

ITSU-XX

NATIONAL REPORT OF THE USA, 2003-2005

EXECUTIVE SUMMARY

In the United States (US), the Tsunami Warning System (TWS) is operated by the National Oceanic & Atmospheric Administration's (NOAA) National Weather Service (NWS). Another component of NOAA, the National Ocean Service (NOS), is primarily responsible for the maintenance of US coastal sea level gauges in the TWS. Tsunami research is conducted by NOAA's Environmental Research Laboratories and by various universities under the direction of the National Science Foundation (NSF). The World Data Center for Solid Earth Geophysics, including tsunamis (WDC), is operated by NOAA's National Environmental Satellite, Data & Information Service's (NESDIS) National Geophysical Data Center (NGDC). NESDIS also supports the TWS by providing communications from remote data platforms through NOAA's Geostationary Operational Environmental Satellite (GOES). The Japan Meteorological Agency (JMA) provides support to the TWS by the use of its Geostationary Meteorological Satellite (GMS) to transmit data from US sea level stations in the westernmost Pacific. The US Geological Survey (USGS) is responsible for seismological research and their National Earthquake Information Center (NEIC) assists the TWS through the provision of real-time seismic data and by cooperation and collaboration on other aspects of seismic data collection and analysis. The US also continues to host the International Tsunami Information Centre (ITIC), as it has since the Centre's inception in 1965, by providing personnel and administrative support for the Centre to carry out its mission in support of the Tsunami Warning System in the Pacific.

NARRATIVE

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2. INTRODUCTION

In the United States (US), the Tsunami Warning System (TWS) is operated by the National Oceanic & Atmospheric Administration's (NOAA) National Weather Service (NWS). Another component of NOAA, the National Ocean Service (NOS), is primarily responsible for the maintenance of US coastal sea level gauges in the TWS. Tsunami research is conducted by NOAA's Environmental Research Laboratories and by various universities under the direction of the National Science Foundation (NSF). The World Data Center for Solid Earth Geophysics, including Tsunamis (WDC) is operated by NOAA's National Environmental Satellite, Data & Information Service's (NESDIS) National Geophysical Data Center. NESDIS also supports the TWS by providing communications from remote data platforms through NOAA's Geostationary Operational Environmental Satellite (GOES). The Japan Meteorological Agency (JMA) provides support to the TWS by the use of its Geostationary Meteorological Satellite (GMS) to transmit data from US sea level stations in the westernmost Pacific. The US Geological Survey (USGS) is responsible for seismological research and their National Earthquake Information Center (NEIC) assists the TWS through the provision of real-time seismic data and by cooperation and collaboration on other aspects of seismic data collection and analysis. The US also continues to host the International Tsunami Information Centre (ITIC), as it has since the Centre's inception in 1965, by providing personnel and administrative support for the Centre to carry out its mission in support of the Tsunami Warning System in the Pacific.

The US continues to operate two major Tsunami Warning Centers in support of the International Co-ordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU). These 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, have real-time or near real-time access to data from large arrays of seismic and sea level stations spanning the Pacific and surrounding regions. The PTWC is the operations centre for the Tsunami Warning System in the Pacific. In this capacity the PTWC provides information on potentially tsunamigenic earthquakes in the Pacific region and subsequent tsunami evaluations to Member States of ITSU, as well as to others who may be threatened by tsunamis resulting from these earthquakes. The PTWC is also the national source of Tsunami Warnings, Watches, Advisories, and Information Bulletins for Hawaii, US possessions, and all other US interests in the Pacific located outside of the continental US, and it operates a Regional Tsunami Warning System for the State of Hawaii. The WC/ATWC provides Tsunami Warnings, Watches, Information Bulletins, and interpretative information to civilian and military officials in Alaska, Canada (British Columbia), Washington, Oregon, and California. In performing this mission, its primary responsibility is the detection, location, and determination of magnitude of potentially

tsunamigenic earthquakes occurring off coasts stretching from Attu, Alaska to the California-Mexico border.

Significant developments have occurred during the intersessional period. Many are the result of an increased awareness of the threat tsunamis pose that was brought to the attention of the world by the tragedy in the Indian Ocean on December 26, 2004. Developments include:

- 1) staffing increases at both PTWC and WC/ATWC to facilitate a 24x7 presence of duty analysts in their operations centers (analysts currently respond from their nearby quarters or homes during after hours);
- 2) expansion of the WC/ATWC area of responsibility to include the U.S. East and Gulf Coasts and the Atlantic coast of Canada;
- 3) expansion of the PTWC area of responsibility to include, on an interim basis, the Indian Ocean and Caribbean Sea;
- 4) expansion over the next two years of the Pacific network of Deep Ocean Assessment and Reporting of Tsunami (DART) gauges from 6 to 32 over the next two years;
- 5) accelerated development of tsunami forecast models that utilize the coastal and DART data as input;
- 6) enhancements to NOS coastal sea level gauges to provide one-minute-sampling and transmissions every six minutes (from six-minute samples transmitted every hour); and
- 7) plans and funding for an upgrade of PTWC's local seismic network in Hawaii.

During the intersessional period, and in accordance with Recommendation ITSU-XIX.3, the U.S. supported the development of a more unified Global Historical Tsunami Database by contributing US\$20,000 to the Novosibirsk Tsunami Laboratory (NTL). Progress on the project will be reported at ITSU-XX by the NTL.

The U.S., in Honolulu during December 2003, hosted a meeting of ITSU Officers in preparation for the twentieth Session of the Group.

3. TSUNAMI WARNING CENTER ACTIVITIES

Pacific Tsunami Warning Center (PTWC)

The PTWC is the operations centre for the Tsunami Warning System in the Pacific. In this capacity the PTWC provides information on earthquakes in the Pacific basin to Member States of ITSU, as well as to others who may be threatened by tsunamis resulting from these earthquakes. This information usually takes the form of Tsunami Bulletins issued for Warnings, Watches, Advisories, and for Information only. The PTWC is also the national source of Tsunami Warnings, Watches, Advisories, and Information Bulletins for Hawaii, US possessions, and all other US interests in the Pacific located outside of the continental United States proper. Lastly, the PTWC operates the Regional Tsunami Warning Network for the State of Hawaii (HRTWN). In this capacity, the PTWC provides rapid warnings to the State of Hawaii for tsunamis generated by large local earthquakes associated primarily with Hawaii's active volcanoes.

Director's report provided as IOC/ITSU-XX/9

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

The West Coast/Alaska Tsunami Warning Center mission is to protect life and property from the tsunami hazard by providing timely, accurate, reliable, and effective tsunami products to coastal populations and emergency management within the area-of-responsibility, as well as by advancing other aspects of tsunami hazard mitigation such as community preparedness and public education. The primary operational warning system objectives for carrying out this mission are to rapidly locate, size, and otherwise characterize major earthquakes, determine their tsunamigenic potential, predict tsunami arrival times, predict coastal runup when possible, and disseminate appropriate warning and informational products based on this information.

The West Coast/Alaska Tsunami Warning Center area-of-responsibility (AOR) consists of the U.S. Atlantic, Gulf of Mexico, Alaskan, and Pacific West Coasts, as well as the east and west coasts of Canada.

The mission of the West Coast and Alaska Tsunami Warning Center (WC/ATWC) is to provide tsunami watches, warnings, information bulletins, and interpretative information to civilian and military officials in Alaska, Canada (British Columbia), Washington, Oregon, and California. In performing this mission, its primary responsibility is the detection, location, and determination of magnitude of potentially tsunamigenic earthquakes occurring in the area from Attu, Alaska to the southern California border.

The WC/ATWC has this same responsibility for tsunamis generated by earthquakes located outside the WC/ATWC area of responsibility. The WC/ATWC also provides, within established criteria, earthquake parameters and other associated information to appropriate local, state, national and international interests. Information bulletins are issued to prevent needless evacuations when earthquakes may be felt along the coast within the AOR. Although numerous non-tsunamigenic earthquakes are automatically detected and processed each month, only a small number of these earthquakes are released to officials and the public.

During the intersessional period, the WC/ATWC AOR expanded considerably. Following the Indian Ocean event, in conjunction with the National Weather Service's (NWS) Eastern and Southern Regions the WC/ATWC established tsunami warning dissemination procedures for the US Atlantic and Gulf of Mexico coasts. While it is accepted that the probability of a dangerous event along these coasts is low, the Indian Ocean event showed that regardless of expectations, tsunami warning communication systems must be in place for all US coastal regions.

WC/ATWC personnel continue to conduct applied research and development to improve the present system, plus continue to analyze collected data. The Center is highly automated for processing earthquakes seismic and sea level data, and disseminating critical information to intended recipients. The earthquake processing software developed at the WC/ATWC, known as EarlyBird, is the seismic processing system used at the center. Near real-time moment tensor computations have been added to the EarlyBird system. The moment tensor results provide a separate estimate of moment magnitude, depth, and fault mechanism. The moment tensor algorithm used to provide important information on the strike-slip mechanism following the June 14 US west coast warning has been re-written to run under the Earthworm platform. The real-time system has been re-configured into approximately 12 modules. The modules operate independently, though interact through Earthworm message structures. Three new magnitude

techniques have been incorporated into the EarlyBird system. The Mwp magnitude, under development for the past several years, is now fully integrated into the system. The Mm (Mw) magnitude technique, developed by the Centre Polynésien de Prévention des Tsunamis in Tahiti, French Polynesia and provided by the PTWC, has also been implemented as an EarlyBird module. Lastly, WC/ATWC has been working with the NEIC to implement their automated Centroid Moment Tensor (CMT) technique as an EarlyBird module. This implementation is still under development. The EarlyBird system software was provided to both the National Earthquake Information Center and the Puerto Rico seismic network in 2002/2003.

A. Tsunami Products

During the intersessional period, four tsunami watches or warnings were issued by the WC/ATWC. A magnitude 7.1 earthquake in the western Aleutian Islands prompted a warning in June 2003. This was followed in September by a warning for the Aleutian Islands region due to the Hokkaido event. In November 2003, a warning was again issued for the Aleutian Islands as a result of an earthquake near Amchitka. The final warning for this period occurred on June 14, 2005. A magnitude 7.2 earthquake occurred off the coast of Northern California which prompted a warning for the US west coast and southwestern British Columbia. This was the first warning ever issued for the US west coast for a local event. None of these events triggered a wave damaging to the WC/ATWC AOR, though all but the first triggered tsunamis which were recorded on tide gages.

In addition to the warnings issued, center personnel responded to over 700 alarmed events which led to the issuance of 82 Tsunami Information Bulletins and over 200 informational messages concerning potentially felt earthquakes along the AOR coast. However, having responded to some 554 earthquake alarms, a total of three Tsunami Advisory Bulletins, 27 Tsunami Information Bulletins, 101 Information Messages, and 143 P-time messages were issued.

Backup procedures between PTWC and WC/ATWC continued to be improved were improved significantly over the last two years. Both centers are now capable of providing each other's services in the event of a catastrophic failure at either center. The centers are also capable of providing a limited set of products through selected communication paths in the event that either center has an outage in just one of their pathways. Each center conducts communication tests for the others AOR twice a year.

New tsunami product development is underway at the WC/ATWC. A browser-based product is now issued to the USGS CISN Display system for all informational messages. Watches and Warnings are presently being converted to this format. This browser-based product, written in '.htm', includes highlighted phrases, upper/lower case wording, embedded hot-links, and other easy-to-read features. A new "Public" product format has also been proposed. Software development is ongoing to generate this product. Lastly, an XML/CAP version of the product has also been developed. This message is posted on the WC/ATWC web site.

A new public tsunami message listserver was implemented during the intersessional period. The listserver, which is accessible through the WC/ATWC web site, allows anyone to sign up to receive either standard long email messages, or shortened versions which are

designed for digital cell phone delivery. The requester can sign up for west coast messages, east coast messages, or watch and warning messages only.

A new national policy directive and procedural instructions controlling both centers' operations were issued in May, 2003. Some of the changes impacting the WC/ATWC are: moment magnitude is the preferred method of sizing earthquakes; tsunami warnings can be left in effect for certain areas of the AOR and not enlarged with each new message; and backup procedures for PTWC were changed.

The WC/ATWC, in conjunction with the USGS and west coast states, has refined response criteria for potentially-felt coastal earthquakes within the AOR. Information message products are issued when earthquakes between magnitude 4 and 5 occur within 50km of the coast, earthquakes between magnitude 5 and 6 occur within 150km of the coast, or earthquakes between magnitude 6 and 6.5 occur within 250km of the coast. Earthquakes located in any west coast state, Alaska, or British Columbia over magnitude 6.5 will prompt the issuance of a tsunami information bulletin.

B. Seismic and Tide Sea Level Data Acquisition

The WC/ATWC continues to maintain a network of 15 seismic sites located throughout the state of Alaska at remote places from the far western Aleutians to Sitka, Alaska, and local sites that are within driving distance from Palmer. During the intersessional period, the network was upgraded from an out-of-date analog system to a state-of-the-art digital, broadband system. Data are transmitted to the WC/ATWC directly from remote sites via satellite. Conversion to this digital system significantly improved data quality. Several of the original sites were relocated to improve coverage within the state of Alaska, and to allow co-location of sea level recorders. The University of Alaska made important contributions to this new system through its **Tsunami Warning and Environmental measurements in Alaska** (TWEAK) program. The data are telemetered to the WC/ATWC for real-time processing and are recorded on computer disk. The WC/ATWC has proposed upgrading the aging analog telemetry equipment to a modern, satellite-based system. To this point, the proposed system has not been funded.

The USGS Earthworm system is used to exchange the seismic data with other centers. Approximately 108 channels of seismic data are recorded and processed at the WC/ATWC. The WC/ATWC exchanges real-time seismic data with the USGS National Earthquake Information Center (NEIC), University of Alaska, Alaska Volcano Observatory, PTWC, USGS Menlo Park Observatory, University of Washington, University of Oregon, Incorporated Research Institutions for Seismology (IRIS), the Southern California Seismic Network, and the Pacific Geosciences Centre in Canada.

The WC/ATWC has access to more than 120 tide sites throughout the Pacific Basin and world's oceans. Most of the US gages are maintained by NOAA's National Ocean Service (NOS). In addition to the NOS sites, other tide gauge networks are operated by agencies such as the Pacific Tsunami Warning Center, Japan Meteorological Agency, and others. The WC/ATWC maintains real-time telemetry equipment at seven several NOS gauges in Alaska, and fully maintains an eighth tide gauge at Shemya, Alaska. Since the last National Report, the instrumentation at Shemya has been replaced with an above-water, radar pinging device.

This device is proving to be a robust method for obtaining water-level data at remote sites. Plans are in place to expand the WC/ATWC network in Alaska to 5 more locations throughout the state.

C. Instrumentation, Maintenance, and Calibrations

The WC/ATWC continues to maintain its seismic network throughout Alaska, the Shemya tide site, and WC/ATWC's transmitters at each of the NOS tide sites. Equipment maintenance, additions, calibrations, and developments are on-going functions at the WC/ATWC's Center and field sites. Field sites are visited yearly or as soon as possible after equipment failure. At the Center, the incoming seismic and tide data are recorded on computer disk. The equipment and systems are monitored daily, by personnel and by other electronic equipment, to ensure a continuous data flow to the Center. Preventative maintenance, calibrations, and parts replacements are performed for all remote seismic and tide equipment, and for major equipment systems in the Center.

D. Communications Systems

Methods for disseminating emergency and routine information are via the National Warning System (NAWAS), Alaska Warning System (AKWAS), National Weather Wire System (NWWS), VHF radio system, Federal Aviation Administration NADIN2 system, dedicated NWS circuits, commercial telephones, Alaska Division of Emergency Services, NOAA Weather Radio, Coast Guard HF Marine Weather Radio, Emergency Alert System (EAS) through the National Weather Service, the NWS Emergency Manager's Weather Information Network (EMWIN), the USGS QDDS/CISN Display system, web page posting, pager notification, and e-mail. The NAWAS, a voice disseminating system, NWWS, NADIN2, and dedicated NWS circuitry are the primary systems used to alert disaster officials in the US and Canada of large earthquakes. The AKWAS, which is the State side of NAWAS, permits immediate voice communication with Alaska disaster officials. The NWWS, NADIN2 system, and NWS circuitry provide recipients with hard copies of watch/warning and other information. Web Page updates, pagers and e-mail are considered secondary systems. All of these systems are monitored and tested daily to ensure that they are operational. The primary systems are also tested monthly using warning product headers. Message receipt at the main communication facilities is verified.

E. Community Preparedness

The WC/ATWC continues to provide a three-part community preparedness program which includes (1) visits to distant coastal communities from Shemya to Southern California; (2) visits to local groups, facilities and schools that are within commuting distance of the Center; and (3) tours of the WC/ATWC's facilities. Public tours of the center are offered weekly on Fridays at 1PM, 2PM and 3PM. Some community preparedness is also done via email and telephone for special projects. Presentations in the community preparedness program usually include: a slide powerpoint presentation concerning the origin and nature of earthquakes and tsunamis; a community's particular hazard potential and their expected response; and a summary of the Center's operations, missions, and capabilities.

During this reporting period, the WC/ATWC staff visited approximately 15 Alaskan

communities and participated in several mitigation meetings on the West Coast. With the high interest in tsunami planning along the US west coast due to the Indian Ocean Tsunami and the June 14 warning, a large number of tsunami planning workshops have taken place. A training session organized by the NWS Southern and Eastern Regions was held in Melbourne, Florida in March, 2005. Warning Coordination Meteorologists from US Gulf and Atlantic coast Weather Forecast Offices attended the training.

The National Weather Service's TsunamiReady program, which was launched in 2001, has captured continues to expand to new at-risk coastal communities the interest of numerous at-risk coastal communities in Alaska, Washington, Oregon and California, and now the east coast, also. To date 18 communities have been designated as TsunamiReady communities (Sitka, Seward, and Homer Alaska; Crescent City, California; Cannon Beach, Oregon; and Ocean Shores, Long Beach, and Quinalt Reservation in Washington) along the US west, east, and Alaskan coasts. The program is based on the NWS 'StormReady' program with the purpose of increasing communication between the Warning Centers and participating communities, and improving tsunami hazard planning and awareness in the community.

F. Personnel and Facilities

The Richard H. Hagemeyer Pacific Tsunami Warning Center

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The West Coast/Alaska Tsunami Warning Center

The WC/ATWC staff level was increased from 6.5 to 15 during the intersessional period. The purpose of the increase is to staff the center 24/7 with two scientists on duty at all times. All scientific personnel had been hired by September, 2005, though not all had yet reported for duty. An intensive training period for the new hires is planned so that the center will be operational 24/7 by April 3, 2006.

The move into the new WC/ATWC facility (Figure 1) was completed during the intersessional period. The move started during early 2003, and was completed by the end of August. A dedication ceremony was held in May, 2004. In April 2002, a ground-breaking ceremony was held on the Palmer, Alaska property for a new building to house the Center. Construction was completed in May 2003 and the move to the new facility was completed in June 2003. The modernized facility contains such upgraded features as a Conference room, a dedicated Electronics workshop, a Command & Control style operations console, raised flooring for computer and network cabling, modular office furniture, and a reference library. The building was built with special consideration to energy-efficient usage and is provided with handicap access throughout. This facility was the first Leadership in Environmental and Engineering Design certified building in Alaska and in the Department of Commerce.



Figure 1. New WC/ATWC facility in Palmer Alaska

Please refer to the WC/ATWC web site for further explanations of issues discussed above: <http://wcatwc.arh.noaa.gov/>.

4. RESEARCH ACTIVITIES

The US National Tsunami Hazard Mitigation Program (NTHMP)

The U.S. National Tsunami Hazard Mitigation Program efforts continue to meet the goals of the founding recommendations to:

- Produce Inundation Maps
- Improve Seismic Networks
- Deploy Tsunami Detection Buoys
- Develop Hazard Mitigation Programs
- Develop State/NOAA Co-ordination and Technical Support

The program received approximately US \$4.3M in FY 03, 04 and 05. Following the December 26 2004 Indian Ocean Tsunami, the NTHMP was expanded from the original 5 Pacific States to a total of 28 U.S. coastal states, Territories and Commonwealths. Efforts are underway to incorporate the additional members and develop a governance structure that will accommodate the larger membership.

Major Efforts:

Short-Term Inundation Forecasting for Tsunami (SIFT). A prototype system has been developed for forecasting tsunamis by Project SIFT (Short-term Inundation Forecasting for Tsunamis), a collaboration of the NOAA Center for Tsunami Inundation Mapping Efforts (TIME), the NOAA Tsunami Warning Centers and academic scientists. SIFT combines numerical modeling and real-time tsunami measurement technologies. The current prototype provides offshore forecasts, advanced versions will provide site-specific forecasts of tsunami

inundation. On November 17, 2003 SIFT demonstrated its utility by helping tsunami analysts determine that no destructive tsunami resulted from a 7.3 earthquake in the vicinity of Rat Island (Figure 2).

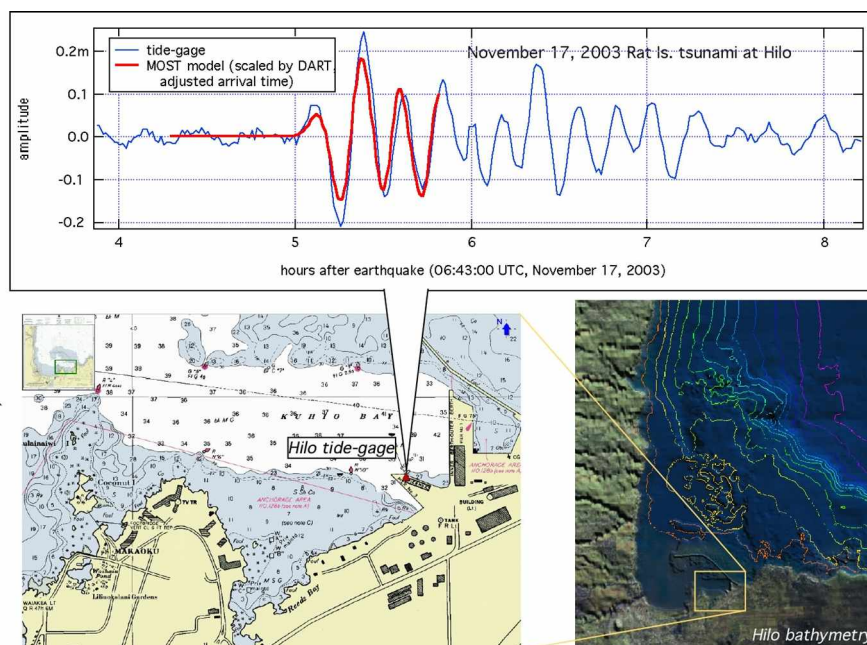


Figure 2: SIFT forecast for Hilo tsunami, November 17, 2003

Immediately following the 26 December 2004 Indian Ocean disaster, the President called for an improved U.S. Tsunami Warning System. As part of the NOAA response, an accelerated and expanded effort was initiated to complete a Tsunami Forecasting System for U.S. coastal communities in the Pacific, Caribbean and Atlantic. This collaborative effort by NOAA's Pacific Marine Environmental Laboratory and the Tsunami Warning Centers integrates DART network data and state-of-the-art tsunami numerical models to provide real-time forecasts of community-specific inundation. During the FY2004-FY2005 period, a prototype, web-based forecast system was implemented, known as SIFT, for Short-term Inundation Forecasting for Tsunamis. This prototype SIFT system is undergoing testing by the Tsunami Warning Centers, and is currently populated by 9 individual Forecast Models capable of forecasting inundation at the associated Pacific coastal communities. Fully operational SIFT systems, physically resident at each Tsunami Warning Center, will be implemented and populated with a total of 74 local inundation forecast models by the end of FY2009.

Deep-ocean Assessment and Reporting of Tsunami Buoys (DART): The DART system, combined with the SIFT models clearly demonstrated their application in advancing tsunami forecasting. During the intersessional period, PMEL made a major advance in the DART program by integrating and testing an Iridium two-way communication capability that allows the warning center analysts to obtain data from the buoy in real-time even when threshold signal level have not been reached.

5. INTERNATIONAL TSUNAMI INFORMATION CENTRE (ITIC)

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6. NATIONAL GEOPHYSICAL DATA CENTER (NGDC) & WORLD DATA CENTER (WDC) FOR SOLID EARTH GEOPHYSICS, BOULDER

The World Data Center for Solid Earth Geophysics, including tsunamis (WDC) is operated by NOAA's National Geophysical Data Center (NGDC). NGDC is one of three environmental data centers within the National Environmental Satellite, Data and Information Service (NESDIS). Operating both National and World Data Centers, NGDC acquires, processes and analyzes global data for terrestrial and marine environments. NGDC and the collocated WDC, has had a major role in the post-event data collection (including the compilation, cataloging, and synthesis) of all available information on tsunami sources and effects to support modeling, engineering, planning and educational purposes. Paula Dunbar is now in charge of the WDC/NGDC tsunami program.

The NGDC is now providing the long-term archive, data management, and access to national and global tsunami data for research and mitigation of tsunami hazards and collaborating with NOAA's Pacific Marine Environmental Lab (PMEL) to provide bathymetry and topography data in support of tsunami inundation modeling. Archive responsibilities include the global historic tsunami event and run-up database, the bottom pressure recorder data (temperature and pressure from both the older BPR and newer Deep Ocean Assessment and Reporting of Tsunamis – DART buoys), and access to event-specific tide-gauge data, as well as other related hazards and bathymetric data and information. To accomplish these activities, NGDC hired two new marine scientists through the Colorado Institute for Research in Environmental Sciences (CIRES), the NOAA – University of Colorado (CU) cooperative institute. NGDC also hired a CU student and funded a researcher and student at Humboldt State University to collaborate on a thorough review of the historic event database. This database will serve as input into a prototype socio-economic impact study to be undertaken in collaboration with Humboldt and an independent economist.