, Newfoundland
Oct. 11, 1918	142	7.2	Puerto Rico
June 15, 1867	30	7.5	U.S. Virgin Islands

* Location refers to the area where the tsunami originated.

Source: NOAA's National Geophysical Data Center Natural Hazards Database (ngdc.noaa.gov/hazard)



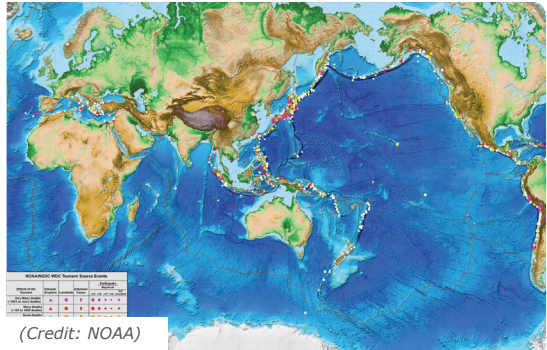
Figure 14. Plastic containers and other debris scattered near the harbor at Aonae, Okushiri Island after the Hokkaido Nansei-Oki tsunami in 1993. (Credit: NOAA/Commander Dennis J. Sigrist)



Figure 15. Debris remaining after the 1992 Indonesia tsunami at one end of the beach at Riangk-roko, Indonesia. Note that large trees were uprooted by the force of the waves. (Credit: University of Washington/Harry Yeh)

Sample Tsunami Images

For additional graphics and reference information visit the NTHMP media corner online through nthmp.tsunami.gov.





(Credit: NOAA/V.K. Gusiakov)



(Credit: NOAA/Commander Dennis J. Sigrist)



(Credit: NOAA/NWS)

Glossary of Terms

Amplitude: See *Tsunami Amplitude*.

Bathymetry: The measurement of the depths of the oceans, seas, and other bodies of water.

Area of Responsibility: The geographical area within which a Tsunami Warning Center has the responsibility for the dissemination of Tsunami Warnings, Watches, Advisories and Information Statements and the provision of interpretive information to emergency managers and other officials, news media, and the public.

Distant tsunami: A tsunami originating from a far away source, generally more than 1,000 km/621 miles or more than 3 hours tsunami travel time from its source to the area impacted. What may be a distant tsunami in one location, can be a local tsunami for another location. See *Local Tsunami*.

Earthquake Magnitude: A number that characterizes the relative size of or energy released by an earthquake. Magnitude is based on measurement of the maximum motion recorded by a seismograph. Several scales have been defined, but the most commonly used are (1) local magnitude (ML), commonly referred to as "Richter magnitude," (2) surface-wave magnitude (Ms), (3) body-wave magnitude (Mb), and (4) moment magnitude (Mw).

Epicenter: The point on the earth's surface vertically above the hypocenter (or focus) where a seismic rupture begins.

Estimated Time of Arrival (ETA): Time of first tsunami wave arrival at some fixed location. The first wave is not always the largest wave.

Evacuation Map: A drawing or representation that outlines the danger zones and designates limits beyond which people must be evacuated to avoid harm from tsunami waves. Evacuation routes and assembly areas are generally designated to ensure efficient movement of people out of the evacuation area and to areas of safety.

Hypocenter: The point within the earth where an earthquake rupture starts.

Inundation: The horizontal distance inland that a tsunami penetrates; generally measured perpendicularly to the shoreline.

Local tsunami: A tsunami generated from a nearby source, generally within 100 km/62 miles or less than 1 hour tsunami travel time from its source to the area impacted. A local tsunami is usually generated by an earthquake, but can also be caused by a landslide or pyroclastic flow from a volcanic eruption or comet or meteorite impacts in the ocean. What may be a local tsunami in one location, can be a distant tsunami for another location. See: *Distant Tsunami*.

Maremoto: Spanish term for tsunami.

Meteo-tsunami: A tsunami-like phenomenon generated by meteorological or atmospheric disturbances. These waves can be produced by atmospheric gravity waves, pressure changes, squalls, gales, typhoons, hurricanes, and other atmospheric sources.

Pyroclastic flow: A ground hugging avalanche of hot ash, pumice, rock fragments, and volcanic ash that rushes down the side of a volcano as fast as 100 km/62 miles per hour or more.

Regional tsunami: A tsunami capable of destruction in a particular geographic region, generally within 1,000 km/621 miles or 1 to 3 hours tsunami travel time from its source to the area impacted. Regional tsunamis generally have very limited and localized effects outside the region.

Runup: The difference between the elevation of maximum inundation line and the sea-level at the time of the tsunami. Can also refer to the elevation to which a tsunami can reach for a particular area.

Seismometer: An instrument used to detect and record seismic waves generated by earthquakes.

Subduction Zone: The place where two of the earth's plates come together, one riding over the other. Subduction zones are the primary source for some of the largest magnitude earthquakes (M8-9) and associated tsunamis.

Teletsunami: See *Distant Tsunami*.

Tsunami: (tsoo-NAH-me / zoo-NAH-me) A series of waves with both a long wavelength and period (time between crests), generated by a large, impulsive displacement of sea or lake water. Time between crests of the

wave can vary from a few minutes to over an hour, but generally are in the range of 15 to 25 minutes. Tsunami is a Japanese word meaning harbor wave. Tsunamis are often incorrectly called tidal waves; they have no relation to the daily ocean tides.

Tsunamigenic: Capable of generating a tsunami. For example, “a tsunamigenic earthquake.”

Tsunami Advisory: A Tsunami Advisory is issued due to the threat of a potential tsunami that may produce strong currents or waves dangerous to those in or near the water. The threat may continue for many hours after the arrival of the initial wave, but significant widespread inundation is not expected for areas under the advisory. Appropriate actions to be taken by local officials may include the closing of beaches and the evacuation of harbors and marinas. People in the Advisory area should heed local official’s instructions to leave affected areas until given the “all-clear”.

Tsunami Amplitude: The deviation of sea level, caused by the tsunami, that is above or below the normal tidal level. Tsunami amplitudes reported by Tsunami Warning Centers usually represent maximum amplitudes observed so far. Reported values may change as new data are received. Tsunami amplitude is usually measured by a sea level gauge.

Tsunami Information Bulletin: Same as a Tsunami Information Statement. The product name “Tsunami Information Bulletin” is used for international text products issued by the Pacific Tsunami Warning Center to the Pacific Tsunami Warning System and Indian Ocean Tsunami Warning System at the request of those respective user communities.

Tsunami Information Statement: A Tsunami Information Statement is issued when an earthquake has occurred or a tsunami warning, advisory, or watch has been issued for another part of the ocean. In most cases, tsunami information statements are issued to indicate there is no threat of a destructive tsunami for the area.

Tsunami Resonance: The continued reflection and interference of tsunamis in a harbor or narrow bay which can cause amplification of the wave heights, and extend the duration of wave activity from a tsunami.

Tsunami Source: Point or area of tsunami origin, usually the site of an earthquake, volcanic eruption, or landslide that caused a large scale and rapid displacement of the water resulting in a tsunami.

Tsunami Travel Time: The time required for a tsunami to propagate from its source to a specific point in the ocean or coastline.

Tsunami Warning: A Tsunami Warning is issued when a potential tsunami with significant widespread inundation is imminent or expected. Warnings alert the public that widespread, dangerous coastal flooding accompanied by powerful currents is possible and may continue for several hours after the arrival of the initial wave. Appropriate actions to be taken by local officials may include the evacuation of low-lying areas. People in the warned areas need to move to higher ground or inland and stay in a safe area until local officials give the “all-clear.”

Tsunami Warning Cancellation: A final product indicating the end of the damaging tsunami threat. A cancellation is usually issued after an evaluation of sea level data confirms that a destructive tsunami will not impact the warned area.

Tsunami Warning System: The collection of resources, processes, and functions that ensure tsunami warnings are issued, disseminated and understood. The system includes observational data (e.g. seismic, sea-level), monitoring, communications and dissemination capabilities, products and services, outreach and education, development of response plans, and the human expertise at each point in the system. Warning systems may exist at local, national, international and global levels. Examples of Tsunami Warning Systems are the Pacific Tsunami Warning System and the Indian Ocean Tsunami Warning System.

Tsunami Watch: A Tsunami Watch is issued when a potentially dangerous, distant seismic event has occurred which may later impact the watch area with a tsunami. Be ready to take action if a tsunami warning or advisory is later issued.

Wave Crest: The highest part of a wave.

Wave Height: The vertical distance between the wave peak and adjacent trough.

Wave Period: The length of time between the arrival time of the highest wave height and the next highest wave height measured on a water level record.

Wave Length: The horizontal distance between similar points on two successive waves measured perpendicular to the crest.

Wave Trough: The lowest part of a wave.