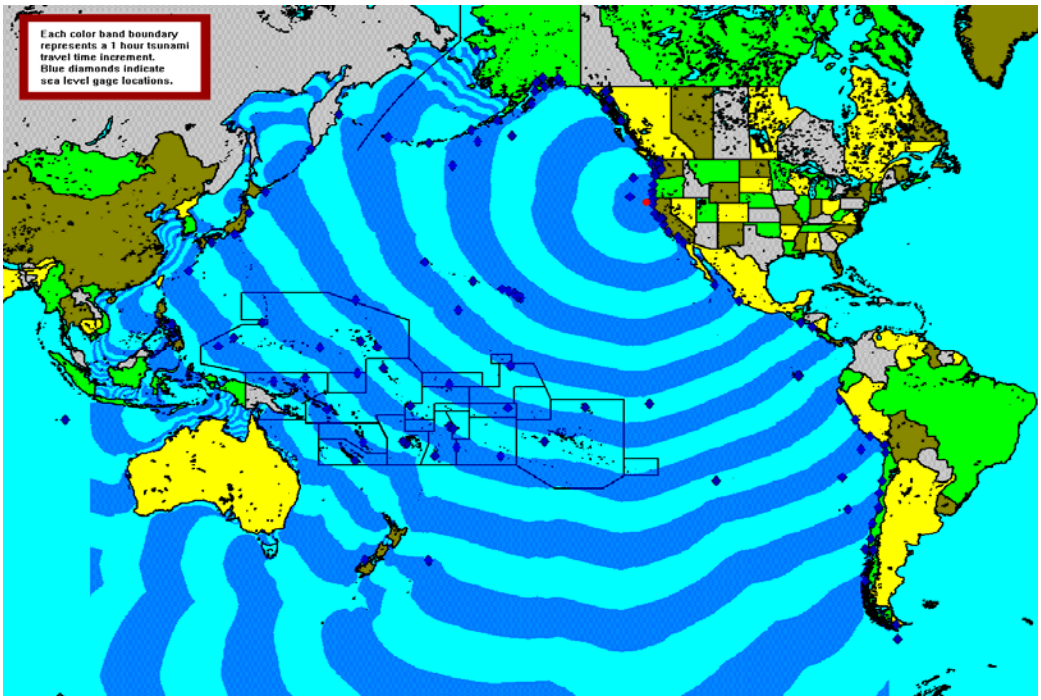
Service Assessment

West Coast Tsunami Warning, June 14, 2005



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
Silver Spring, Maryland

Cover graphic – Tsunami wave travel time contours (isochrones) created by the West Coast and Alaska Tsunami Warning Center for the June 14, 2005, earthquake. Each color change signifies a one-hour travel time.

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November 2005

NOAA's National Weather Service
David L. Johnson
Brigadier General, USAF (ret.)
Assistant Administrator for Weather Services

Preface

On June 14, 2005, an earthquake measuring magnitude 7.2 occurred approximately 90 miles off the northern California coast, prompting NOAA's West Coast and Alaska Tsunami Warning Center to issue a tsunami warning for the West Coast of the United States.

While no tsunami was generated by the earthquake, the event did prove to be, as one emergency manager put it, "*an excellent test*." Processes and procedures were exercised, and in some cases, problems within the system were noted and are being addressed.

Emergency managers received the information in a timely fashion, and many successfully exercised evacuations or other plans to protect life and property.

Notification of the public at large, however, was less timely and efficient. Some equipment malfunctions were noted and some procedures require improvement. There was a degree of confusion about what to do when a tsunami warning is received and about the warning itself. While we encourage the public to listen and follow the direction of their emergency managers, citizens also need to understand what to do and to be prepared to respond immediately when a warning is issued.

This assessment evaluates the performance of the National Weather Service (NWS) during the event and provides recommendations to improve services in the future. It takes into consideration the affected audiences in the emergency management community as well as the public.

Service assessments significantly enhance ongoing efforts to improve the quality and timeliness of NWS products and services. Findings of this assessment will further NOAA's goal to serve society's needs for water and weather information.

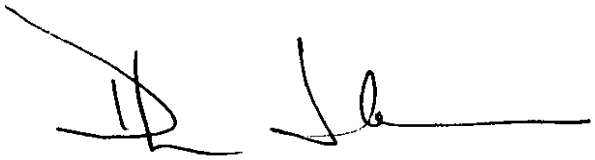

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Table of Contents

Service Assessment Team

The Service Assessment Team was formed on July 12, 2005. The team was activated to evaluate the performance of the NWS during this event in order to identify and share best case operations, procedures, and practices; and address service deficiencies, if noted.

The following members were on the team:

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Acronyms

ABA	Alaska Broadcasters Association
AFTN	Aeronautical Fixed Telecommunications Network
AK	Alaska
AR	Alaska Region
ARH	Alaska Region Headquarters
AWIPS	Advanced Weather Interactive Processing System
BC	British Columbia
CA	California
CRS	Console Replacement System (NOAA Weather Radio)
DART	Deep-ocean Assessment and Reporting of Tsunamis
DHS&EM	Division of Homeland Security and Emergency Management
EAS	Emergency Alert System
EOC	Emergency Operations Center
FAA	Federal Aviation Administration
FSL	Forecast Systems Laboratory
LSR	Local Storm Report
LP1	Local Primary 1 (broadcast station for EAS)
NAWAS	National Warning System
NCF	Network Control Facility
NEIC	National Earthquake Information Center
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NWR	NOAA Weather Radio All Hazards
NWRFC	Northwest River Forecast Center
NWS	National Weather Service
NWSH	National Weather Service Headquarters, Silver Spring, MD
NWSI	National Weather Service Instruction
NWSPD	National Weather Service Policy Directive
NWSTG	National Weather Service Telecommunication Gateway
NWWS	NOAA Weather Wire Service
OCIO	Office of the Chief Information Officer
OCWWS	Office of Climate, Water, and Weather Services, Silver Spring, MD
OES	Office of Emergency Services
OOS	Office of Operational Systems
OR	Oregon
PA	Public Affairs
PDT	Pacific Daylight Time
PIL	Product Identification List
PMEL	Pacific Marine Environmental Laboratory
PNSN	Pacific Northwest Seismic Network
PRH	Pacific Region Headquarters
PTWC	Pacific Tsunami Warning Center
RFC	River Forecast Center

SAME	Specific Area Message Encoder
SBN	Satellite Broadcast Network
SCSN	Southern California Seismic Network
SPS	Special Weather Statement
SRH	Southern Region Headquarters
TIB	Tsunami Information Bulletin
TLS	Tsunami Local Statement
TMA	Tsunami Message Acknowledgement
TWC	Tsunami Warning Center
UGC	Universal Generic Code
USGS	United States Geological Survey
VACT	Volcanic Ash Collaboration Tool
WA	Washington
WAN	Wide Area Network
WC/ATWC	West Coast/Alaska Tsunami Warning Center
WFO	Weather Forecast Office
WMO	World Meteorological Organization
WRH	Western Region Headquarters
WSO	Weather Service Office

Service Assessment Report

Executive Summary

At 7:51 p.m. Pacific Daylight Time (PDT), on Tuesday, June 14, 2005, a magnitude 7.2 earthquake occurred 85 miles northwest of Eureka, CA. In accordance with NWS policy, the West Coast and Alaska Tsunami Warning Center (WC/ATWC) issued a tsunami warning at 7:56 p.m. PDT for areas within a two hour wave travel time of the earthquake. This warning area encompassed coastal areas from the California-Mexico Border to the northern tip of Vancouver Island, British Columbia (BC). The earthquake did produce a small tsunami: a 10-15 centimeter wave was recorded at the Crescent City, CA, tide gage. NOAA tide gage data were received at the Tsunami Warning Centers (TWC) at approximately 9:00 p.m. PDT along with Deep-ocean Assessment and Reporting of Tsunamis (DART) buoy data indicating a negligible tsunami. After confirmation that a destructive tsunami did not develop, the WC/ATWC cancelled the warning at 9:09 p.m. PDT.

Emergency management officials at all government levels, media, and citizens in affected communities recognized and appreciated the National Weather Service (NWS) warning efforts. The WC/ATWC quickly disseminated the warning on the National Warning System (NAWAS) as it was circulating through NWS communications to the Weather Forecast Offices (WFO). Coastal communities who had done preparation work for tsunamis utilized multiple dissemination systems to notify people at risk. The warning prompted the successful evacuation of numerous coastal communities and beaches, created a large amount of public interest, and generated national media coverage. However, not all aspects of the warning system functioned properly during this event.

Due to the relative infrequency of tsunami warnings in the U.S. compared to weather-related hazards, the NWS viewed the June 14 event as an opportunity to improve its role in the tsunami warning system. This assessment examines NWS operations and services and provides nineteen recommendations for possible improvements. These suggested courses of action address many facets of the tsunami warning system; from the communications systems used to disseminate information to the effectiveness of the content of the warning messages to the public response to the warning itself.

In summary, the assessment team found that improvements are needed to the tsunami warning product suite in order to provide emergency officials, the media, and the public with information they can understand and quickly act upon. In particular, the format, content, and update cycle should be addressed. Also, procedures at NWS offices need to be formalized and routinely practiced to ensure efficient and consistent tsunami warning operations; likewise, public tests of the tsunami warning system paired with increased outreach through TsunamiReady and other awareness programs will lead to a greater level of community and state-level preparedness for this relatively rare hazard. Finally, enhancements to coordination and collaboration throughout the NWS and with

its partners are possible to better leverage the knowledge and expertise applied to the tsunami warning process and to the information conveyed to the public. Specific recommendations addressing these issues and others are detailed in the following report.

Introduction

The mission of the NWS Tsunami Warning Program 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 the area of responsibility; and 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.

The WC/ATWC, located at Palmer, Alaska, prepares and disseminates tsunami warnings, watches, advisories, and information bulletins for the coastal areas of Alaska, British Columbia, Washington, Oregon, and California, as well as the U.S. Atlantic and Gulf of Mexico coasts. It has secondary responsibility for the detection and evaluation of earthquakes located outside its area of responsibility and is the backup center for the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC). The PTWC, located in Ewa Beach, Hawaii, provides warnings for teletsunamis to most countries in the Pacific Basin as well as to Hawaii and all other U.S. interests in the Pacific outside of Alaska and the U.S. West Coast. A teletsunami, also called a distant-source or far-field tsunami, occurs when the source of the tsunami is more than 620 miles (1,000 km) away from a land contact point.

Coastal WFOs must be ready at all times to assist in the tsunami warning dissemination process. The WFO's role includes broadcasting watch and warning information on NOAA Weather Radio All Hazards (NWR), activating the Emergency Alert System (EAS), and working directly with local emergency management officials, the media, and the public to increase awareness and preparedness for this hazard. This outreach does not occur simply during the warning event but is cultivated throughout the year.

A cornerstone for NWS tsunami hazard preparedness and awareness activities is the TsunamiReady program. TsunamiReady promotes tsunami hazard readiness as an active collaboration among Federal, state and local emergency management agencies, the public, and the NWS tsunami warning system. These partnerships support better and more consistent tsunami awareness and mitigation efforts among communities at risk. The main goal is improvement of public safety during tsunami emergencies. More information on TsunamiReady can be found at:
http://www.stormready.noaa.gov/tsunamiready/index.htm

This assessment reviewed operations, products, and services at the Tsunami Warning Centers (TWC) and the WFOs. Opportunities for improvement were found there, as well as in the general areas of dissemination, coordination, and outreach. This report is organized accordingly.

TWC Operations, Products, and Services

The WC/ATWC disseminated the tsunami warning within five minutes of the earthquake, which is exceptional by NWS policy standards[1] and practical operational capabilities. The earthquake was observed at 7:51 p.m. PDT, and the on-call staff was immediately paged. The warning product (TSUWCA) was issued at 7:56 p.m. PDT. (A chronology of the June 14, 2005 event, including products issued and coordination activities, is provided in **Appendix A.**)

Normal business hours for both TWCs are Monday through Friday from 7:00 a.m. to 5:00 p.m. local time. During non-business hours, the staffs are on call. An automated paging system notifies the staff of an earthquake, and they are required to be in the office within five minutes. Customers were concerned about the lack of 24/7 staffing. This issue was addressed, and Congress approved supplemental funding for the tsunami program in fiscal year 2005. Both Centers plan to have their operations expanded to 24/7 in-house coverage by April 2006.

The PTWC issued a tsunami information bulletin (TIB) which caused widespread confusion among customers. The bulletin was intended to be a stand-alone product for Pacific interests *outside of* Alaska and the west coast, and it advised that a tsunami warning was not in effect for those areas. Many perceived this bulletin to be a follow-up message to the initial warning issued by the WC/ATWC and, as a result, thought the tsunami warning for the West Coast was canceled three minutes after it was issued.

Several media said they found a variety of official and unofficial reports that indicated the tsunami warning was canceled. The Oregon Warning Point and some media outlets thought the tsunami warning was canceled, when in fact it was still in effect. Thirty-minutes of broadcasts from a television station in the Portland, OR, area stated that the warning had been canceled even though it was still in effect. As a result of believing the warning had been canceled, many communities made no effort to evacuate.

Confusion about the PTWC product was compounded by additional factors: (a) many members of the public and media were unfamiliar with the TIB product and with each TWC's area of responsibility; (b) the tsunami.gov website was not an effective portal for people seeking clarification on the perceived inconsistency. (Refer to recommendations under the Dissemination section of this report.)

Fact – PTWC issued a TIB "*for all areas of the Pacific Basin except Alaska - British Columbia - Washington - Oregon - California*" at 7:59 p.m. PDT, three minutes after WC/ATWC's tsunami warning. The bulletin went on to say there was no tsunami warning or watch in effect.

[1] NWS Instruction 10-701, "Tsunami Warning Center Operations," states, "The initial bulletin should be disseminated within 15 minutes of the earthquake origin."

Finding 1 – The TIB contained Universal Generic Codes (UGC) for WA, OR, CA and AK for which it did not apply. Some readers focused on the phrase, "there is no tsunami warning or watch in effect," and overlooked the statement that the bulletin was for all areas except AK/BC/WA/OR/CA.

Recommendation 1 – Format and content specifications for tsunami watch/warning products should be standardized in NWS policy to address and alleviate the potential for contradiction and confusion. Product specifications for NWS watches and warnings for hazardous weather should be considered as input, since these products are already institutionalized and consistent with World Meteorological Organization (WMO) standards.

The present format and content of tsunami text products evolved over a period of many years. International customers and emergency managers, who were directly familiar with required actions in the event of a tsunami, tailored the products for use. During this event, many emergency management officials, as well as the media and public, found the bulletins of both TWCs to be confusing and difficult to read. The greater availability of information to the public directly via the Internet requires that NWS take a proactive approach in making this information user-friendly.

Prior to June 14, the WC/ATWC had acknowledged the value and need for more user-friendly products and worked with a team to design a suite of such products. These user-friendly products are expected to be implemented by 2006 and will include elements more consistent with the NWS public weather warning program, such as call-to-action statements and watch/warning definitions. An example of a user-friendly tsunami warning product in development can be viewed in **Appendix B.**

It was widely reported the tsunami warning product was not easily understood when immediate response was needed. There was concern the header information was too verbose and detracted from the pertinent information in the body of the message. The important parts of the bulletin were lost due to all letters being capitalized, the headers being long, and the message not being written in "plain text." In addition, many users were confused about the definitions of tsunami watches and warnings and found definitions in NWS Internet sites to be inconsistent.

Fact - Work continues on implementing user-friendly tsunami products.

Fact – Most NWS warning products have call to action statements at the end of the product along with specific definitions of the warning element.

Finding 2 – While the new user-friendly TIB will include tsunami watch and warning definitions, inclusion of these definitions within the standard product will provide further information to aid in the public's response.

Recommendation 2 – Formal definitions of "tsunami watch" and "tsunami warning" should be included in PTWC and WC/ATWC's associated products and included on their respective Internet sites.

NWS policy for issuing products in all capital letters is based on guidelines set by the WMO.

Fact – In accordance with NWSI 10-1701, tsunami warning products are issued in all capital letters.

Finding 3 – Capitalizing all the letters caused some customers to overlook important elements of the tsunami warning products.

Recommendation 3 – The NWS should work with the WMO to remove the all-caps requirement for non-coded text products distributed via international circuits. Mixed case text products should be made available via the Internet. The NWS should also ensure that all NWS product generation and telecommunication systems support creation and dissemination of mixed-case messages.

While the first WC/ATWC tsunami warning product was disseminated at 7:56 p.m. PDT, the next WC/ATWC product, which cancelled the warning, was not disseminated until 9:09 p.m. PDT, one hour and 13 minutes later. Emergency management, the media, and the public wanted updates more frequently. The lack of new information from the WC/ATWC caused confusion and speculation.

Fact – Per NWS directives, tsunami warning updates are to be issued at least hourly.

Finding 4 – Most customers wanted updates while the tsunami warning was in effect.

Recommendation 4 – Both Centers should work with their customers and partners to determine the most appropriate update frequency during local tsunami events and publicize this information within their products and websites. At a minimum, updates should be issued on an event or news-driven basis (i.e., if new information regarding the event is available, the update should not wait for a scheduled time.)

The warning chronology referenced PTWC needing to provide WC/ATWC with an evaluation of the Crescent City tide gage, the first coastal gage to record the tsunami. Although the DART data had been retrieved as expected, the "ground truth" Crescent City tide gage data was still needed prior to canceling the warning. Problems in retrieving this data contributed to the delay in the WC/ATWC's issuance of the warning update/cancellation.

Facts – Transmissions from the Crescent City gage were not being transmitted or recorded properly on June 14, 2005. In early July 2005, the National Ocean Service upgraded the Crescent City tide gage, resolving the issues that contributed to this problem

for that gage. All of the Hawaii tide gages have already been upgraded, Alaska tide gages are slated to be upgraded by winter 2005-2006, and the rest of the West Coast gages are scheduled to be upgraded within one year.

WFO Operations, Products, and Services

A tsunami is a rare event. This makes it difficult for the WFO forecaster to prepare for the stress and urgency of the situation. As with any rare event, the workload increases significantly.

Fact – Not all aspects of the WFO warning system functioned properly during the June 14, 2005, West Coast tsunami warning. Following the initial warning, local procedural errors were made and dissemination of the warning through the EAS was not timely. Clear and concise tsunami event instructions are required for the duty forecaster.

Policy and operational procedures for the provision of tsunami-related products and services are contained in NWS Policy Directive 10-7, Tsunami Warning Services, and several NWS Instructions (NWSI) issued at the national and regional level. These directives serve as references during non-routine operations, and they are often the basis for other more detailed instructions provided in the office Station Duty Manual (SDM).

Finding 5a – These directives did not meet the needs of the affected offices. They were considered vague, disorganized, and incomplete. National Weather Service Policy Directive 10-7, NWSIs 10-701, 10-702, 10-703, and associated regional supplements are being updated to address these problems.

Finding 5b– Quick reference checklists were not available for WFOs, and the SDM sections covering tsunamis were inadequate.

Recommendation 5 – Regional Tsunami Program managers should distribute a tsunami quick reference guide to appropriate WFOs. The template should include EAS instructions and the Emergency SDM guidelines.

The Tsunami Message Acknowledgement (TMA) is a feedback tool used by both Centers to verify the success of their routine tests. Standard operating procedures at the WFOs also require them to develop/create these products for transmission during real warning events.

Fact – One of the first actions many of the WFOs took was to develop/create and disseminate the TMA product, which exhausted valuable time.

Finding 6 – The highest priority actions for the WFOs upon receipt of a tsunami warning are EAS activation and NWR emergency tone alert.

Recommendation 6 – The Centers should evaluate the need for TMAs during warning events.

Some of the Southern California WFOs issued Special Weather Statements (SPS) to update the public on the tsunami warning. The media and public were pleased with the local information from the SPS. This high media attention event needed a scientific

source of information on the local level and the SPS product met the demand in a timely manner.

Fact – The SPS product from a WFO had never been issued before during a tsunami threat. The WFOs have the option to issue a local informational product such as an SPS during a tsunami threat. Customers indicated a specific product containing updated information while a tsunami warning is in effect would be helpful.

Finding 7 - A preliminary poll of emergency managers from states along the Pacific coast found they endorse a new product providing updated information while a tsunami warning is in effect such as a Tsunami Local Statement (TLS). The TLS product would be similar to the Hurricane Local Statement product issued by WFOs for hurricanes.

Recommendation 7 – The NWS should look further into the need for a TLS.

Dissemination

Tsunami warning products generated at WC/ATWC took over five minutes to reach the AWIPS Network Control Facility (NCF) for relay to the WFOs via the Satellite Broadcast Network (SBN). This directly delayed the NWR broadcast and EAS activation by the WFOs.

Fact – The NWS Telecommunication Gateway (NWSTG) receives tsunami warning products via a point-to-point communication path with ARH, from an NWWS downlink and from the FAA. The first received instance of the product is sent to the AWIPS NCF via a point-to-point communication path. Switching delays at the NWSTG routinely exceed five minutes.

Fact - A replacement for the NWSTG is currently under development, which has a performance goal of ten (10) seconds for switching priority products, including watches and warnings. Subsequent testing at ARH has resulted in an interim solution. Tsunami products have been introduced onto the AWIPS Wide Area Network (WAN). This transfer of data takes approximately 20 seconds and is a reliable backup of tsunami products to the NWSTG.

Finding 8 – A significant delay in dissemination of tsunami warning products occurred within the NWSTG.

Recommendation 8 – PTWC should investigate the capability to implement a similar additional communications route (as demonstrated by WC/ATWC) for their products.

Upon receipt of a tsunami warning, the WFOs create a product for NWR that will broadcast the warning message and activate the EAS. Any slight error in the product coding could potentially delay EAS activation.

Fact – Several of the WFOs did not disseminate the warning through NWR and EAS in a timely manner.

Finding 9 – The creation of an automated WFO tsunami message based on information received within the WC/ATWC tsunami warning would alleviate potential errors in the CRS warning message generated by WFOs. A similar automated generation tool has already been developed at WFO Juneau, AK for dam failures and could be modified for tsunami warnings.

Recommendation 9 – An automated WFO tsunami message for NWR should be developed for implementation at all coastal WFOs.

Following the June 14 tsunami warning issuance, several NWR transmitters in the Pacific Northwest failed to broadcast the Specific Area Message Encoder (SAME)/EAS codes with the warning, even though the WFOs properly sent the signal. Expansion of

NWR, specifically to remote locations, has resulted in some technical issues regarding communication paths from the WFO and verification of the tone alert (1050 Hz) on these transmitters. Phone lines in remote locations are usually unavailable.

Fact – NWR is a vital piece of the government's "all hazards" emergency response network.

Fact – WFOs verify the success of the NWR tone alert weekly tests of NWR transmitters by utilizing weather spotters, cooperative observers, and emergency managers.

Fact – The NWS is working on a "Weather Radio Improvement Plan," (WRIP).

Finding 10 – A significant factor in the failure to disseminate the tsunami warning rapidly was some NWR communication lines had been faulty for a number of days. This was the cause of several NWR transmitters failing to broadcast the SAME/EAS codes with the tsunami warning. Weekly NWS tone alert tests were being conducted on the transmitters, but the transmitters were in remote locations, and no successful test confirmation ever took place.

Recommendation 10 - The WRIP should include enhancements for monitoring remote transmitters.

Annual tsunami warning tests were conducted along the west coast and in Alaska in September 2003 and 2004. Although test messages were received, very few actions were taken.

Facts – In March 2005, the NWS Alaska Region (AR) and Alaska's Division of Homeland Security and Emergency Management (DHS&EM), in cooperation with local emergency management offices and the Alaska Broadcasters Association (ABA), successfully conducted the first-ever live test of the Alaska Tsunami Warning System. The WC/ATWC initiated the test by issuing a warning message with appropriate test annotations. Initiation of the EAS and NWR followed within minutes by the appropriate NWS offices. The message was then relayed over commercial radio and television channels to test the actual tsunami warning EAS code.

Finding 11 – End-to-end testing of the tsunami warning system is the only way to test completely each portion of the dissemination, notification, and response portions of the system.

Recommendation 11 – The NWS should continue end-to-end dissemination tests to ensure the message is received and proper actions are taken to remedy any deficiencies revealed by those tests.

There were a number of problems identified with regard to navigation, content, consistency, and performance of NWS websites as a result of the June 14 event. Customers complained the WC/ATWC web site had a slow response, and some could not

even find the appropriate site. Tsunami warning products were not displayed on some of the national and regional warning display web pages. This resulted in customer confusion. In addition, the media and the public did not know where to go for timely, accurate information.

Fact – AR and the NWS Office of the Chief Information Officer (OCIO) are working to improve the communications infrastructure and reconfigure their Internet server. AR has also issued a work order to double the bandwidth of its Internet service. This should temporarily improve the web responsiveness to its customers, but the final solution resides with a reconfiguration by the service provider. The service provider is conducting an engineering analysis of the recommended reconfiguration.

Fact – For products to be displayed on the NWS web site watch and warning maps, the product identifier must be included in a national configuration table.

Finding 12 – Not all web server farm configuration tables contained the tsunami warning product identifier. Distribution of updates to web server farm configuration tables involves manual processes.

Recommendation 12 – NWS OCIO should work with the regional headquarters to improve the process for updating the product identifier configuration table.

Finding 13 – A centralized source for the latest tsunami information is necessary to avoid confusion and promote a more efficient response.

Recommendation 13 – NWSH should enhance navigation and content on the tsunami.gov website to provide consolidated, comprehensive information. The site must offer current tsunami warning/watch information; definitions of TIBs, watches, warnings and cancellations; general safety information on tsunami preparedness; and links to state emergency management resources.

Coordination

During the hour following the event, the media sought information and interviews with experts. Unfortunately, conflicting tsunami information was provided to the media and emergency management by other public entities outside of NWS, specifically, the Southern California Seismic Network (SCSN) and the Pacific Northwest Seismic Network (PNSN). The SCSN and the PNSN are cooperative projects involving the U.S. Geological Survey (USGS), several universities, and other state and federal agencies.

Fact – USGS and NOAA are partners in the U.S. tsunami warning system. Both SCSN and PNSN are tasked with locating earthquakes throughout their respective areas. These scientists have long been the spokespeople for the media during earthquake events; however, in this case, they made statements contrary to the official tsunami warning from NWS.

The USGS supports offices primarily focused on seismic activity and earthquake location. While the two NWS TWCs are also concerned with earthquake magnitude, their expertise lies within earthquakes as they relate to tsunamigenic potential. To help clarify these roles, Brig. Gen. D.L. Johnson, Assistant Administrator for Weather Services, had a telephone conversation with Dr. David Applegate, USGS Senior Science Advisor for Earthquake and Geologic Hazards, to ensure that each agency does its part to remind the media of the role each plays.

Finding 14 – It is crucial the NWS and the USGS work collaboratively to ensure consistent warning information is being disseminated to the public.

Recommendation 14 – NWSH Public Affairs (PA) and USGS PA should develop and implement a media outreach plan to educate and inform media about the roles and responsibilities of Federal agencies in tsunami warning coordination efforts.

Several public agencies, as well as members of the emergency management community, stated the warning should have been canceled once WC/ATWC determined the earthquake mechanism was strike-slip in nature. The conventional wisdom is that strike-slip earthquakes produce mainly horizontal motion and little of the vertical motion necessary to create a tsunami.

Facts – The extreme position is that strike-slip means horizontal motion. Even if this were true, the stage can be set for a tsunami. When horizontal motion occurs on a submarine slope, the effect on the ocean is the same as what would happen if a wedge was pushed horizontally. The ocean would still be moved vertically. Strike-slip earthquakes have also triggered subaerial and submarine landslides, which in turn produced tsunamis.

Finding 15 – WC/ATWC conducted an analysis of their recorded earthquakes over magnitude 5 that occurred after 1977. Of the 3,667 earthquakes listed for this period, 109

produced a tsunami and 41 of those produced wave amplitudes over one meter. Additionally, of the 109 tsunamis, 15 (14%) were purely strike-slip in nature.

Recommendation 15 – The TWCs should not discount the tsunamigenic potential of an earthquake based simply on knowledge of earthquake behavior.

Fact – The WC/ATWC conducted more than 60 media interviews within 24 hours after the event.

Fact – NWSH PA received notification of the warning via a cell phone text message generated by the PTWC advisory, not the WC/ATWC warning. They were not contacted by WC/ATWC for assistance.

Finding 16 – **In this instance, TWC staffs tried to focus on verification and potential impact of the warning but they spent much of their time responding to media inquiries. PA offices can provide initial information about tsunami warning events and arrange for interviews as time permits.**

Recommendation 16 – Media calls to the TWCs during a tsunami warning event should be directed through the WFOs (as appropriate), Regional PA, and/or NWSH PA. NWSH PA should develop a public affairs media notification procedure for use by the Tsunami Warning Centers, Regional Headquarters and WSH PA.

In addition to the interagency coordination needs between the USGS and NWS, the TWCs have a requirement to coordinate with each other in real-time for responses to seismic and potentially tsunamigenic events.

Fact – Similar interagency coordination occurs during volcanic eruptions. To facilitate real-time collaboration during North Pacific volcanic eruptions, a pilot project was instituted in 2003 between the NWS, NOAA's Office of Atmospheric Research Forecast Systems Laboratory (FSL), and USGS to develop a Volcanic Ash Collaboration Tool (VACT). The VACT allows for shared access to satellite and meteorological data and provides interactive collaboration capabilities for the NWS and USGS offices involved in the project.

Finding 17 – The development and use of a tool similar to VACT would improve real-time collaboration/coordination between all necessary parties during an earthquake or potentially tsunamigenic event.

Recommendation 17 – NWS should continue to work with FSL to develop a coordination tool for use in tsunami warning situations.

The Northwest River Forecast Center (NWRFC) developed a stage-to-stage relationship by varying coastal tsunami wave heights at the Pacific Ocean boundary point of Astoria, Oregon, and the river forecast points on the confluence of the Columbia and

Willamette rivers. The NWRFC is investigating other approaches that may lend support to the WFO.

The tsunami to inland peak stage height relationship is currently the most practical form of WFO support provided by the RFC. The tsunami to inland peak stage relationship remains unverified in real time.

Finding 18 – RFCs can provide valuable information to WFOs during a tsunami event and coordinate with state and federal flood centers.

Recommendation 18 – All regions should evaluate the potential role of RFC involvement during tsunami warning events.

Outreach

Education and outreach must be primary elements within the NWS Tsunami Program for the tsunami warning system to be effective. It is vital that the necessary precautions be taken to ensure our communities are prepared in the event of a tsunami. NWS Warning Coordination Meteorologists work with their partners in federal, state, and local emergency management to build awareness and preparedness for this hazard through the TsunamiReady program as well as routine interaction on all hazards preparedness activities.

NWS websites are also a key source of information during potentially hazardous events when an immediate public response is needed. There was confusion among the media and the public as to where to find accurate and timely information during the tsunami warning. (See **Recommendation 12**.)

Fact – Several communities issued evacuation orders and residents heeded the warnings. People on the beach were also advised to seek "higher ground." Crescent City, CA was one of the TsunamiReady communities included in the June 14 warning event, and they evacuated accordingly. News coverage of Crescent City's response to the warning generated interest in TsunamiReady and how other communities could emulate Crescent City's preparedness.

Fact – In some areas, the media reports highlighted people heading to the beach to see the tsunami rather than evacuating.

Finding 19 – Instances of people going to the beach to watch a potential tsunami rather than seeking higher ground indicates a serious lack of public awareness.

Recommendation 19a – NWS must continue their outreach efforts in support of the TsunamiReady Strategic Plan to educate at risk communities on the potential hazards from tsunamis and how to prepare and respond to a warning.

Recommendation 19b – NWS should discuss warning content with social scientists familiar with public reaction to warnings and make improvements if possible.

Conclusion

The June 14, 2005, tsunami warning issued by WC/ATWC was a true end-to-end test of the nation's tsunami warning system. Overall, the warning system had some problems but the recommendations discussed here can improve the system. While many changes and upgrades have already been implemented, the one resounding message is the need for vigilance. The only way we can ensure our public servants, equipment, communication lines, and the public are prepared is to test the systems, conduct routine drills, and educate. Redundant communication systems can broadcast the warning far and wide but unless the public is knowledgeable on how to respond, our efforts fall short of our mission to protect lives and property.

Appendix A

Chronology of Events and Products June 14, 2005 (times listed are PDT)

7:51 p.m.: A magnitude 7.2 earthquake occurred 85 miles northwest of Eureka, CA (41.4N, 125.6W).

7:54 p.m.: Duty personnel arrived at WC/ATWC.

7:55 p.m.: Coordination message sent from PTWC to WC/ATWC.

7:56 p.m.: Tsunami warning issued by WC/ATWC for coastal areas from the California-Mexico Border to the northern tip of Vancouver Island, BC.

7:57 p.m.: WC/ATWC initiated NAWAS announcement of warning.

7:59 p.m.: Tsunami Information Bulletin issued by PTWC.

8:02 p.m.: NAWAS announcement of WC/ATWC warning was completed.

8:10 p.m.: Oregon Warning Point announced PTWC Bulletin on NAWAS – "no tsunami warning is in effect." WFO Medford called Oregon Warning Point and corrected them. The California State Office of Emergency Services (OES) sent a message to the County Emergency Operations Centers (EOC) that said "no tsunami warning was in effect at 8 pm." The exact time of the California OES message could not be verified.

8:10 p.m.: At approximately 8:10 p.m., media interview requests and phone calls began flooding into the offices.

8:15 p.m.: Predicted time of arrival of possible tsunami at Cape Mendocino, CA. This was the earliest wave arrival prediction.

8:16 p.m.: NOAA Pacific Marine Environmental Laboratory (PMEL) ran experimental forecast. Forecast predicts one centimeter tsunami at DART station off the Oregon coast at 8:40 p.m.

8:52 p.m.: WC/ATWC called PTWC to discuss canceling the warning. PTWC provided evaluation of Crescent City tide data.

9:09 p.m.: Tsunami warning cancelled by WC/ATWC for coastal areas from the California-Mexico Border to the northern tip of Vancouver Island, BC.

9:12 p.m.: NAWAS issued announcement of WC/ATWC warning cancellation.

9:52 p.m.: Tsunami cancellation statement is corrected for errors[2] by WC/ATWC.

[2] The initial tsunami cancellation statement included some format wording stating, "A small tsunami was observed at the following sites. Water levels remain normal at all coastal sites. No wave has been detected." This generated confusion so a corrected statement was sent stating, "Water levels remain normal at all coastal sites. No waves have been detected."

Appendix B
Sample of a User Friendly Tsunami Product

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WEAK51 PAAQ 022145
TSUAK1

URGENT – TSUNAMI BULLETIN
NOAA/NWS WEST COAST AND ALASKA TSUNAMI WARNING CENTER
245 PM PDT THU SEP 2 2004

PKZ176-175-170>172-155-150-132-136>138-141-140-120-121-125>130-051>053-
041>043-011>013-021-022-031>036-PZZ130>135-150-153-156-110-250-210-255-
350-353-356-450-455-550-530-535-555-670-673-650-655-750-AKZ191-185-181-
171-145-111-101-121-125-131-135-017>029-

WAZ001-002-005>011-013>016-021-ORZ001-002-021-022-CAZ001-002-005>007-
075-074-009-034-035-039>043-046-0222345-

COASTAL RESIDENTS IN CALIFORNIA/OREGON/WASHINGTON/
BRITISH COLUMBIA AND ALASKA
245 PM PDT THU SEP 2 2004

This is a SAMPLE Initial Public Tsunami Warning

...A TSUNAMI WARNING HAS BEEN ISSUED FOR THE COASTAL AREAS FROM THE
CALIFORNIA/MEXICO BORDER TO POINT CONCEPCION-CA INCLUSIVE...

...A TSUNAMI WATCH HAS BEEN ISSUED FOR THE COASTAL AREAS FROM POINT
CONCEPCION-CA TO PORT SAN LUIS-CA...

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. THIS TSUNAMI WARNING IS
BASED SOLELY ON EARTHQUAKE INFORMATION – THE TSUNAMI HAS NOT YET BEEN
CONFIRMED.

A TSUNAMI WATCH MEANS... ALL COASTAL RESIDENTS IN THE WATCH AREA SHOULD
PREPARE FOR POSSIBLE EVACUATION. A TSUNAMI WATCH IS ISSUED TO AREAS
WHICH WILL NOT BE IMPACTED BY THE TSUNAMI FOR AT LEAST TWO HOURS.
WATCH AREAS WILL EITHER BE UPGRADED TO WARNING STATUS OR CANCELED.

AT 2:35PM PACIFIC DAYLIGHT TIME ON SEPTEMBER 2 A MAGNITUDE 7.7
EARTHQUAKE LOCATED OFF THE COAST OF CHILE OCCURRED AND MAY HAVE
GENERATED A TSUNAMI. IF A TSUNAMI HAS BEEN GENERATED THE WAVES WILL
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FIRST REACH LA JOLLA, CA AT 4:30AM PDT ON SEPTEMBER 3. ESTIMATED TSUNAMI ARRIVAL TIMES AND MAPS ALONG WITH SAFETY RULES AND OTHER INFORMATION CAN BE FOUND ON THE WEB SITE WCATWC.ARH.NOAA.GOV.

TSUNAMIS CAN BE DANGEROUS WAVES THAT ARE NOT SURVIVABLE. WAVE HEIGHTS ARE AMPLIFIED BY IRREGULAR SHORELINE AND ARE DIFFICULT TO PREDICT. 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.

THE PACIFIC TSUNAMI WARNING CENTER WILL ISSUE TSUNAMI BULLETINS FOR HAWAII AND OTHER AREAS IN THE PACIFIC OUTSIDE CALIFORNIA/ OREGON/ WASHINGTON/ BRITISH COLUMBIA AND ALASKA.

ADDITIONAL BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT. THE TSUNAMI WARNING AND WATCH 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 WEST COAST AND ALASKA TSUNAMI WARNING CENTER WEB SITE AT WCATWC.ARH.NOAA.GOV.