Intergovernmental Oceanographic Commission
technical series

United Nations
Educational, Scientific and
Cultural Organization

87

Operational Users Guide for the Pacific Tsunami Warning and Mitigation System (PTWS)

January 2009

UNESCO

87

Operational Users Guide for the Pacific Tsunami Warning and Mitigation System (PTWS)

January 2009

UNESCO 2009

IOC Technical Series No. 87
Paris, 2 February 2009
English only

EXECUTIVE SUMMARY

The Pacific Tsunami Warning and Mitigation System (PTWS) was founded in 1965 by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, following 5 major destructive Pacific tsunamis in the previous 19 years, to help reduce the loss of life and property from this natural hazard.

The Operational Users Guide for the Pacific Tsunami Warning and Mitigation System (PTWS) provides a summary of the tsunami message services currently provided to the PTWS by the U.S. National Oceanic and Atmospheric Administration's (NOAA) Pacific Tsunami Warning Center (PTWC), the NOAA West Coast / Alaska Tsunami Warning Center (WC/ATWC) and the Japan Meteorological Agency's (JMA) Northwest Pacific Tsunami Advisory Center (NWPTAC). This 2009 version, formerly called the Communications Plan for the Tsunami Warning System in the Pacific, has been completely revised to include descriptions of the operations of these three Centres in the main body, with additional technical information given in Annexes. The Guide is intended for use by the responsible agencies within each country of the PTWS who are recipients of tsunami messages from the international Centres.

Section 1 provides the objectives and purposes of the Guide. Section 2 describes the administrative procedures, the organizations involved, and how to subscribe to services offered. Section 3 provides an overview of the three operational Centers, while Sections 4-6 describe in detail the services each of them provide. Annexes provide additional background on tsunamis, earthquake source characterizations, message interpretation and emergency response, sea level measurements, travel time calculations and wave forecasting.

The Guide's primary purpose is to provide a summary of the operational procedures of the Centers, an overview of the seismic and sea level monitoring networks used by the Centers, the criteria for issuing tsunami messages, and the methods by which messages are sent.

The three international Centres work closely together to ensure the timely delivery of tsunami messages with consistent information. The analyses and evaluations provided by the Centers, while performed using slightly different methods and data networks, are usually very similar. It is recommended, however, that when discrepancies do occur the responsible national agencies should assume the more conservative case in making their decisions regarding life safety.

Tsunami messages from the Centers are sent to the official PTWS Tsunami Warning Focal Points (TWFPs) of each country, as submitted to the Intergovernmental Oceonographic Commission. Designation of official Tsunami Warning Focal Point(s) and a single authority within each country for the dissemination of information is essential to avoid any confusion that could result if conflicting information is disseminated from multiple authorities.

(IOC/2009/TS/87)

TABLE OF CONTENTS

page

page

page

page

page

SECTION 1 - INTRODUCTION

1.1 OBJECTIVE

The primary purpose of the Users Guide for the Pacific Tsunami Warning and Mitigation System (PTWS), formerly called the Communications Plan for the Tsunami Warning System in the Pacific, is to serve as a reference document for national Tsunami Warning Focal Points (TWFPs) who are receiving the messages provided by the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC), the West Coast / Alaska Tsunami Warning Center (WC/ATWC), and the Japan Meteorological Agency Northwest Pacific Tsunami Advisory Center (JMA NWPTAC). The Guide includes a summary of the operational procedures, monitoring and detection data networks that are used by the warning centers, the criteria for the reporting and issuing of tsunami information messages, the recipients of the information, and the methods by which the messages are sent.

Section 1 provides background information on the objectives and purposes of the Guide. Section 2 describes the administrative procedures, including contacts points of the IOC Tsunami Co-ordination Unit, ITIC, and the PTWS international tsunami centers, and how to subscribe to bulletins from those centers through the designation of Tsunami Warning Focal Points. Section 3 provides an overview of the PTWS Tsunami Advisory Centers, including brief explanations on the global seismographic network, the PTWS sea level network, communications tests, and methods of alert dissemination. Sections 4-6 describes in detail the bulletins and operations of the PTWC, WC/ATWC, and JMA NWPTAC, respectively. This includes criteria for bulletin issuance, definitions of products, meanings of words used in bulletins, templates of bulletins, sample messages and the communication means by which customers can receive the products.

The Users Guide contains a number of Annexes that provide background information to assist customers in understanding the products that are issued. Annex I provides information on the science of tsunamis and earthquakes. Annex II provides information on earthquake source characterization, including hypocentral determination, magnitude estimation and seismological observatory practice. Annex III provides information on how to interpret message products for emergency response and public safety. Annex IV gives guidance on the how tsunami sea level measurements are made and what terms are used to describe the different measurements. Annex V describes how travel time calculation is carried out, their accuracy, and how estimated and observed arrival times are reported. Annex VI describes wave forecasting methods, and how these information are used and interpreted. Annex VI gives a glossary of common terms associated with tsunami warnings.

1.2 INTERNATIONAL COORDINATION

In order to maintain consistency of terminology, Member States through the UNESCO Intergovernmental Oceanographic Commission (IOC) have established for each TWS Intergovernmental Coordination Groups (ICG) that use the following terms of reference to describe, at the national level, the points of contact for international coordination of tsunami warning and mitigation:

Tsunami National Contact (TNC)
The person designated by a Member State to an Intergovernmental Coordination Group (ICG) to represent his/her country in the coordination of international tsunami warning and mitigation activities. The person is part of the main stakeholders of the national tsunami warning and mitigation system. The person may be the Tsunami Warning Focal Point, from the national disaster management organization, from a technical or scientific institution, or from another agency with tsunami warning and mitigation responsibilities.

Tsunami Warning Focal Point (TWFP)

The 7x24 contact person, or other official point of contact or address, is available at the national level for rapidly receiving and issuing tsunami event information (such as warnings). The Tsunami Warning Focal Point either is the emergency authority (civil defense or other designated agency responsible for public safety), or has the responsibility of notifying the emergency authority of the event characteristics (earthquake and/or tsunami), in accordance with national standard operating procedures. The Tsunami Warning Focal Point receives international tsunami warnings from the PTWC, WC/ATWC, the JMA NWPTAC, or other regional warning centers.

1.3 TSUNAMI WARNING CENTERS – AN OVERVIEW

The mission of a Tsunami Warning Center (TWC) is to provide early warnings on potentially destructive tsunamis. It provides this information to emergency officials, and as appropriate, directly to the public. In order to carry out its mission, the TWC uses local and global seismographic networks transmitting seismograms in real-time to continuously monitor seismicity in order to locate and size potentially tsunamigenic earthquakes. Earthquakes are the primary cause of tsunamis. TWC also use sea level networks reporting data in real and near real-time to verify the generation and evaluate the severity of a tsunami. TWC then disseminate tsunami advisory and warning messages to designated national or local authorities for their subsequent action. TWC must respond fast, be as accurate as possible, and be reliable in order to be effective.

For a local tsunami, a TWC should respond within minutes (e.g., issues alerts within 2-5 minutes). For a distant tsunami, a TWC should respond within 10-20 minutes of the earthquake's occurrence. TWCs acquire data and disseminate advisory messages through multiple communications paths and should have redundant and backup methods and services in case of primary service failures. Routine communications tests are carried out to ensure that telecommunications lines are working. A TWC should provide a Users Guide for customers who will receive, and have to interpret and take action based on the TWC advisories. The Pacific TWS Users Guide provides information on the international services.

When a large earthquake occurs, the TWC personnel determine the earthquake's hypocenter, the initial rupture point of the earthquake, and its magnitude. If the hypocenter is under or near the ocean and not too deep within the earth, and if the magnitude is sufficiently large, then tsunami generation is possible. On the basis of this seismic evidence, the Center issues a local tsunami warning or advisory to areas located near the epicenter. A regional (sometimes ocean-wide, if the earthquake is significantly large) tsunami watch or advisory is also issued to areas located further from the epicenter if the magnitude is so large that there is the possibility of a long-range destructive tsunami. All remaining areas may also be notified that an event has occurred. The initial bulletin tells participants that an earthquake has occurred, where and when it occurred, and that a destructive tsunami is possible. For a local tsunami warning, the advisory may suggest immediate evacuation inland and to higher ground, or to clear the beach, since waves are imminent.

The first indication of a tsunami usually comes from the sea level stations located nearest the earthquake. In the case of local tsunamis, close-by stations can confirm a tsunami within minutes, but at a regional scale, confirmation may take 1-2 hours if sea level stations are not near to the source area. Fortunately, most large earthquakes with tsunamigenic potential do not generate long-range destructive tsunamis and the warning and watch will be cancelled. But if confirmation of a potentially destructive, long-range tsunami is received, a regional TWC will issue an ocean-wide tsunami warning to advise designated national authorities. This message alerts all warning system participants to the approach of potentially destructive tsunami waves and provides estimated tsunami arrival times for key locations. Because tsunamis move through the water in accordance with known physical laws, estimated arrival times can be quickly computed. Tsunami wave forecasts, or estimated wave heights may also be included if there is enough data and the model results are judged by TWC staff to be reasonable. Typically, during a tsunami event, bulletins containing updated information are issued as necessary, until the tsunami has crossed the entire ocean or additional evidence is received to indicate there is no further tsunami threat.

Messages are disseminated in accordance with procedures outlined in the Users Guide for the Tsunami Warning and Mitigation System area of coverage (such as the Caribbean, Indian Ocean, Mediterranean and North Atlantic, and Pacific). Emergency authorities have the responsibility for immediately interpreting the science-based alerts issued by the TWC (international, regional, national, and/or local), and quickly disseminating safety information to the public on what to do. They also have the ongoing responsibility for educating the public concerning the dangers of tsunamis and for developing safety measures to be taken to avoid the loss of life and reduce property damage.

Current operational weaknesses of tsunami warning centers include an inability to detect landslide and volcanic sources, and an inability to provide early-enough warnings for local tsunamis. Additionally, to ensure public safety and provide the fastest early warning to allow the greatest preparation time, TWCs issue advisory warnings for a potentially destructive tsunami based only on earthquake information, and then will cancel a warning as soon as sea level information confirms non-destructive waves. This practice may reduce the credibility of the TWC for issuing warnings because the public may erroneously view the alert to be a false alarm.

SECTION 2 - ADMINISTRATIVE PROCEDURES

This section contains information on the administrative arrangements of the Pacific Tsunami Warning System, including the responsible organizations coordinating and providing timely international advisories, and how countries can subscribe to the services through the official designation of Tsunami Warning Focal Points.

2.1 COORDINATION, FACILITATION AND CAPACITY STRENGTHENING ENTITIES OF THE PTWS

2.1.1 UNESCO Intergovernmental Oceanographic Commission (IOC)

Under the IOC of UNESCO, participating countries in the Pacific Ocean and adjacent marginal seas are organized as the Intergovernmental Co-ordination Group for the PTWS (ICG/PTWS). Annex I to this section provides a summary of the PTWS organizational and governance structure.

The ICG/PTWS was established by IOC Resolution IV-6 in 1965 as a subsidiary body of the IOC, and has met every two years since 1968. As a regional body, the ICG is comprised of Member States in the Pacific, with other countries outside the region and organizations considered Observers. Each Member State is represented by a Tsunami National Contact (TNC) who serves as the intergovernmental contact person for the coordination of international tsunami warning and mitigation activities. Within each country, a Tsunami Warning Focal Point (TWFP) either is the emergency authority (civil defense or other designated agency responsible for public safety), or has the responsibility of notifying the emergency authority of the event characteristics (earthquake and/or tsunami), in accordance with national standard operating procedures. TNC and TWFP designation shall follow formal official procedures as describe in Section 2.3.

2.1.2 IOC Tsunami Co-ordination Unit (TCU)

The IOC Tsunami Co-ordination Unit (TCU) provides global coordination of tsunami warning and mitigation systems, including those in the Pacific and Indian Oceans, Caribbean and adjacent seas, and North-eastern Atlantic and Mediterranean and interconnected seas. The TCU is based at the IOC Secretariat in Paris, France, and is composed of the Unit Head, the Secretariats of the ICGs, the ITIC, and technical and professional staff.

Contact information for the Head of the IOC TCU is:

Dr. Peter Koltermann
Head, IOC TCU
1 Rue Miollis
75732 Paris Cedex 15
FRANCE
Tel: +33 1 45 68 40 15
Fax: +33 1 45 68 58 10,
E-mail: p.koltermann@unesco.org

2.1.3 International Tsunami Information Center (ITIC)

The IOC International Tsunami Information Center (ITIC) is located in Honolulu, Hawaii, United States of America

The ITIC was established in 1965 by the IOC under Resolution IOC/IV.6. It is hosted by the United States of America Department of Commerce, National Oceanic and Atmospheric Administration National Weather Service (US NOAA NWS) Pacific Region, which provides its Director and staff. Chile Servicio Hidrografico y Oceanografico de la Armada de Chile (SHOA, Naval Hydrographic & Oceanographic Service of the Armada of Chile) has provided the ITIC Associate Director since 1998. The JMA is providing one technical professional staff since 2007.

The ITIC works to strengthen national and regional capacities and assist countries in establishing tsunami warning and mitigation systems that will mitigate the effects of tsunamis. ITIC has been mandated to (Resolution IOC/X.23) :

- Monitoring international tsunami warning activities in the Pacific and other oceans, and recommending improvements in communications, data networks, acquisition and processing, tsunami forecasting methods, and information dissemination;
- Bringing to countries information on tsunami warning and mitigation systems (TWS), on the affairs of IOC and ITIC, and on how to become active participants in the TWS;
- Assisting countries in the establishment of national and regional warning and mitigation systems, and the reduction of tsunami risk through comprehensive mitigation programmes in risk assessment, warning guidance and emergency response, preparedness, education and awareness;
- Acting as a technical and information resource for the fostering of research and its application to prevent loss of life and minimize damage to property, and for the development, publication, and distribution of educational and preparedness materials on tsunamis and tsunami hazards;
- Acting as an information resource on tsunami events, cooperating with the World Data Center for Solid Earth Geophysics – Tsunamis to collect and make available through appropriate channels all records pertaining to tsunami events, and assisting national authorities in making investigations of all aspects of major tsunamis, including the development of standard survey procedures for such investigations.

The contact information for IOC/ITIC is:

Dr. Laura Kong
Director, International Tsunami Information Center
737 Bishop Street, Suite 2200
Honolulu, Hawaii 96813
U.S.A.
Tel: +1 808 532 6422
Fax: +1 808 532 5576
E-mail: ptws.tsunami@unesco.org, itic.tsunami@unesco.org
URL: http://ioc3.unesco.org/ptws, http://www.tsunamiwave.info

2.2 PTWS OPERATIONS: INTERNATIONAL TSUNAMI WARNING CENTERS

The U.S. National Oceanic and Atmospheric Administration's (NOAA) Pacific Tsunami Warning Center (PTWC), the NOAA West Coast /Alaska Tsunami Warning Center (WC/ATWC), and the Japan Meteorological Agency (JMA) Northwest Pacific Tsunami Advisory Center (NWPTAC) are the operational tsunami warning centers providing international services for the PTWS.

2.2.1 United States of America

The U.S. Department of Commerce, National Oceanic and Atmospheric Administration National Weather Service operates and administers the tsunami warning centers for the U.S. These are the Pacific Tsunami Warning Center in Ewa Beach, Hawaii and the West Coast / Alaska Tsunami Warning Center in Palmer, Alaska. U.S. tsunami warning operations are the responsibility of the Tsunami Program Operations Leader (TPOL) who is the Director, NWS Pacific Region, in Honolulu, Hawaii. Tsunami warning center operations are described by US NOAA NWS Directives, NDS 10-7 Tsunami Warning Services (http://www.weather.gov/directives/010/010.htm).

The contact information for the TPOL is:

Mr. Jeff LaDouce, Director
NWS Pacific Region
737 Bishop Street, Suite 2200
Honolulu, Hawaii 96813
U.S.A.
Phone: 1-808-532-6416
Fax: 1-808-532-5569

Pacific Tsunami Warning Center

The PTWC started in 1949 following an unwarned tsunami from Alaska in 1946 that killed 159 people in Hawaii. It is administratively part of the NOAA NWS Pacific Region. Its mission responsibilities include serving as the:

- International Tsunami Warning Center for the PTWS, and headquarters and coordinator of warning center activities in the Pacific;
- Tsunami Warning Center for all US national interests in the Pacific outside of Alaska and the US West Coast;
- Hawaii Regional Tsunami Warning Center;
- Interim Tsunami Watch Provider for the Indian Ocean (along with JMA);
- Interim Tsunami Warning Center for the South China Sea (along with JMA NWPTAC)
- Interim Tsunami Watch Provider for the Caribbean and adjacent regions.

The contact information for PTWC is:

Dr. Charles McCreery, Director
Pacific Tsunami Warning Center
91-270 Fort Weaver Road
Ewa Beach, Hawaii 96706
U.S.A.
Phone: 1-808-689-8207
Fax: 1-808-689-4543
Email: ptwc@ptwc.noaa.gov
URL : http://www.prh.noaa.gov/ptwc

West Coast / Alaska Tsunami Warning Center

The WC/ATWC started in 1967 after 1964 Alaska earthquake as the warning center for Alaska. It expanded to include the west coast of North America in 1982, and to all coasts of North America in 2005. It is administratively part of the NOAA NWS Alaska Region. Its mission responsibilities include serving as the:

- US Tsunami Warning Center for all US states except Hawaii
- US and International Tsunami Warning Center for Puerto Rico and Virgin Islands
- International Tsunami Warning Center for Canada

The contact information for WC/ATWC is:

Mr. Paul Whitmore, Director
West Coast / Alaska Tsunami Warning Center
910 Felton St.
Palmer, AK 99645
U.S.A.
Phone: +1-907-745-4212
Fax: +1-907-745-6071
Email: wcatwc@noaa.gov
URL : http://wcatwc.arh.noaa.gov/

2.2.2 Japan.

The Ministry of Land, Infrastructure and Transport of Japan oversees the Japan Meteorological Agency that operates and administers the tsunami warning programme for Japan.

Japan Meteorological Agency

The Director of the Earthquake and Tsunami Observations Division within the Seismological and Volcanological Department of JMA administers the Tsunami Warning Center in Japan. The JMA National Center in Tokyo has mission responsibility as:

- National tsunami warning center (started in 1952),
- International Advisory service for the Northwest Pacific (through the NWPTAC, since 2005)
- Interim Tsunami Watch Provider for the Indian Ocean (with USA PTWC, since 2005);
- Interim Tsunami Advisory Center for the South China Sea as part of the expanded coverage of the NWPTAC (with USA PTWC, since 2006)

The contact information for the JMA Tsunami Warning Center is:

Mr. Yohei Hasegawa
Senior Coordinator for International Earthquake and Tsunami Information
Seismological and Volcanological Department
Japan Meteorological Agency (JMA)
1-3-4 Otemachi, Chiyoda-ku, Tokyo 100-8122, JAPAN
Phone: +81-3-3284-1743
Fax: +81-3-3215-2963
Email: yhasegawa@met.kishou.go.jp
URL : http://www.jma.go.jp/jma/indexe.html

2.3 USERS GUIDE RESPONSIBILITIES

The PTWC, WC/ATWC, JMA, and ITIC are responsible for the preparation and revision of the PTWS Users Guide. The PTWS Secretariat is responsible for the dissemination of the PTWS Users Guide and the issuance of changes thereto. All changes and comments concerning the Users Guide should be submitted to the ICG/PTWS Secretariat for inclusion in the next revision to the Users Guide. Copies of the Users Guide may be obtained from the PTWS Secretariat or from the PTWS web site http://ioc3.unesco.org/ptws

The following organizations should maintain up-to-date copies of the Users Guide: Tsunami Warning Focal Points and all designated operational contact points for receiving international tsunami bulletins; PTWC, WC/ATWC, JMA, ITIC; IOC Tsunami Co-ordination Unit, Paris; Tsunami National Contacts; communication centers serving the above; and others who have a demonstrable need for the Guide.

2.4 TNC AND TWFP DESIGNATION

Participation in the PTWS and its ICG is through each UNESCO and/or IOC Member State's designated Tsunami National Contact (TNC). International tsunami message services provided by PTWC, WC/ATWC and JMA are available to each UNESCO and/or IOC Member State through their officially designated national Tsunami Warning Focal Point (TWFP). Designation of the TNCs and TWFPs and corresponding updates should be communicated in writing using the IOC Tsunami National Contact Form and IOC Tsunami Warning Focal Point Form, respectively, attached in Annex II of this section.

UNESCO and/or IOC Member States shall forward to the ADG/IOC (Assistant Director General), IOC Executive Secretary, designations for Tsunami Warning Focal Points through one of the following channels:

1. Minister of Foreign Affairs.
2. Head of UNESCO National Commission.
3. Permanent Delegate to UNESCO
4. Head of the specified national coordinating body for liaison with the Commission ("IOC Focal Point"). UNESCO/IOC shall request validation through either the Permanent Delegate to UNESCO, the Head of the UNESCO National Commission or the Minister of Foreign Affairs.

Updates to TWFP lists involving a change in agency designation shall follow the same procedures as described above.

Updates of only TNC or TWFP contact information (i.e., name of person, phone, email, fax) shall be communicated by the present TNC or TWFP to the IOC.

Upon receipt and confirmation, the IOC will inform the international tsunami warning centers through the ICG/PTWS Secretariat to officially include the TWFP dissemination in their customer list.

ANNEX I: ICG/PTWS ORGANIZATIONAL STRUCTURE AND GOVERNANCE

ICG/PTWS Organizational Structure and Governance

The ICG/PTWS (formerly ITSU) is a subsidiary body of the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). It has been in operation since 1965, and is currently comprised of 30 Pacific Member States who have officially designated Tsunami National Contacts (TNC) and Tsunami Warning Focal Points (TWFP). The ICG/PTWS coordinates international tsunami warning and mitigation activities, including the issuance of timely and understandable warnings in the Pacific. Comprehensive tsunami mitigation programmes require complementary and sustained activities in tsunami hazard risk assessment, tsunami warning and emergency response, and preparedness. Stakeholder involvement and coordination is essential, and community-based, people-centered mitigation activities will help to build tsunami resiliency.

Information sheets on the PTWS and the ITIC can be downloaded from http://ioc3.unesco.org/ptws/ptws_structure.php

The following describes the various components of the ICG and how they work together to enable an effective international warning system.

Intergovernmental Coordination Group (ICG)

The ICG is an IOC subsidiary body that reports to the IOC Assembly or Executive Council. The ICG/ITSU was established by IOC Resolution IV-6 in 1965 as a regional international body, and has met every two years since 1968. The ICG/ITSU renamed itself to be the ICG/PTWS intergovernmental body in 2005 through Resolution IOC/ITSU-XX.3 endorsed by IOC/EC-XXXIX.8.

Official delegates to the ICG represent member states' interests in the ICG. The ICG activities are member state driven according to the needs of the region taking the advice of experts contributing to Working Groups and other tertiary bodies. As a regional subsidiary body, the ICG Terms of Reference specify that it is comprised of Member States in that region. Other countries outside the region, and organizations are considered Observers to the ICG.

In addition to the Pacific, TWS were formally established in 2005 for the Caribbean (ICG/CARIBE-EWS), Indian Ocean (ICG/IOTWS), and North East Atlantic and Mediterranean and Connected Seas (ICG/NEAMTWS), and have met frequently starting in 2005. The development of these systems is based on a basin-focused strategy and approach that considers the characteristics of the region and the communities at risk. It acknowledges a region's unique oceanographic, geophysical, technical, educational, cultural, and political interests.

ICG/PTWS Officers

PTWS leadership is guided by member state's elected Officers (Chairperson, 2 Vice-Chairpersons) along with the members of the Steering Committee composed by the elected Officers (Chair and Vice Chairs), the current intersessional Working Group Chairs and other members representatives by invitation. The Steering Committee meets during the inter-sessional period to review progress, identify new priorities, and plan for the upcoming ICG.

ICG Working Groups

PTWS work is enabled through Working Groups (WG). Intra-sessional (or sessional) WGs work during an ICG and report back to the ICG in which they were established. Inter-sessional WGs work between ICGs and report at the next ICG. Inter-sessional WGs may decide to meet, or may carry their work out through e-mail, teleconferences, in-person meetings, or other means. Terms of Reference for WGs are stated through Recommendations endorsed by the

ICG. The Recommendation may also state the WG members. A WG Chair may be designated by the ICG, or elected by WG members. The Chair provides leadership for the WG and is responsible for written reports summarizing its work. Working Group members are nominated by Member States according to their individual abilities to contribute to the tasks of the WG. A WG should dissolve after its tasks have been completed.

Member States / Tsunami National Contacts (TNC)
Each Member State is represented by a Tsunami National Contact that serves as the ICG contact and the country's coordinator of its international tsunami warning and mitigation activities. The person is usually part of the main stakeholders of the national tsunami warning and mitigation system programme.

Tsunami Warning Focal Point (TWFP)
The 7x24 contact person, or other official point of contact or address, is designated by an ICG member state for rapidly receiving and issuing tsunami event information (such as warnings). The Tsunami Warning Focal Point has the responsibility of notifying the emergency authority (civil defense or other designated agency responsible for public safety) of the event characteristics (earthquake and/or tsunami), in accordance with the procedures of the Tsunami Response Plan. The Tsunami Warning Focal Point receives international tsunami warnings from the PTWC, WC/ATWC, JMA NWPTAC, or other regional warning centers.

TNC and TWFP for each country are officially-designated through high-level processes.

Tsunami Co-ordination Unit (TCU)- IOC Secretariat
The IOC TCU presently coordinates the four tsunami warning and mitigation systems and works to identify the commonalities in terms of specifications, guidelines, standards, procedures and processes including developing synergies with existing technical groups dealing with related matters. The TCU as part of the IOC Secretariat is based in Paris, France, and composed of the Unit Head, the Secretariats of the ICGs, the ITIC, and technical and professional staff. The TCU provides guidance for the final integration of ICG's basin-driven work that occurs at the IOC Governing Bodies level.

ICG/PTWS Secretariat
The IOC Executive Secretary provides, upon request by the IOC governing bodies, secretarial support for the ICG. The PTWS Technical Secretary coordinates and facilitates the activities of the ICG interacting directly with Member States and regional organizations, oversees in coordination with the PTWS Officers the arrangement, conduct, and reporting of the ICG's sessions and other meetings, and facilitates the ICG's Action Plan working with Member State Tsunami National Contacts for overall international activities, with Tsunami Warning Focal Points for issues directly related to tsunami alerts and warnings, and with the international warning centers (PTWC, WC/ATWC, JMA) and the ITIC. The PTWS Technical Secretary is part of the IOC's Tsunami Co-ordination Unit

International Tsunami Information Center (ITIC)
The ITIC serves as the operational capacity building and system implementation center assisting all PTWS Member States to develop new or strengthen existing national and sub-regional warning and mitigation systems. ITIC information services cover warning center operations, training and technology transfer, education and public awareness, mitigation and countermeasures, historical tsunami catalogues and post-tsunami surveys.

Pacific Tsunami Warning Center (PTWC)
The PTWC serves as the international operational tsunami warning headquarters for the PTWS. Sub-regional centers in Alaska (WC/ATWC), USA and Japan (NWPTAC) work closely with the PTWC. The centers issue timely tsunami alerts to designated national authorities who then take action to protect their populations.

IOC decisions on PTWS
PTWS Resolutions and Recommendations are developed by Member States in coordination with the Secretariat. These are reported to the next IOC Governing Body for endorsement and official adoption

Cooperation with other organizations
The PTWS, through its ITIC, PTWC and the ICG/PTWS Secretariat, has established many cooperations with international agencies in order to support, sustain, and coordinate its operational tsunami warning and mitigation system. The PTWS's goal is to save lives and property, and as such, seeks to work in partnership with all appropriate agencies. The IOC's United Nations partners include, for example, the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), the International Strategy for Disaster Reduction (ISDR), the United Nations Development Programme (UNDP) and the World Meteorological Organization (WMO). Specialized and regional organizations include the International Union of Geodesy and Geophysics Tsunami Commission (IUGG-TC), Pacific Applied Geosciences Council (SOPAC), Pacific Regional Environmental Programme (SPREP), Association of Southeast Asian Nations (ASEAN), and Centro de Coordinación de la Prevención de Desastres Naturales en América Central (CEPREDENAC).

PTWS Users Guide (formerly Communications Plan)
The Guide is intended for use by National Tsunami Warning Focal Points as customers receiving the advisories from the (interim) tsunami warning centers. It includes a summary of the operational procedures, instrument networks used, criteria for the reporting and issuing of tsunami alerts, recipients of the information, and the methods for message transmission, as well as a number of Annexes that provide explanatory and background information on technical evaluation methods and other guidance in order to assist customers in understanding the products that are issued. The Users Guide is updated at least annually, and will next be updated in August 2007.

ANNEX II: TWFP AND TNC FORMS

UNESCO IOC
7/24 TSUNAMI WARNING FOCAL POINT (TWFP) FORM

Note that more than one contact point may be designated using a new Form for each

Name of Country ____

Place in Country * ____
**Only if this Contact Point is not for the entire country's coast. For example, a remote island.*

Do you agree to share your TWFP information with other TWFP contacts? Yes ____ No ____

1. **Tsunami Warning Focal Point for receiving Tsunami Bulletins**

The Tsunami Warning Focal Point (TWFP) is a 7x24 contact person, or other official point of contact or address, designated by a government for receiving and issuing tsunami event information. The TWFP receives international tsunami information from the PTWC, NWPTAC, WC/ATWC, or other regional warning centers. It then has the responsibility of notifying the emergency authority of the event characteristics (earthquake and/or tsunami).

The TWFP contact information requires 7x24 telephone, facsimile, or e-mail information. It represents who should be contacted for clarification concerning the designated communication method, or who will be contacted in an emergency if all designated communication methods fail.

Agency name ____

Contact Person in Agency or Officer in Charge:

Name ____

Position ____

Telephone Number ____

Fax ____

Cellular Telephone Number ____

E-mail Address: ____

Postal Address ____

____

____

2. Designated Communication Method Information (operational on 7/24 basis).

Please specify GTS (WMO-Global Telecommunication System), AFTN (Aeronautical Fixed Telecommunications Network), Fax, or E-mail in a priority order. Note that bulletins from JMA are not available by AFTN. Please recognize that Fax and E-mail alone are not the timeliest and should not be used as the primary means. Also include with the international 4-letter GTS

Location Indicators used in the abbreviated headings, the 8-letter AFTN Address Indicator, the Fax number, or the E-mail address, respectively. For GTS Location Indicators see http://www.wmo.int/web/www/ois/Operational_Information/VolumeC1/VolC1.html. The AFTN Address Indicators are found in ICAO (International Civil Aviation Organization) Documents 7910 and 8585, and consist of a 4-letter location indicator and 4-letter type-of-operations indicator. In general, the GTS and AFTN dedicated, private communication methods guarantee timely receipt of bulletins within several minutes, whereas Facsimile and E-mail may incur delays of tens of minutes during peak usage times. Note that while all dissemination methods designated below will be made simultaneously by the issuing centers, but bulletins may reach their destinations at different times depending on the communication method.

Primary: ____

Alternate 1: ____

Alternate 2: ____

Alternate 3: ____

Alternate 4: ____

Alternate 5: ____

Please specify telephone number for voice communication, in a priority order. In general, due to language barriers, the operational warning centers do not use voice communication as the primary means of warning dissemination, but as a backup or for confirmation when urgently needed of message receipt through the above means.

Primary:

Alternate 1: ______________________________

Alternate 2: ______________________________

Alternate 3: ______________________________

3. Comments: ____

____

____

Date:____________________ Submitted by: ______________________________

UNESCO IOC
TSUNAMI NATIONAL CONTACT (TNC) FORM

Note that more than one contact point may be designated using a new Form for each

Name of Country ____

Tsunami National Contact

The person designated by an ICG Member State government to represent his/her country in the coordination of international tsunami warning and mitigation activities.

Agency name ____

Contact Person in Agency or Officer in Charge:

Name ____

Position ____

Telephone Number ____

Fax ____

Cellular Telephone Number ____

E-mail Address: ____

Postal Address ____

____

____

Comments: ____

____

____

Date:____________________ Submitted by: ______________________________

SECTION 3 - PTWS OPERATIONS

3.1 INTRODUCTION

One of the most important activities of the ICG/PTWS is to ensure the timely issuance of tsunami warnings to threatened coastal areas of the Pacific. The international operational Centers of the PTWS provide tsunami information and warnings to officially designated Tsunami Warning Focal Points of the countries of the PTWS. The Centers continuously monitor the Pacific region in order to detect and locate major earthquakes, determine whether they have generated tsunami waves, and forecast the tsunami threat based on all available data. When such an event occurs, the Centers provide timely and effective tsunami information and warnings for coastal communities in the Pacific to minimize the hazards of tsunamis, especially to human life and welfare.

3.2 GENERAL DESCRIPTION

International warning operations of the PTWS require the participation of many seismic, sea level, analysis, communication, and dissemination facilities operated by many nations throughout the Pacific Region. To achieve its objective, the Pacific TWS continuously monitors the seismic and sea level activity of the Pacific Basin and disseminates timely tsunami threat information.

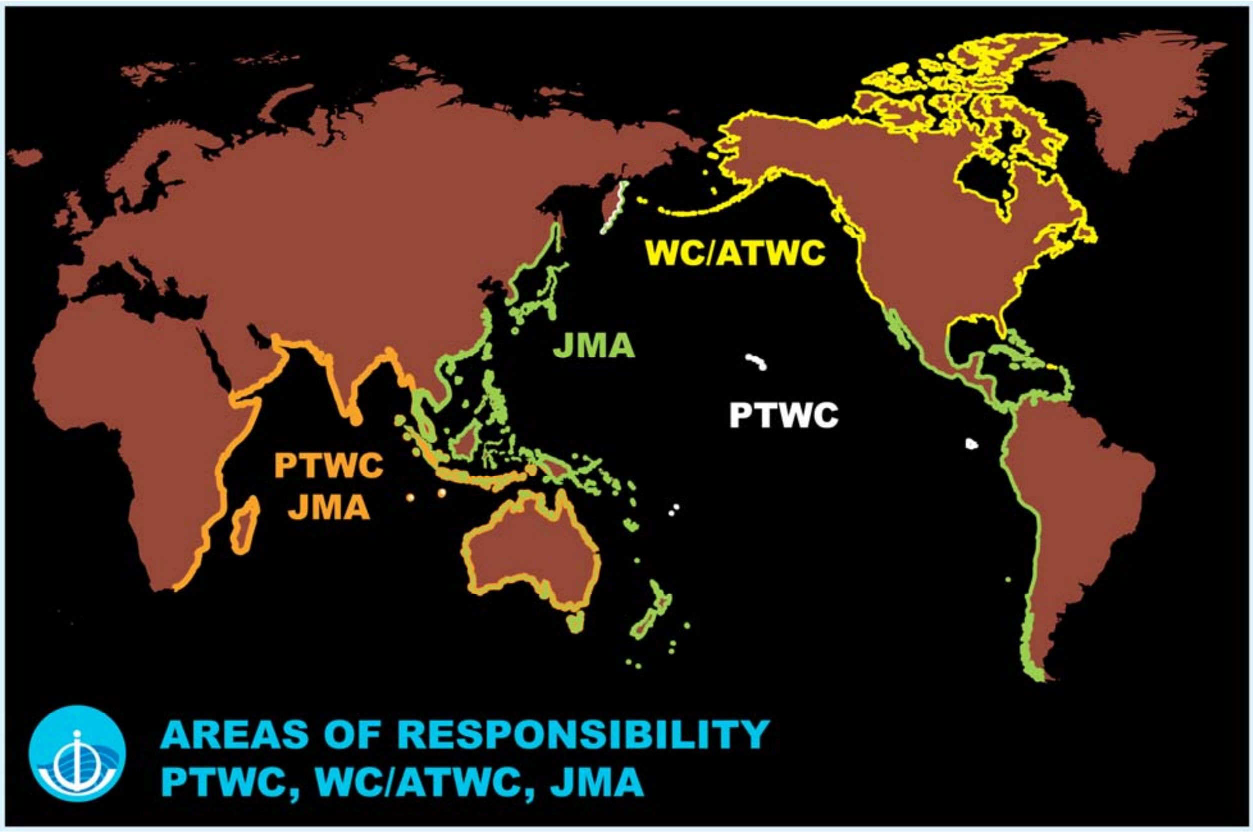
The Pacific Tsunami Warning Center serves as the operational center for the PTWS; sub-regional Centers in Japan and Alaska work with PTWC to provide international warnings and advisories for the Pacific and its marginal seas. The international Tsunami Warning Centers (TWC) collect and evaluate data provided by participating countries, and issue appropriate bulletins to both participants and other nations, states or dependencies within or bordering the Pacific Ocean basin regarding the occurrence of a major earthquake and possible or confirmed tsunami generation. The messages are advisories to national authorities, as each country is individually responsible for issuing warnings and public safety information to its own population.

In some areas of the Pacific Basin national or local tsunami warning systems function to provide timely and effective tsunami information and warnings to affected populations. For those coastal areas nearest the tsunami source region, the need for very rapid data analyses and communication is obvious. Because the seismic and sea level data utilized by international TWCs are from a relatively sparse Pacific-wide network, international advisories are not timely for areas where the tsunami can strike within minutes of being generated. To provide early warning within the first minutes after generation for tsunamis in the local area, or to provide independent tsunami evaluation capabilities, national local warning systems have been established. In general, these tsunami warning systems require dense seismographic and sea level networks to quickly detect and characterize the event and to issue the earliest of warnings.

National Tsunami Warning Centers, acting as local warning systems, are active in a number of countries. The oldest are in the Russian Federation (Sakhalin and Kamchatka Tsunami Warning Centers started after the 1952 Kamchatka tsunami), in Chile (Servicio Hidrográfico y Oceanográfico de la Armada de Chile (SHOA) Sistema Nacional de Alarma de Maremotos (SNAM), started in 1964 after the 1960 Chilean tsunami), and in Tahiti, France (Centre Polynésien de Prévention des Tsunamis (CPPT) started in 1965 after the 1964 Alaska tsunami and providing tsunami warnings for French Polynesia which encompasses a large geographic area of the south Pacific).

3.3 AREAS OF RESPONSIBILITY

The areas of responsibility of the PTWC, WC/ATWC, and JMA NWPTAC are summarized in the figure below. To ensure consistency and minimize confusion to customers, the TWC will coordinate prior to official bulletin issuance and through agreed-upon rules of procedures on which TWC provides the authoritative earthquake source information, will use identical earthquake parameters in their respective bulletins.



3.4 OPERATIONAL PROCEDURES

Functioning of the system begins with the detection of an earthquake of sufficient size to trigger an alarm at the TWC. Generally, this will occur within a few minutes of the occurrence of any earthquake in the Pacific region with a magnitude above about 5.0. Duty personnel respond immediately and begin their analysis of the event. The TWC are staffed on a 7x24 basis to be able to immediately respond. The analysis includes automatic and interactive processes for determining the earthquake's epicenter, depth, and origin time, as well as its magnitude. Based on these parameters, a decision is made concerning further action. If a warning is issued, subsequent bulletins are issued at least hourly that provide additional information and, because the tsunami is propagating outward from the epicenter.

A general summary of the criteria used by PTWC, WC/ATWC, and NWPTAC for the issuance of bulletins is given below. For details on the specific bulletin types, please refer to the chapters on each TWC in this guide.

CRITERIA	PTWC, WC/ATWC, NWPTAC ACTIONS
Mw greater than Alarm threshold.	PTWC, WC/ATWC: Issue an Observatory Message providing preliminary earthquake parameters NWPTAC: No bulletins issued.
Pacific region event, Mw > 6.5, but less than or equal to 7.5. Or an earthquake that is larger but is deep inside the earth, clearly inland, or outside the Pacific Basin. * Thresholds lower for some earthquake source regions. See WC/ATWC and NWPTAC chapters for details	PTWC: Issue a Tsunami Information Bulletin, with the evaluation that a widespread destructive tsunami was not generated. WC/ATWC: Issue Information Statement for M6.5 to 7.0 NWPTAC: a. Shallow undersea Northwest Pacific event with Mw greater than 6.5, but less than or equal to 7.0: Very small possibility of destructive local tsunami b. Shallow undersea Northwest Pacific event with Mw greater than 7, but less than or equal to 7.5: Possibility of destructive local tsunami within 100 km of the epicenter
Shallow undersea Pacific Basin event, Mw > 7.5 but less than or equal to 7.8 * Thresholds lower for some earthquake source regions. See WC/ATWC, and NWPTAC chapters for details	PTWC: Issue a Regional Fixed Tsunami Warning Bulletin for coastal areas within 1000 km of the epicenter. Update hourly until sea level gauge readings confirm no further threat exists. NWPTAC: Issue an Advisory stating a possibility of destructive regional tsunami within 1000 km of the epicenter
Shallow undersea Pacific Basin event, Mw > 7.8	PTWC: Issue a Regional Expanding Tsunami Warning and Watch Bulletin putting coastal areas within 3 hours tsunami estimated time of arrival (ETA) into a Warning and areas within 3-6 hours tsunami ETA into a Watch. NWPTAC: Issue an Advisory stating a possibility of ocean-wide destructive tsunami.
Confirmed tsunami with destructive potential far from the source	PTWC: Issue a Pacific-wide Tsunami Warning Bulletin putting all coastal areas in a Warning

Whenever there is a strong tsunami threat potential, the TWC will continuously check sea level data from stations located near the epicenter for evidence of a tsunami. Based on these data and on any credible reports of tsunami wave activity from the media or national agencies, and using historical data and numerical model outputs as a reference, further evaluation of the threat is made. If a tsunami has been generated that poses a continuing threat, the current warning will continue or be expanded until there is no longer the threat of a destructive tsunami. In response to a warning or watch, national or regional authorities implement their own pre-determined procedures that include issuing evacuation instructions to coastal areas when appropriate. If sea level data indicate, however, that either a negligible or no tsunami has been generated the TWC will issue a cancellation of its previously disseminated warning. This is most often the case since most large earthquakes with the potential to generate a destructive tsunami do not actually do so.

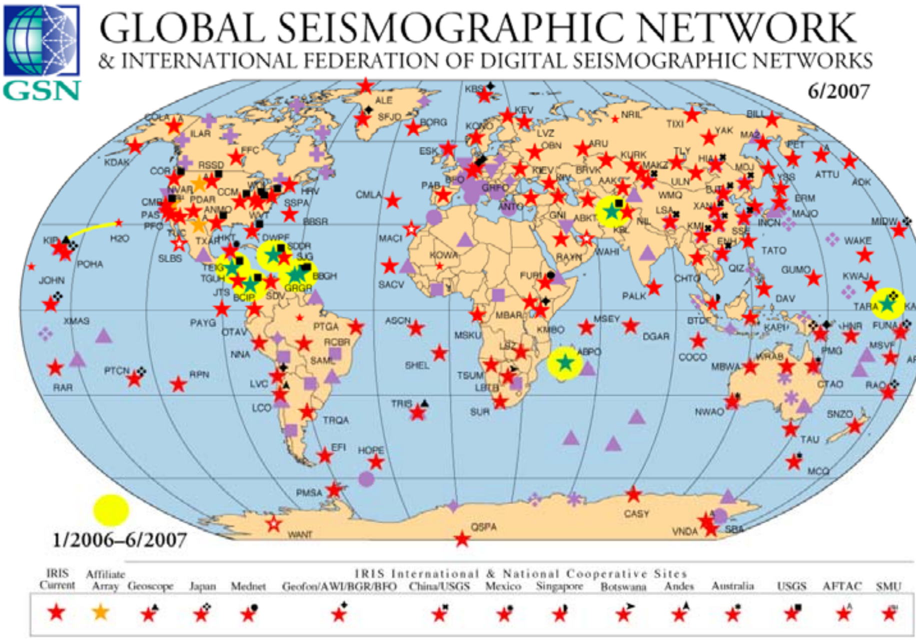
3.5 DETECTION NETWORKS

The rapid acquisition of seismic and sea level data by the international TWCs is critical for operation of the Pacific TWS.

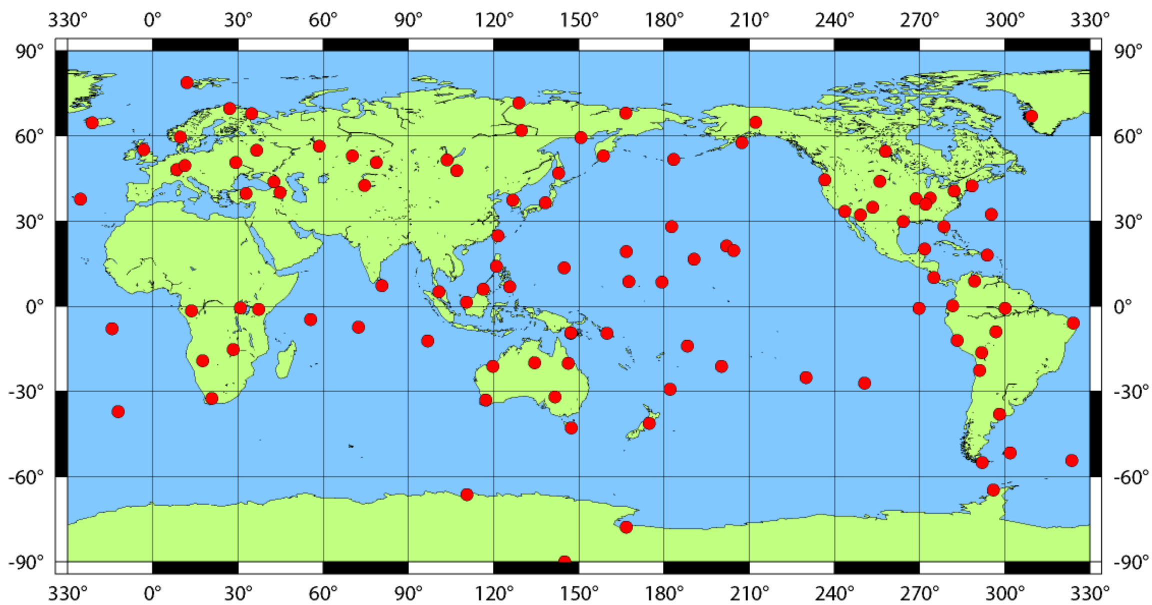
3.5.1 Seismic Networks and Analysis

SEISMIC NETWORKS

Data from seismic stations around the Pacific, primarily broadband stations, are the basis for the preliminary earthquake epicenters and magnitudes determined by the TWC. Most of these data are provided the IRIS Global Seismic Network. Data are sent in real time in the form of continuous digital waveforms using a variety of communications methods and circuits. The current network (June 2007) of the GSN is shown by the figure below.



The current network (April 2007) of the PTWC, comprising both the GSN and other US national network stations is given below. The WC/ATWC and NWPTAC use almost the same network for the determination of the hypocenter and magnitude.



SEISMIC ANALYSIS

Seismic Alarms
Seismic data streams are continually monitored by computers. Whenever a large earthquake occurs the signals it produces are detected and processed. If they meet certain criteria then the duty analysts are notified by a paging system. They typically are notified and begin their interactive analyses within a few minutes of the earthquake.

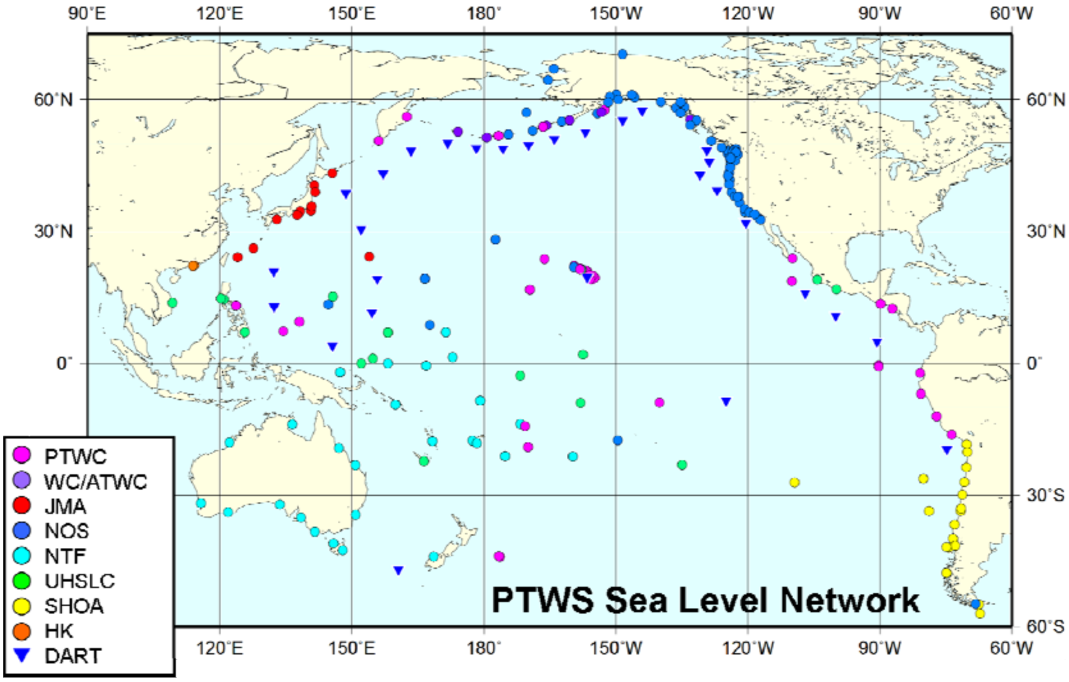
Hypocenter Determination
Earthquake hypocenters (latitude, longitude, and depth of the start of the rupture) are determined by automatic as well as interactive processes. The analyst reviews the quality of the solutions and re-determines the hypocenter with additional or corrected data as needed until an acceptable quality is achieved. The earthquake origin time is also produced by this process. For tsunamigenesis to be possible the hypocenter must be within 100 km of the earth's surface and either under the sea or very near the sea.

Magnitude Determination
Earthquake moment magnitude, Mw, is reported in bulletins. It is based on the long-period components of the seismic signal and is more accurate for very large earthquakes than the formerly used Richter magnitude. The TWCs initially compute Mw from signals of the first arriving seismic P-waves (Mwp). This methodology permits a preliminary magnitude to be determined within 5-20 minutes of the earthquake and an initial bulletin to be issued in the same time frame. A second method based on later arriving, longer period seismic waves trapped in the upper layers of the earth (Mw based on mantle magnitude) gives an independent result a few tens of minutes later. The earthquake magnitude gives an indication if it has the potential to generate a tsunami and it is used as key criteria for issuing tsunami warnings. But the tsunami waves must still be detected and measured with sea level data to accurately evaluate the tsunami threat.

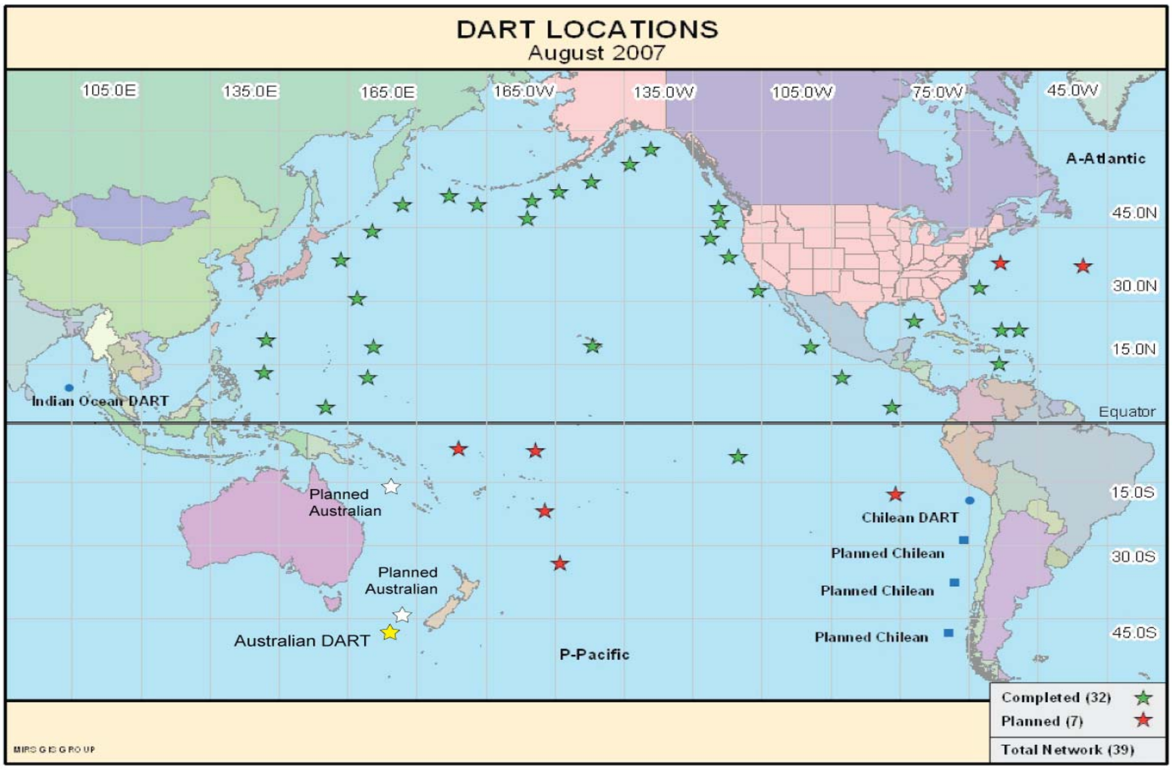
3.5.2 Sea Level Networks and Analysis

SEA LEVEL NETWORKS

Data from sea level stations around the Pacific are the basis for the detection and evaluation of tsunami waves. Coastal stations are operated by a number of countries and organizations, including the Global Sea Level Observing System (GLOSS), and are contributing their data for tsunami warning purposes. These data are being transmitted in near real-time through the WMO GTS and other dedicated communications links. Data transmission intervals range from real-time to 60-min intervals. Altogether, about 120 coastal sea level stations are received by the PTWC, with more than 50% reporting at 12-60 min intervals. In order to confirm tsunami generation faster, and to be able to improve on the accuracy of tsunami warnings, coastal sea level stations are planned to be upgraded for transmission every five minutes. The current sea level stations (August 2007) whose data are received by the international TWCs are shown in the Table attached at the end of this section, and in the map below.



In addition, PTWC receives data from ten deep-ocean stations called DARTs (Deep-ocean Assessment and Reporting of Tsunamis). Most of these stations send their data to PTWC through geostationary meteorological satellites on an hourly transmission schedule. The DART systems as well as stations on U.S. coasts operated by the National Ocean Service (NOS) have internal tsunami triggers that activate more frequent transmissions and a higher sampling rate if a tsunami is detected.



SEA LEVEL ANALYSIS

Sea Level Alarms
In general, the TWCs begin to monitor sea levels after the issuance of tsunami advisories that issue a tsunami threat concern. Within the operations center, computer screens are continuously displaying sea level data as they are received.

The Pacific DART buoys as well as the NOAA National Ocean Service (NOS) coastal gauges located in Hawaii are monitored by PTWC software for tsunami-triggered transmissions. If such transmissions are detected then PTWC duty analysts will immediately be paged. This process can provide an alert for tsunami waves from a non-seismic source such as an undersea landslide that might otherwise go undetected.

Sea Level Measurements
For any potentially tsunamigenic earthquake, estimated arrival times (ETAs) of the tsunami are computed for all sea level gauges. Gauges with the earliest ETAs are monitored as data from their scheduled or triggered transmissions arrive. If tsunami waves are observed in these data their amplitude and period (the time of one complete wave cycle) is measured by the analyst using a graphical interface. The measurements are evaluated in the context of any historical tsunami measurements as well as model predictions. Coastal gauge signals are often highly influenced by near shore effects and this must be taken into consideration. DART readings, when available, provide the truest measurement of what is crossing the ocean basin. They are therefore are the most important readings for tsunami forecasting. Selected sea level measurements may be reported in bulletins.

Tsunami Forecasting
The science of forecasting tsunami impacts is still imprecise but improving. Forecasts provided by the NWPTAC are based on pre-computed scenarios. Planned for 2008 implementation are forecast tools at the PTWC and WC/ATWC for wave forecasting using the DART data. The goal is to provide the best estimate based on all seismic and sea level data available at the time as well as any historical data. Presently, a forecasting tool developed by WC/ATWC and based on pre-run numerical models is used as a reference by the PTWC and WC/ATWC. The forecast currently provided in bulletins is very general, only indicating whether or not a destructive tsunami threat exists. Given the uncertainties involved, a conservative approach is taken that results in over-warning.

3.6 TSUNAMI BULLETINS

3.6.1 Types of Bulletins

The TWC issues several different types of messages, which contain the same information, but with slightly different formats or descriptive text. Significant coordination and agree-upon rules of authority and procedures are in place between the international TWC in order to ensure consistency in evaluation and reporting to their respective customers.

The PTWC issues international and US domestic messages. The types of international messages are:

- **Pacific-Wide Tsunami Warning Bulletin** - A warning issued to all PTWS participants after there is confirmation of tsunami waves capable of causing destruction beyond the local area.

- **Regional Expanding Tsunami Warning and Watch Bulletin** - A message based initially on only seismic information that alerts all PTWS participants of the possibility of a widely destructive tsunami.
- **Regional Fixed Tsunami Warning Bulletin** - A message based initially on only seismic information that alerts all PTWS participants of the possibility of a regional tsunami. The area placed in Tsunami Warning status encompasses coastal regions within 1000-km of the earthquake epicenter.
- **Tsunami Information Bulletin** - A message issued to advise PTWS participants of the occurrence of a major earthquake in or near the Pacific, with an evaluation that there is either: a) no widespread tsunami threat but the small possibility of a local tsunami or b) there is no tsunami threat at all.
- **Tsunami Communication Test Dummy Message** – A test message issued by PTWC at unannounced times to test the operation of the warning system

The WC/ATWC issues of messages for the US and Canada

- **Tsunami Warning:** A Tsunami Warning is issued by when a potential tsunami with significant widespread inundation is imminent or expected.
- **Tsunami Advisory:** A Tsunami Advisory is issued by the Tsunami Warning Centers due to the threat of a potential tsunami, which may produce strong currents or waves dangerous to those in or near the water.
- **Tsunami Watch:** A Tsunami Watch is issued by the Tsunami Warning Centers to alert emergency management officials and the public of an event, which may later impact the Watch area.
- **Information Statement:** An Information Statement is issued to inform emergency management officials and the public that an earthquake has occurred. In most cases, Information Statements are issued to indicate there is no threat of a destructive tsunami

The NWPTAC issues only one kind of message, the Northwest Pacific Tsunami Advisory. With the NWPTA, the following information is given:

- earthquake focal parameters
- earthquake tsunamigenic potential, such as a local, regional, or ocean-wide tsunami possibility
- estimated height and arrival time of tsunami at agreed-upon forecast points
- observations of the tsunami

3.6.2 Forecast Points

As part of their standard operating procedures for responding to potentially tsunamigenic events, tsunami warning centers (TWC) calculate expected tsunami arrival times to various, pre-determined forecast points. Forecast points are agreed-upon points chosen by the TWC and countries. They may correspond to important coastal cities or populations, and/or to the locations of sea level gauges. All TWCs calculate tsunami arrival times for the forecast points.

The NWPTAC additionally calculates tsunami wave forecasts at the forecast points in order to decide on the level of potential tsunamigenic threat.

The PTWC and WC/ATWC use the estimated arrival times to determine whether a country or other region should be placed in a regional Warning or Watch status. If any forecast point within a country meets the criteria for a Warning or Watch, then the entire country is put in that status. Further, when a country is in a Warning or Watch status, the ETAs for its forecast points that met the criteria are listed in the bulletin.

Customers should be aware that the estimated arrival times given in tsunami bulletins should only be used as general guidance about when a tsunami impact might commence. This is because the TWC use slightly different calculation methods and may use different bathymetry data sets, the reported estimated arrival times may be different. Due to the dependency of propagation speed on the bottom topography and morphology, especially near-shore where the accuracy of the calculation is most heavily dependent on the accuracy of the bathymetry, actual arrival times of the first-arriving significant wave may vary substantially from the predicted times. Thus, the primary value of quickly calculating an estimated tsunami arrival time is to provide immediate guidance to the TWC and to other emergency response stakeholders responsible for issuing and acting upon tsunami alerts to ensure public safety.

3.6.3 Tsunami Bulletin Identifiers

PTWC and WC/ATWC tsunami bulletins are US NOAA National Weather Service products. The NWPTA bulletin is a JMA product. All products that are transmitted over the GTS are described by World Meteorological Organization (WMO) headers. The following table describes the products provided by the TWC for the Pacific and other oceans.

For the Pacific, the international messages are watch, warning, advisory, information bulletins, or information statements. The standard products have the headers
WEPA40 and WEPA 42 (PTWC, PHEB station originating code),
WEPA40 (NWPTAC, RJTD station originating code), or
WEPA41, WEPA43, and SEAK71 and
SEUS71 (WC/ATWC, PAAQ station originating code).

The WC/ATWC also issues Pacific public-friendly messages under WEAK51 and WEAK53.

Tsunami Product Codes - WMO Headers *(August 2007)*
NOAA Pacific Tsunami Warning Center (PTWC, PHEB)
NOAA West Coast / Alaska Tsunami Warning Center (WC/ATWC, PAAQ)
Japan Meteorological Agency (JMA, RJTD)

TWC	WMO Header	Product Explanation	Coverage
PTWC	WEPA40 PHEB	Tsunami Warnings and Watches [> M7.5]; Test	Pacific
PTWC	WEPA42 PHEB	Tsunami Information Bulletin [M6.5 to 7.5]	Pacific
PTWC	WEHW40 PHEB	Tsunami Warning, Watch, or Advisory for Hawaii Civil Defense [Hawaii source, > M6.8; Pacific source, > M7.5]	Hawaii
PTWC	WEHW42 PHEB	Tsunami Information Statement for Hawaii Civil Defense [Pacific source, M6.5 to 7.5]	Hawaii
PTWC	SEHW70 PHEB	Earthquake Information Statement [Hawaii source, up to M6.9]	Hawaii
PTWC	WEHW50 PHEB	Public Tsunami Warnings [Hawaii source, > M6.8]	Hawaii
PTWC	WECA41 PHEB	Tsunami Watch [> M7.0; Atlantic source > M7.8]; Test	Caribbean
PTWC	WECA43 PHEB	Tsunami Information Bulletin [M6.0 to 7.0; Atlantic source M6.5 to 7.8]	Caribbean
PTWC	WEIO21 PHEB	Tsunami Watch [> M7.0]; Test	Indian Ocean
PTWC	WEIO23 PHEB	Tsunami Information Bulletin [M6.5 to 7.0]	Indian Ocean
JMA	WEPA40 RJTD	Northwest Pacific Tsunami Advisory; Test	NW Pacific
JMA	WEPA40 RJTD	Tsunami Forecast	Japan
JMA	WEIO40 RJTD	Tsunami Watch and Information [Indian Ocean, Information M6.5 to 7.0; Watch > M7.0]; Test	Indian Ocean
WC/ATWC	WEPA41 PAAQ	Tsunami Warnings, Watches, and Advisories; Test	Alaska, British Columbia, Canada, and US West Coast
WC/ATWC	WEPA43 PAAQ	Tsunami Information Statement [M6.5 to 7.0]	Alaska, British Columbia, Canada, and US West Coast
WC/ATWC	WEAK51 PAAQ	Public Tsunami Warnings, Watches, and Advisories	Alaska, British Columbia, Canada, and US West Coast
WC/ATWC	WEAK53 PAAQ	Public Tsunami Information Statement	Alaska, British Columbia, Canada, and US West Coast
WC/ATWC	SEAK71 PAAQ	Tsunami Information Statement [Alaska, < M6.5]	Alaska, British Columbia, Canada, and US West Coast
WC/ATWC	SEUS71 PAAQ	Tsunami Information Statement [US West Coast & BC, < M6.5]	Alaska, British Columbia, Canada, and US West Coast
WC/ATWC	WEXX20 PAAQ	Tsunami Warnings, Watches, and Advisories; Test	Puerto Rico/Virgin Islands, US East, Gulf, and Canadian Maritime Provinces
WC/ATWC	WEXX22 PAAQ	Tsunami Information Statement	Puerto Rico/Virgin Islands, US East, Gulf, and Canadian Maritime Provinces
WC/ATWC	WEXX30 PAAQ	Public Tsunami Warnings, Watches, and Advisories	Puerto Rico/Virgin Islands, US East, Gulf, and Canadian Maritime Provinces
WC/ATWC	WEXX32 PAAQ	Public Tsunami Information Statement	Puerto Rico/Virgin Islands, US East, Gulf, and Canadian Maritime Provinces
WC/ATWC	SEXX60 PAAQ	Tsunami Information Statement [< M6]	Puerto Rico/Virgin Islands, US East, Gulf, and Canadian Maritime Provinces

3.7 DISSEMINATION OF MESSAGES

3.7.1 Authoritative Agencies

Description

Bulletins issued by TWC are guidance or advisory for national and local authorities. The authoritative tsunami warning agency for each country, territory, or administrative area is designated by its national government or administrative head. This agency has the fundamental responsibility for public safety in a tsunami emergency. The authority for issuing tsunami warning instructions to the public resides with this agency and not with the international TWC. It is recommended that only a single agency should be designated to ensure a single authoritative voice within an area. A national agency is usually designated as the 7x24 PTWS Tsunami Warning Focal Point (TWFP) for receiving official tsunami information from the international tsunami warning centers.

Contact Points

To ensure the proper operation of the warning system, the TWFP of the PTWS must submit to the IOC the 7x24 TWFP emergency contact point or points for receiving tsunami bulletins, and the communications methods required. The TWFP form for providing this input is attached in Annex II of the Section 2 of this document.

Function and Responsibilities

The authoritative agency provides the last vital link between the PTWS and the public, the ultimate user of the warning information. As such, the dissemination agency must motivate the public (both by education and, where so mandated, by law) to take necessary and desired actions to protect life and property. The authoritative agency and/or the governing body of an area subject to tsunami danger has the continuing responsibility for educating the public regarding the dangers of tsunamis and for developing safety measures that must be taken to avoid loss of life and to reduce property damage.

It is the ultimate responsibility of the authoritative agency to evaluate the tsunami information received from the international TWC and other national TWC and to decide on appropriate action after the receipt of a Tsunami Bulletin. These actions include issuing warnings in the country. In order to enable countermeasures to be started when there is an imminent tsunami, national tsunami warnings may be categorized into several grades to facilitate immediate clear actions. Based on the grades, appropriate pre-determined countermeasures, already described in official written documents such as a national disaster management plan, are put into action by authorities to properly and smoothly handle the emergency situation.

One of the best practices is in Japan. The JMA sets the warning grades according to the estimated tsunami height, where "Major Tsunami Warning" is for tsunamis of 3m or greater, "Tsunami Warning" for 1m and 2m, and "Tsunami Attention" for 0.5m or less. Local governments, who are responsible for giving directions to the public, usually recommend people to evacuate when JMA issues a "Warning." A "Attention" does not trigger evacuation because such tsunamis do not run up to inland. Since these waves can produce significant currents that can cause injuries, however, people are prohibited from swimming in the ocean during a "Tsunami Attention", though they do not have to evacuate.

Responsible agencies should have well-developed emergency plans for all threatened localities. These plans should clearly delineate areas of possible inundation. Evacuation routes should be designated and safe areas should be marked. The amount of advance warning necessary to ensure evacuation from danger areas also should be known. Emergency duties and responsibilities should be designated, and all affected officials should be thoroughly familiar with their duties. Tsunami alert information may be passed (depending on the time and facilities available) to the coastal population by any or all of the following methods: radio, television, sirens, bells, whistles, warning flags, mobile loud speakers, traditional and indigenous methods, and personal contact.

The IOC, through its ITIC, has many educational materials about tsunamis and tsunami warning and mitigation for reproduction and distribution. A number of these are provided as electronic documents which can be easily customized according to national and local conditions and actions.

3.7.2 Dissemination Communication Methods

To ensure the timely and effective dissemination of tsunami warnings and information, communication methods capable of rapidly reaching all PTWS participants are essential. Since such traffic is relatively infrequent, existing communication channels are used instead of establishing a separate communication system. These include the communications systems of the World Meteorological Organization, the International Civil Aviation Organization, the U.S. National Weather Service, the U.S. Defense Information Systems Agency and other more common systems such as telephone circuits, facsimile, and the internet e-mail and web postings.

It should be noted that the later common methods are not through dedicated communications channels, and as such, cannot be guaranteed for timely delivery; these common methods should be used as a secondary and/or backup means of communications by TWC. Specifically, ***Fax and E-mail alone are not the timeliest and should not be used as the primary means for receiving messages.*** *In general,* ***the GTS and AFTN dedicated, private communication methods guarantee timely receipt of bulletins within several minutes****, whereas Facsimile and E-mail may incur delays of tens of minutes during peak usage times. Thus, while all dissemination methods designated below will be made simultaneously by the issuing centers, but bulletins may reach their destinations at different times depending on the communication method*

The PTWC and WC/ATWC utilize the following communications services for international message dissemination:

	Service	Communication Link	User Audience
International	GTS	Dedicated GTS Circuit	U.S. and other nations' Meteorological Services
	AFTN	Dedicated AFTN Circuit	Designated U.S. and other nations' Airfield Facilities; U.S. Federal Aviation Administration and International affiliates
	EMWIN	GOES Satellite	Openly Available; U.S. and International Weather Forecast Subscribers, including National Disaster Management Offices unable to access GTS- or AFTN-transmitted messages.
	FAX	Standard Telephone Line	Many national government agencies
	EMAIL	Standard Internet Connection	Designated national government agencies
	WEB	Standard Internet Connection	Available to all PTWS Users

The NWPTAC emphasize the use of the GTS as the primary reliable method. Dissemination by E-mail and facsimile are also available.

3.7.3 Description of Services

- **WMO/GTS**

The Global Telecommunications System (GTS) is operated by the World Meteorological Organization (WMO) primarily to exchange weather information between National Meteorological and Hydrometerorological Services (NHMSs) of countries around the globe. NMHSs subscribe to products based on each product's WMO identifier. The PTWC and WC/ATWC use dedicated communication lines to the U.S. National Weather Service Telecommunications Gateway (NWSTG) that serves as a WMO Regional Telecommunications Hub. The JMA NWPTAC provides its messages directly through the JMA Tokyo that also serves as a WMO Regional Telecommunications Hub. Because messages usually flow through the GTS within a few minutes, and because the GTS has 24x7 support and a high reliability record, it is a preferred method for receiving TWC products.

- **AFTN**

The Aeronautical Fixed Telecommunications Network (AFTN) is a world-wide system of circuits for the exchange of messages and/or digital data primarily for the safety of air navigation and for the regular, efficient and economical operation of air services. Since many flight service facilities must operate on a 7X24 basis they are logical contact points for tsunami messages that can require an immediate response.

- **EMWIN**

The Emergency Managers Weather Information Network -- EMWIN -- is a service that allows users to obtain PTWC Tsunami Bulletins as well as weather forecasts, warnings, and other information directly from the US National Weather Service (NWS) through satellite broadcast on the NOAA GOES-East and West satellites which cover the USA, the Caribbean, and South and Central America, and most of the Pacific Ocean. It is intended to be used primarily by emergency managers and public safety officials who need this timely information to make critical decisions.

- **FAX, EMAIL, WEB**

The TWCs send FAX over standard telephone lines to designated agencies. To ensure rapid distribution to multiple fax numbers, a commercial service with many outgoing lines is utilized. Telefax should only be used as a primary method of receipt for agencies that do not have access to the preferred communication services. Otherwise, telefax should be considered as a backup method of receipt

The TWCs send email over the internet by high speed links to lists of designated recipients. Email should only be used as a primary method of receipt for agencies that do not have access to the preferred communication services. Otherwise, email should be considered as a backup method of receipt.

The TWCs post their messages, along with other relevant information such as location maps, on website that can be accessed through the web sites

PTWC: http://www.prh.noaa.gov/ptwc/

NWPTAC: http://www.jma.go.jp/en/distant_tsunami/WEPA40/index.html

WC/ATWC: http://wcatwc.arh.noaa.gov/events/eventmap.php

And other web sites such as http://www.ioc-tsunami.org/ and http://ioc3.unesco.org/ptws.

- **COMMUNICATION TESTS**

Tsunami Communications test messages are sent at regular intervals approximately every one to three months to test the communication pathways between the International TWC and TWFP. In addition to testing the operation of the warning system, the tests also serve to keep communications personnel familiar with procedures for handling tsunami message traffic, and to determine transmission times of messages to TWFP. The PTWC (quarterly) and WC/ATWC (monthly) send communications tests at unannounced times. The NWPTAC provides a courtesy notification to TWFP prior to the actual communications test.

The text of these test messages begins with the words "COMMUNICATION TEST" to distinguish them from other action bulletins transmitted by the TWC.

The TWC report the results of their Communications Tests to ITIC to help facilitate its monitoring the performance of the PTWS, and report results to the TWFP through the PTWS Secretariat.

3.8 REFERENCES

Japan Meteorological Agency, "Tsunami Warning Service in Japan", paper presented in Agenda 1 (Summary of the Present System) of the Intergovernmental Oceanographic Commission Working Group on International Aspects of the Pacific Tsunami Warning and Mitigation System meeting at Honolulu. Hawaii. April 27-30. 1965. Tokyo. 1965.

Japan Meteorological Agency, Manual on Operations and Systems for Tsunami Warning Service, 86 pp. March 2007.

National Weather Service, Directives: NDS 10-7 Tsunami Warning Services, http://www.weather.gov/directives/010/010.htm

UNESCO-IOC ICG/ITSU, ITSU Master Plan, Second Edition, 28 pp., April 1999.

Wadati, K.; Hirono, T.: and Hisamoto, S., "On the Tsunami Warning Service in Japan", International Union of Geodesy and Geophysics Monograph 24, Proceedings of the Tsunami Meetings Associated With the Tenth Pacific Science Congress, University of Hawaii, August-September 1961, Imprime par L'institut Geographique National, Paris, France, July 1963.

http://www.ioc-tsunami.org/

ANNEX I: PTWS SEA LEVEL NETWORK

Sea Level Observation Station Monitored by the PTWS International Centers

Station Name	Country / Region	Latitude	Longitude	Owner	Sensor Type	Sapmling Rate (min)	Transmit Interval (min)	Relay	WMO Header	Platform ID	Code	Monitoring		
												PTWC	WC/A TWC	NWP TAC
Acajutla_SV	El_Salvador	13.5739	-89.8383	PTWC	sps,spb	2	60	GOESE	SEMS40	93229372	acaj	O	O	
Acapulco_MX	Mexico	16.8333	-99.9166	UHSLC	prs,rad	1	5	GOESW	SEPA40	3540E15A	acap	O	O	
Adak	USA-Alaska	51.8631	-176.6319	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360F60E	adak	O	O	
Adak	USA-Alaska	51.8631	-176.6319	PTWC	bub	2	60	GOESW	PHAK03	9321870A	adak	O	O	O
Aden	Yemen	12.1167	45.0000			1			SXXX33	YE-AD	adenA		O	
Aguadilla_Pier		18.4075	-67.1410	NOS		1			SXVA03	335E4798	agprA		O	
Aguadilla_Pier		18.4075	-67.1410	NOS		6			SXVA03	335E4798	agprD		O	
Akutan_AK	USA-Alaska	54.1330	-165.7778	ATWC	pwl	1	0	DREAL	-	ATWC0007	akut	O	O	
Alameda_CA	USA-California	37.7720	-122.2980	NOS	pwl,bwl	1	6	GOESW	SXXX03	3362E08C	alam	O	O	
Alitak_US	USA-Territory	56.8975	-154.2481	NOS	pwl,bwl	1	6	GOESW	SXXX03	3363341E	alak	O	O	
Amchitka_AK	USA-Alaska	51.3783	-179.3019	ATWC	pwl	1	0	DREAL	-	ATWC0002	amka	O	O	
Anchorage_AK	USA-Alaska	61.2380	-149.8880	NOS	pwl,bwl	1	6	GOESW	SXXX03	3363B20A	anch	O	O	
Ancud	Chile	-41.8600	-74.3500	SHOA	sps	2	60	GOESE	SXCH40	ADC070AE	ancu	O		O
Antarctica_AR	Argentina	-63.4000	-56.9833	NOS	pwl	6	180	GOESW	SXXX03	3351410A	anta	O		
Antofagasta	Chile	-23.6500	-70.4167	SHOA	sps	2	60	GOESE	SXCH40	ADC020D2	anto	O	O	O
Apalachicola_FL	USA-FL	29.7270	-84.9820	NOS	pwl,bwl	1	6	GOESE	SXXX03	336747B4	apfl	O		
Apalachicola_FL	USA-FL	29.7270	-84.9820	NOS	pwl,bwl	1	6	GOESE	SXXX03	336A07D8	apflA		O	
Apalachicola_FL	USA-FL	29.7270	-84.9820	NOS	pwl,bwl	6	6	GOESE	SXXX03	336A07D8	apflD		O	
Apia	Samoa	-13.8169	-171.7500	NTF	paq,baq	6	60	GOESW	SXPS81	99991756	apia	O	O	O
Apia	Samoa	-13.8169	-171.7500	NTF	prs	1	6	GOESE	SZPS01	99966840	upol	O	O	
Arecibo_PR	Puerto_Rico	18.4669	-66.7024	NOS	pwl,bwl	1	6	GOESE	SXXX03	3366454E	arec	O	O	
Arena_Cove_CA	USA-California	38.9130	-123.7050	NOS	pwl,bwl	1	6	GOESW	SXXX03	3368115A	aren	O	O	
Arica_CL	Arica_Chile	-18.4720	-70.3350	SHOA	bub	2	60	GOESE	SECH40	9320E016	aric	O	O	
Astoria_OR	USA-Oregon	46.2080	-123.7670	NOS	pwl,bwl	1	6	GOESW	SXXX03	3362856A	asto	O	O	
Atico_PE	Peru	-16.2311	-73.6944	PTWC	sps,sps	2	60	GOESE	SEPR40	9323727A	atic	O	O	
Atka	USA-Alaska	52.1000	-174.4000	NOS		1			SXXX03	3363428E	atkaA		O	
Atka	USA-Alaska	52.1000	-174.4000	NOS		6			SXXX03	3363428E	atkaD		O	
Atlantic_City	USA-NJ	39.3550	-74.4183	NOS		1			SXXX03	3367B730	acnjA		O	
Atlantic_City	USA-NJ	39.3550	-74.4183	NOS		6			SXXX03	3367B730	acnjD		O	
Baltimore_MD	USA-MD	39.2670	-76.5780	NOS	pwl,bwl	1	6	GOESE	SXXX03	336577DA	bamd	O	O	
Baltra,Galapags_EC	Ecuador	-0.4333	-90.2833	PTWC	enc,enb	2	60	GOESW	SEEQ40	932040EE	balt	O	O	
Bar_Harbor_ME	USA-ME	44.3916	-68.2050	NOS	pwl,bwl	6	60	GOESE	SXXX03	335446CA	bame	O		
Bar_Harbor_ME	USA-ME	44.3916	-68.2050	NOS	pwl,bwl	1	60	GOESE	SXXX03	336747B4	bameA		O	
Bar_Harbor_ME	USA-ME	44.3916	-68.2050	NOS	pwl,bwl	6	60	GOESE	SXXX03	336747B4	bameD		O	
Battery_The_NY	USA-NY	40.7000	-74.0200	NOS	pwl,bwl	1	6	GOESW	SXXX03	336670D4	btny	O		
Beaufort_NC	USA-NC	34.7200	-76.6700	NOS	pwl,bwl	1	6	GOESE	SXXX03	3364C6AE	benc	O	O	
Benoa	Indonesia	-8.7667	115.2167	UHSLC	sps,rad	1	15	METEOSAT5	SXXX32	22856700	beno	O	O	O
Bergen_Point_NY	USA-NY	40.6400	-74.1500	NOS	pwl,bwl	1	6	GOESE	SXXX03	33669326	bpny	O	O	
Bermuda_UK	UK	32.2200	-64.7000	NOS	pwl,bwl	6	60	GOESE	SXXX03	33573754	bmda	O	O	
Betio	Kiribati	1.3500	172.9169	UHSLC	enc,enb	4	180	GOESW	SEPA80	35403732	beti	O	O	
Betio	Kiribati	1.3500	172.9169	NTF	paq,baq	6	60	GOESW	SXPS80	99991611	beti	O	O	O
Biloxi	USA-MS	30.4116	-88.9033	NOS		6			SXMS03	335BF3D6	bxmsD		O	
BordenFlatsLight_MA	USA-MA	41.7000	-71.2000	NOS	pwl,bwl	6	180	GOESE	SXXX03	335000FA	flma	O	O	
Boso	Japan	34.7500	140.7600	JMA	prs	1	15	NMC	SWJP50	BOSO	boso	O	O	O
Boston_MA	USA-MA	42.3600	-71.0500	NOS	pwl,bwl	6	60	GOESE	SXXX03	334D547E	boma	O		
Boston_MA	USA-MA	42.3600	-71.0500	NOS	pwl,bwl	1	60	GOESE	SXLA43	335E54EE	bomaA		O	
Boston_MA	USA-MA	42.3600	-71.0500	NOS	pwl,bwl	6	60	GOESE	SXLA43	335E54EE	bomaD		O	
Brandywine_Shoal_Light	USA-DE	39.0000	-75.1000	NOS		6			SXXX03	3357745E	bsdeD		O	
Bridgeport_CT	USA-CT	41.1700	-73.1800	NOS	pwl,bwl	6	60	GOESE	SXXX03	334B3156	bgct	O		
Bridgeport_CT	USA-CT	41.1700	-73.1800	NOS	pwl,bwl	1	60	GOESE	SXXX50	3358F4D8	bgctA		O	
Bridgeport_CT	USA-CT	41.1700	-73.1800	NOS	pwl,bwl	6	60	GOESE	SXXX50	3358F4D8	bgctD		O	
Broome_AU	Australia	-18.0008	122.2186	NTF	prs	1	6	GOESE	SZAU01	99962650	brom	O	O	
Burlington_NJ	USA-NJ	40.0800	-74.8700	NOS	pwl,bwl	6	60	GOESE	SXXX03	3357C7D0	blnj	O	O	
Burnie_AU	Australia	-41.0501	145.9150	NTF	prs	1	6	GOESE	SZAU01	99960910	burn	O	O	
Cabo_San_Lucas_MX	Mexico	23.8830	-109.9000	PTWC	enc,enb	2	60	GOESW	SEMX03	93209686	cabo	O		
Caldera_CL	Chile	-27.0580	-70.8340	SHOA	bub	2	60	GOESE	SECH40	9321011E	cald	O	O	
Callao	Peru	-12.0711	-77.1739	PTWC	enc,sps	2	60	GOESE	SEPR40	93205D4A	call	O	O	O
Cambridge_MD	USA-MD	38.5700	-76.0700	NOS	pwl,bwl	6	60	GOESE	SXXX03	3354232C	cbmd	O		
Cambridge_MD	USA-MD	38.5700	-76.0700	NOS	pwl,bwl	1	60	GOESE	SXXX03	3366E5B6	cbmdA		O	
Cambridge_MD	USA-MD	38.5700	-76.0700	NOS	pwl,bwl	6	60	GOESE	SXXX03	3366E5B6	cbmdD		O	
Cape_Ferguson_AU	Australia	-19.2775	147.0586	NTF	prs	1	6	GOESE	SZAU01	99959260	ferg	O	O	
Cape_May	USA-NJ	38.9683	-74.9600	NOS		1			SXXX03	335D53E0	cmnjA		O	
Cape_May	USA-NJ	38.9683	-74.9600	NOS		6			SXXX03	335D53E0	cmnjD		O	
Capetown_ZA	South_Africa	-34.1833	18.4333	UHSLC	rad,pr1	1	15	ESSA	SXXX33	22306108	cape	O		
Cedar_Key	USA-FL	29.1350	-83.0316	NOS		6			SXFL03	33413004	ckflD		O	

Charleston_OR	USA-Oregon	43.3450	-124.3217	NOS	pwl,bwl	1	6	GOESW	SXXX03	336874BC	char	O	O	
Charleston_SC	USA-SC	32.7820	-79.9250	NOS	pwl,bwl	1	6	GOESE	SXXX03	336410C6	chsc	O	O	
Charlotte-Amalie_VI	Virgin_Islands	18.3333	-64.9167	NOS	pwl,bwl	1	6	GOESE	SXXX03	3364A348	amal	O	O	
Cherry_Point_WA	USA-Washington	48.8630	-122.7580	NOS	pwl,bwl	1	1	GOESW	SXXX03	336BB6AC	chrp	O	O	
Chesapeake_Bay_VA	USA-VA	36.9670	-76.1130	NOS	pwl,bwl	1	6	GOESE	SXXX50	3358D234	cbva	O	O	
Chesapeake_City	USA-MD	39.5266	-75.8100	NOS		6			SXPA03	334D4708	ccmdD		O	
Chittagong_BA	Bangladesh	22.3333	91.6333	UHSLC	prs,rad	1	30	EESA	SXXX33	12BCC18A	chtt	O		
Choshi	Japan	35.7500	140.8670	JMA				NMC	-	-	chos			O
Christiansted_Harbor	USA-VirginIs.	17.4500	-64.4230	NOS		1			SXXX03	3365B2C4	stcrA		O	
Christiansted_Harbor	USA-VirginIs.	17.4500	-64.4230	NOS		6			SXXX03	3365B2C4	stcrD		O	
Christiansted_Harbor	USA-VirginIs.	17.4500	-64.4230	NOS		6			SXXX03	3365B2C4	stcrZ		O	
Christmas_AU	Australia	-10.4167	105.6667	NTF	prs	1	6	GOESE	SZIO01	99946290	chrs	O	O	
Christmas	Kiribati	1.9839	-157.4731	UHSLC	sps,pwl	4	60	GOESW	SEPA40	35402444	xmas	O	O	O
Cilacap	Indonesia	-7.7500	109.0000	UHSLC		1	15	METEOSAT7	SXXX33	22A004C8	cili	O	O	O
Clearwater_Beach_FL	USA-FL	27.9780	-82.8320	NOS	pwl,bwl	1	6	GOESW	SXXX50	3358C142	cwfl	O	O	
Cocos	Cocos-Isl.	-12.1167	96.8919	NTF	prs	1	6	GOESE	SZIO01	99962650	cocb	O		
Cocos	Cocos-Isl.	-12.1167	96.8919	NTF	prs	1	6	GOESE	SZIO01	99946280	cocoA		O	
Cocos	Cocos-Isl.	-12.1167	96.8919	NTF	paq,baq	6	60	GOESW	SXPS90	99996997	coco	O	O	O
Colombo	Sri-Lanka	6.9500	79.8500	UHSLC	prs,enb	1	15	MTSAT	SWIO40	SWIO40	coloA	O	O	O
Colombo	Sri-Lanka	6.9500	79.8500	UHSLC	prs,enb	1	15	MTSAT	SWIO40	SWIO40	coloB		O	
Colombo	Sri-Lanka	6.9500	79.8500	UHSLC	pr2,rad	1	15	EESA	SXXX33	22373340	colo	O	O	
Conimicut_light_RI	USA-RI	41.7200	-71.3400	NOS	pwl,bwl	6	180	GOESE	SXXX03	335124EC	clri	O	O	
Coquimbo	Chile	-29.9300	-71.3500	SHOA	sps	2	60	GOESE	SXCH40	ADC033A4	coqu	O	O	O
Cordova_AK	USA-Alaska	60.5580	-145.7530	NOS	pwl,bwl	1	6	GOESW	SXXX03	335FA690	cord	O	O	
Corinto_NI	Nicaragua	12.4836	-87.1675	PTWC	sps,spb	2	60	GOESE	SEMN40	9322A6E8	cori	O	O	
Corpus_Christi	USA-TX	27.5800	-97.2166	NOS		6			SXTX03	33428484	cctxD		O	
Corral	Chile	-39.8667	-73.4333	SHOA	sps	2	60	GOESE	SXCH40	ADC05642	corr	O	O	O
Craig_AK	USA-Alaska	55.4770	-133.1410	ATWC	pwl	1	0	DREAL	-	ATWC0005	crag	O	O	
Crescent_City_CA	USA-California	41.7450	-124.1830	NOS	pwl,bwl	1	6	GOESW	SXXX03	33622592	cres	O	O	
Culebra_Is_PR	Puerto_Rico	18.3008	-65.3028	NOS	pwl,bwl	1	6	GOESE	SXXX03	335CB2E8	cule	O	O	
CutlerNavalBase_ME	USA-ME	44.6400	-67.3000	NOS	pwl,bwl	6	60	GOESE	SXXX03	3354305A	cnme	O		
CutlerNavalBase_ME	USA-ME	44.6400	-67.3000	NOS	pwl,bwl	1	60	GOESE	SXXX03	33672252	cnmeA		O	
CutlerNavalBase_ME	USA-ME	44.6400	-67.3000	NOS	pwl,bwl	6	60	GOESE	SXXX03	33672252	cnmeD		O	
Dakar	Senegal	14.7000	-17.4000			6			SXXX03	33531482	dkslD		O	
DART_Acapulco_43413	off_Acapulco	10.8400	-100.0850	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD5F	dacp	O	O	
DART_Acapulco_43413	off_Acapulco	10.8400	-100.0850	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD60	dacp	O	O	
DART_Adak_46413	off_Adak	48.8610	-175.6010	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD3B	dadk	O	O	
DART_Adak_46413	off_Adak	48.8610	-175.6010	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD3C	dadk	O	O	
DART_Amchitka_21414	off_W_Aleutians	48.9420	178.2700	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD42	dnwp	O	O	
DART_Amchitka_21414	off_W_Aleutians	48.9420	178.2700	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD44	dnwp	O	O	
DART_Amukta_46408	off_C_Aleutians	49.6261	-169.8714	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD3F	dchu	O	O	
DART_Amukta_46408	off_C_Aleutians	49.6261	-169.8714	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD40	dchu	O	O	
DART_Anchorage46410	Gulf_of_Alaska	57.5000	-144.0000	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDDDE	danc	O	O	
DART_Anchorage46410	Gulf_of_Alaska	57.5000	-144.0000	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDDDF	danc	O	O	
DART_Astoria_46404	Oregon	45.8589	-128.7781	NDBC	pwl	15	360	GOESW	SXAK91	14039360	dpor	O	O	
DART_Astoria_46404	Oregon	45.8589	-128.7781	NDBC	bwl	15	360	GOESW	SXAK91	1403A6FA	dpor	O	O	
DART_Atlantic_41420	Bahamas	23.3119	-67.6611	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD2A	dstl	O	O	
DART_Atlantic_41420	Bahamas	23.3119	-67.6611	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD2B	dstl	O	O	
DART_Atlantic_41421	N_of_Virgin_Is	23.3994	-63.9000	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD2E	dat3	O	O	
DART_Atlantic_41421	N_of_Virgin_Is	23.3994	-63.9000	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD2F	dat3	O	O	
DART_Atlantic_41424	off_S_Carolina	32.9281	-72.4689	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD30	datl	O	O	
DART_Atlantic_41424	off_S_Carolina	32.9281	-72.4689	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD32	datl	O	O	
DART_Attu_Is_21415	off_Attu_AK	50.1720	171.8370	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD70	datu	O	O	
DART_Attu_Is_21415	off_Attu_AK	50.1720	171.8370	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD72	datu	O	O	
DART_Australia_55401	Tasman_Sea	-46.9220	160.5620	NDBC	pwl	15	360	GOESE	SXXX46	DDDDDD4A	daus	O	O	
DART_Australia_55401	Tasman_Sea	-46.9220	160.5620	NDBC	pwl	15	360	GOESE	SXXX46	DDDDDD4B	daus	O	O	
DART_Caribbean42407	Caribbean	15.2600	-68.2294	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD2C	dcar	O	O	
DART_Caribbean42407	Caribbean	15.2600	-68.2294	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD2D	dcar	O	O	
DART_Chile_32401	Chile	-19.5478	-74.8136	SHOA	pwl	15	360	GOESW	SXXX46	DDDDDD4C	dchi	O	O	
DART_Chile_32401	Chile	-19.5478	-74.8136	SHOA	bwl	15	360	GOESW	SXXX46	DDDDDD4D	dchi	O	O	
DART_Guam_52405	S_Philippine_Sea	12.8800	132.3336	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD58	dgum	O	O	
DART_Guam_52405	S_Philippine_Sea	12.8800	132.3336	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD5A	dgum	O	O	
DART_GulfMex_42408	Gulf_of_Mexico	25.4097	-86.7989	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD34	dgul	O	O	
DART_GulfMex_42408	Gulf_of_Mexico	25.4097	-86.7989	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD36	dgul	O	O	
DART_Hawaii_51407	west_of_Hawaii	19.6338	-156.5069	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDDD0	dhaw	O	O	
DART_Hawaii_51407	west_of_Hawaii	19.6338	-156.5069	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDDD2	dhaw	O	O	
DART_Kamchatka21416	Kamchatka	48.3903	163.4881	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD6E	dkam	O	O	
DART_Kamchatka21416	Kamchatka	48.3903	163.4881	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD6F	dkam	O	O	
DART_Kodiak_46409	off_Kodiak	55.3000	-148.5000	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDDDB	dkod	O	O	
DART_Kodiak_46409	off_Kodiak	55.3000	-148.5000	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDDDC	dkod	O	O	
DART_Kuril_Is_21417	Japan	43.1917	157.1417	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD6C	dkur	O	O	
DART_Kuril_Is_21417	Japan	43.1917	157.1417	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD6D	dkur	O	O	
DART_Kwajalein52402	N_of_Pohnpei	11.5750	154.5878	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD1B	dkwa	O	O	
DART_Kwajalein52402	N_of_Pohnpei	11.5750	154.5878	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD1C	dkwa	O	O	
DART_LA_46412	off_S_California	32.2461	-120.6983	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD4E	dlos	O	O	
DART_LA_46412	off_S_California	32.2461	-120.6983	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD4F	dlos	O	O	

DART_Manila_52404	N_Philippine_Sea	20.9369	132.3150	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD54	dphi	O	O	
DART_Manila_52404	N_Philippine_Sea	20.9369	132.3150	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD56	dphi	O	O	
DART_Marquesas51406	E_of_Marquesas	-8.4889	-125.0061	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD46	dmar	O	O	
DART_Marquesas51406	E_of_Marquesas	-8.4889	-125.0061	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD48	dmar	O	O	
DART_N_Cal_46411	off_N_California	39.3400	-127.0070	NDBC	pwl	15	60	GOESW	SXXX46	B140962A	dcal	O	O	
DART_N_Cal_46411	off_N_California	39.3400	-127.0070	NDBC	bwl	15	60	GOESW	SXXX46	B14CB15A	dcal	O	O	
DART_NicobarIs23401	Bay_of_Bengal	8.9050	88.5369	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD50	dnic	O	O	
DART_NicobarIs23401	Bay_of_Bengal	8.9050	88.5369	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD52	dnic	O	O	
DART_Oregon_46405	Oregon	42.9031	-130.9089	NDBC	pwl	15	60	GOESW	SXXX46	1404F4B2	dorg	O	O	
DART_Oregon_46405	Oregon	42.9031	-130.9089	NDBC	bwl	15	60	GOESW	SXXX46	1402178E	dorg	O	O	
DART_Panama_32411	Costa_Rica	4.9239	-90.6850	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD62	dpan	O	O	
DART_Panama_32411	Costa_Rica	4.9239	-90.6850	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD64	dpan	O	O	
DART_Saipan_52401	Saipan	19.2800	155.7600	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD18	dsai	O	O	
DART_Saipan_52401	Saipan	19.2800	155.7600	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD1A	dsai	O	O	
DART_SanDiego_46482	San_Diego_CA	31.9693	-120.4517	SAIC	pwl	15	360	GOESW	SXXX46	DDDDDD22	dsdi	O	O	
DART_SanDiego_46482	San_Diego_CA	31.9693	-120.4517	SAIC	bwl	15	360	GOESW	SXXX46	DDDDDD24	dsdi	O	O	
DART_Seattle_46419	off_Vancouver_I	48.4781	-129.3589	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD38	dsea	O	O	
DART_Seattle_46419	off_Vancouver_I	48.4781	-129.3589	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD3A	dsea	O	O	
DART_Sendai_JP21418	Japan	38.7100	148.6700	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD6A	dsen	O	O	
DART_Sendai_JP21418	Japan	38.7100	148.6700	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD6B	dsen	O	O	
DART_Shumagin_46403	Shumagin_Is	52.6500	-156.9400	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD10	dshu	O	O	
DART_Shumagin_46403	Shumagin_is	52.6500	-156.9400	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD12	dshu	O	O	
DART_Test_NDBC00000	NDBC	30.3574	-89.6107	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD26	dtst	O	O	
DART_Test_NDBC00000	NDBC	30.3574	-89.6107	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD28	dtst	O	O	
DART_Tokyo_21413	Japan	30.5500	152.1186	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD14	dtok	O	O	
DART_Tokyo_21413	Japan	30.5500	152.1186	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD16	dtok	O	O	
DART_Truk_52403	Truk	4.0300	145.5950	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD1D	dtru	O	O	
DART_Truk_52403	Truk	4.0300	145.5950	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD1E	dtru	O	O	
DART_Unimak_46402	E_Aleutians	51.0689	-164.0100	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD3D	duni	O	O	
DART_Unimak_46402	E_Aleutians	51.0689	-164.0100	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD3E	duni	O	O	
DARTManzanillo43412	off_Manzanillo	16.0367	-107.0010	NDBC	pwl	15	360	GOESW	SXXX46	DDDDDD5D	dmnz	O	O	
DARTManzanillo43412	off_Manzanillo	16.0367	-107.0010	NDBC	bwl	15	360	GOESW	SXXX46	DDDDDD5E	dmnz	O	O	
Darwin	Australia	-12.4666	130.8500	NTF		1			SZAU01	99963230	darwA		O	
Dauphin_Island_AL	USA-AK	30.2000	-88.1000	NOS	pwl,bwl	6	60	GOESE	SXXX03	335752B2	dial	O	O	
Davao	Philippines	7.1000	125.7000	UHSLC		1	15	MTSAT	SWPH41	06505F20	davo	O	O	O
Degaussing_Structure	USA-FL	30.3900	-81.4500	NOS		6					dsflD		O	
Dekehtik_Pohnpei_FM	Fed_States_Micr	0.0000	158.2001	NTF	prs	1	6	GOESE	SZPA01	99967950	deke	O		
Delaware_City_DE	USA-DE	39.5800	-75.5900	NOS	pwl,bwl	6	60	GOESE	SXXX03	335784DA	dede	O	O	
Diego_Garcia	USA-Territory	-7.2333	72.4333	UHSLC	prs,rad	1	15	METEOSAT7	SXXX33	360CC710	garc	O	O	O
Diego_Ramirez	Chile	-57.0000	-67.2670	SHOA		2				334CC3E6	dramB		O	
Djibouti	Djibouti	11.6000	43.1666	UHSLC		1	15	METEOSAT5	SXXX32	DJ-BOUT-06	djib	O	O	O
Duck_Pier	USA-NC	36.1833	-75.7466	NOS		1			SXLA03	335DD5F4	dpncA		O	
Duck_Pier	USA-NC	36.1833	-75.7466	NOS		6			SXLA03	335DD5F4	dpncD		O	
Duke_Mar_Lab_Beaufort	USA-NC	34.7200	-76.6700	NOS		6			SXNC03	334AB5B8	bmncD		O	
Durban	South_Africa	-29.8833	31.0333	UHSLC	rad,pr1	1	15	ESSA	SXXX33	22DEB682	durb	O		
Durban	South_Africa	-29.8833	31.0333			1			SXXX33	ZA-DU	durbA		O	
Dutch_Hbr,Unalaska	USA-Alaska	53.8800	-166.5370	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360A672	dutc	O	O	
Dutch_Hbr,Unalaska	USA-Alaska	53.8800	-166.5370	PTWC	bub	2	60	GOESW	PHAK03	9321B290	dutc	O	O	
East_Bank_1_LA	USA-LA	30.0500	-90.3680	NOS	pwl,bwl	1	6	GOESW	SXXX03	3368A2D4	ebla	O	O	
East_Port_ME	USA-ME	44.9000	-66.9900	NOS	pwl,bwl	6	60	GOESE	SXXX03	334D9160	epme	O		
East_Port_ME	USA-ME	44.9000	-66.9900	NOS	pwl,bwl	1	60	GOESE	SXXX03	3365875E	epmeA		O	
East_Port_ME	USA-ME	44.9000	-66.9900	NOS	pwl,bwl	6	60	GOESE	SXXX03	3365875E	epmeD		O	
Easter	Chile	-27.1531	-109.4481	SHOA	sps,pwl,bwl	2	60	GOESE	SXCH40	93202BDA	east	O	O	O
Elfin_Cove_AK	USA-Alaska	58.1933	-136.3433	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360C394	elak	O	O	
Elliot_Bay,Seattle	USA-Washington	47.6020	-122.3350	NOS	pwl,bwl	1	6	GOESW	SXXX03	3368022C	ellb	O		
Esperance_AU	Australia	-33.8709	121.8954	NTF	prs	1	6	GOESE	SZAU01	99962080	espe	O	O	
Esperanza	Antarctica	-63.4083	-56.9833	NOS		6			SXXX03		ata1D		O	
Esperanza	Antarctica	-63.4083	-56.9833	NOS		6			SXXX03		ata2D		O	
Eugene_Island_LA	USA-LA	29.3700	-91.3900	NOS	pwl,bwl	6	60	GOESE	SXXX03	3352A5F6	eila	O	O	
Fajardo_PR	Puerto_Rico	18.3336	-65.6311	NOS	pwl,bwl	1	6	GOESE	SXXX03	3366C35A	faja	O	O	
Fall_River_MA	USA-MA	41.7100	-71.1600	NOS	pwl,bwl	6	60	GOESE	SXXX03	335000FA	fama	O		
Fall_River_MA	USA-MA	41.7100	-71.1600	NOS	pwl,bwl	6	60	GOESE	SXXX03	3353326E	famaD		O	
Fernadina_Beach_FL	USA-FL	30.6720	-81.4650	NOS	pwl,bwl	1	6	GOESE	SXXX03	336782AA	fbfl	O	O	
FongafaleFunafutiTV	Tuvalu	-8.5025	179.1952	NTF	prs	1	6	GOESE	SZPS01	99967440	fong	O		
Fort_Fourchon_LA	USA-LA	29.1200	-90.2000	NOS	pwl,bwl	6	60	GOESE	SXXX03	334FE204	pfla	O		
Fort_Myers_FL	USA-FL	26.6500	-81.8700	NOS	pwl,bwl	1	6	GOESE	SXXX03	336754C2	fmfl	O	O	
Fort_Point_NH	USA-NH	43.0700	-70.7100	NOS	pwl,bwl	6	180	GOESE	SXXX03	33518414	fpnh	O	O	
Fort_Pulaski_GA	USA-GA	32.0330	-80.9020	NOS	pwl,bwl	1	6	GOESE	SXXX03	335F151E	fpga	O	O	
Free_Port_TX	USA-TX	28.9500	-95.3100	NOS	pwl,bwl	1	6	GOESW	SXXX03	3368E1DE	fptx	O	O	
Friday_Harbor_WA	USA-Washington	48.5467	-123.0100	NOS	pwl,bwl	1	6	GOESW	SXXX03	336BD34A	frih	O	O	
Fripps_Inlet	USA-SC	32.4000	-80.5000	NOS		6			SXMD30	3356433E	fiscC		O	
Ft_Point,San_Fran	USA-California	37.8070	-122.4650	NOS	pwl,bwl	1	6	GOESW	SXXX03	336172	fpnt	O		
Funafuti	Tuvalu	-8.5000	179.2000	NTF	paq,baq	6	60	GOESW	SXPS88	99991642	funa	O	O	O
Funafuti	Tuvalu	-8.5000	179.2000	NTF	paq,baq	1	3	GOESW	SZPS01	99991642	funaA		O	
Galveston_Bay_Entrance	USA-TX	29.3583	-94.7250	NOS		6					betxD		O	
Galveston_Pier_TX	USA-TX	29.3100	-94.7930	NOS	pwl,bwl	1	6	GOESW	SXXX03	336AB456	gptx	O		

Galveston_Pier_TX	USA-TX	29.3100	-94.7930	NOS	pwl,bwl	1	6	GOESW	SXXX03	336AB456	gptxA		O	
Galveston_Pier_TX	USA-TX	29.3100	-94.7930	NOS	pwl,bwl	6	6	GOESW	SXXX03	336AB456	gptxD		O	
Galveston_Pleasure_Pier		29.2850	-94.7883	NOS		6			SXTX03	334BF448	pptxD		O	
Gan	Maldives	-0.6867	73.1517	UHSLC	prs,rad,enc	1	15	METEOSAT5	SXXX32	32D8A2BE	ganm	O	O	O
Garibaldi_OR	USA-Oregon	45.5550	-123.9117	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360B504	gaor	O	O	
Grand_Isle	USA-LA	29.2633	-89.9566	NOS		1			SXLA03	335DA364	gilaA		O	
Grand_Isle	USA-LA	29.2633	-89.9566	NOS		6			SXLA03	335DA364	gilaD		O	
Guam_US	USA-Territory	13.4380	144.6520	NOS	pwl,bwl	1	6	GOESW	SXXX03	33610470	guam	O	O	
Hachinohe	Japan	40.5330	141.5330	JMA				NMC	-	-	hach			O
Haleiwa,Oahu	USA-Hawaii	21.6000	-158.1100	PTWC	enc	2	0	LARC	-	LARC0007	hale	O		
Hanalei,Kauai	USA-Hawaii	22.2156	-159.5008	PTWC	enc	2	0	LARC	-	0HANALEI	hana	O		
Hanasaki	Japan	43.2800	145.5700	JMA	enc	1	15	NMC	SWJP40	HANASAKI	hnsk	O	O	O
Hanimaadhoo	Maldives	6.7667	73.1667	UHSLC	prs,rad,enc	1	15	METEOSAT5	SXXX32	26CB10AC	hani	O	O	O
Hillarys_Harbor_AU	Australia	-31.8255	115.7386	NTF	prs	1	6	GOESE	SZAU01	99962237	hill	O	O	
Hilo,Hawaii	USA-Hawaii	19.7307	-155.0558	PTWC	bub	0	0	ANAL	-	MIC23060	hil_	O		
Hilo,Hawaii	USA-Hawaii	19.7330	-155.0580	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360636C	hilo	O	O	
Hiva_Oa,Marquesas	French-Poly	-9.8047	-139.0344	FGL	sps	2	60	GOESW	SEHI40	9322451A	hiva	O		
Honiara	Solomon_Islands	-9.4333	159.9500	UHSLC	enc,enb	4	180	GOESW	SRUS40	35407438	honi	O		
Honiara	Solomon_Islands	-9.4333	159.9500	NTF	paq,baq	6	60	GOESW	SXPS87	99991519	honi	O	O	O
Honokohau,Hawaii	USA-Hawaii	19.6710	-156.0280	PTWC	enc	2	0	LARC	-	0HONOKOH	hkhu	O	O	
Honokohau,Hawaii	USA-Hawaii	19.6710	-156.0280	PTWC	sps	2	0	DREAL	-	VHF12380	hkhu	O	O	
Honolulu,Oahu	USA-Hawaii	21.3033	-157.8645	PTWC	bub	0	0	ANAL	-	VHF22720	hon_	O	O	
Honolulu,Oahu	USA-Hawaii	21.3170	-157.8857	NOS	pwl,bwl	1	6	GOESW	SXXX03	33602066	hono	O	O	
Honuapo,Hawaii	USA-Hawaii	19.0870	-155.5530	PTWC	bub	0	0	ANAL	-	MIC22720	honu	O	O	
Hulhule	Maldives	4.1833	73.5167	UHSLC		1			SXXX32	16289262	maleA		O	
Hulhule	Maldives	4.1833	73.5167	UHSLC		15			SXXX32	16289262	maleX		O	
Inhambane_MZ	Mozambique	-23.9167	35.5000	UHSLC	rad,pr1	1	15	ESSA	SXXX33	229C0324	inha	O		
Inhambane_MZ	Mozambique	-23.9167	35.5000	UHSLC	rad,pr1	1	15	ESSA	SXXX32	MZ-NIH2	inhaA		O	
Iquique	Chile	-20.2167	-70.1700	SHOA	sps	2	60	GOESE	SXCH40	ADC01548	iqui	O	O	O
Ishigakijima	Japan	24.2000	124.1000	JMA	enc	1	15	NMC	SWJP40	ISHIGAKIJIMA	ishi	O	O	O
Isla_San_Pedro_CL	Chile	-47.7167	-74.8833	SHOA	sps	2	60	GOESE	SXCH40	ADC0802A	sped	O		
Jackson_Bay	New_Zealand	-43.9750	168.6150	NTF	paq,baq	6	60	GOESW	SXPS93	99993713	jack	O	O	O
Johnston_Is.	USA-Territory	16.7381	-169.5250	NOS	pwl,bwl	6	60	GOESW	PHPO03	334467B8	john	O		
Johnston_Is.	USA-Territory	16.7381	-169.5250	PTWC	sps,spb	2	60	GOESW	SXHW11	9322C30E	john	O		O
Juan_Fernandez	Chile	-33.6167	-78.8333	SHOA	bub	2	60	GOESE	SXCH40	93215162	juan	O	O	O
Juneau_AK	USA-Alaska	58.2983	-134.4117	NOS	pwl,bwl	1	6	GOESW	SXXX03	33636462	june	O	O	
Kahului,Maui	USA-Hawaii	20.8980	-156.4720	NOS	pwl,bwl	1	6	GOESW	SXXX03	33604580	kahu	O	O	
Kahului,Maui	USA-Hawaii	20.8980	-156.4720	PTWC	enc	2	0	LARC	-	LARC0002	kahu	O		
Kalaupapa,Molokai	USA-Hawaii	21.2100	-156.9800	PTWC	enc	2	0	LARC	-	PHON3060	kala	O	O	
Kanton	Kiribati	-2.8011	-171.7181	UHSLC	enc,enb	4	60	GOESW	SEPA40	3540A250	kant	O	O	O
Kapingamarangi	Fed_States_Micro	1.0850	154.7681	UHSLC	enc,enb	4	60	GOESW	SEPA40	3540F22C	kapi	O	O	O
Kapoho,Hawaii	USA-Hawaii	19.5000	-154.8170	PTWC	enc	2	0	LARC	-	MIC22380	kapo	O	O	
Karachi	Pakistan	24.8500	67.0300	UHSLC		1	15	METEOSAT7	SXXX33	KARACHI-06	kara	O	O	O
Kaumalapau	USA-Hawaii	20.7800	-156.9000	UHSLC	prs,rad	1	5	GOESW	SEPO40	3542C242	kaum	O		
Kawaihae,Hawaii	USA-Hawaii	20.0360	-155.8320	NOS	pwl,bwl	1	6	GOESW	SXXX03	336056F6	kawa	O	O	
Ketchikan_AK	USA-Alaska	55.3333	-131.6250	NOS	pwl,bwl	1	6	GOESW	SXXX03	336351F8	ketc	O	O	
Key_West_FL	USA-FL	24.5530	-81.8080	NOS	pwl,bwl	1	6	GOESE	SXXX03	336717C8	kwfl	O	O	
King_Cove_AK	USA-Alaska	55.0594	-162.3236	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360D0E2	kgak	O	O	
Kings_Point_NY	USA-NY	40.8100	-73.7700	NOS	pwl,bwl	1	6	GOESE	SXXX03	336663A2	kgny	O	O	
Kings_Wharf_Suva_FJ	Fiji	-18.1342	178.4236	NTF	paq,baq	6	60	GOESW	SXPS92	99991689	suva	O	O	
Kiptopeke_VA	USA-VA	37.1700	-75.9900	NOS	pwl,bwl	1	6	GOESW	SXXX03	336564AC	kpva	O	O	
Kirinda_LK	Sri_Lanka	6.1966	81.3200	UHSLC	prs,rad	1	15	EESA	SXXX33	22738628	kiri	O	O	
Ko_Miang	Thailand	8.5500	97.6333	UHSLC	sps	1	15	METEOSAT5	SXXX32	3285238E	komi	O	O	O
Ko_Taphao_Noi	Thailand	7.8167	98.4167	UHSLC	sps,rad	1	15	METEOSAT5	SXXX32	121D955A	kota	O	O	O
Kodiak_AK	USA-Alaska	57.7317	-152.5117	NOS	pwl,bwl	1	6	GOESW	SXXX03	33626698	kodi	O	O	
Kodiak_AK	USA-Alaska	57.7317	-152.5119	PTWC	bub	2	60	GOESW	SEAK03	9321C400	kodi	O		O
Kodiak_AK	USA-Alaska	57.7317	-152.5119	PTWC	bub	2	60	GOESW	PHAK03	9321C400	kodiB		O	
Kwajalein_MH	Marshall_Island	8.7367	167.7383	NOS	pwl,bwl	1	6	GOESW	SXXX03	336131EA	kwaj	O	O	
La_Jolla_CA	USA-California	32.8670	-117.2580	NOS	pwl,bwl	1	6	GOESW	SXXX03	3362A386	lajo	O	O	
La_Libertad_EC	Ecuador	-2.2090	-80.9020	PTWC	sps,spb	2	60	GOESE	SEEQ40	93205398	lali	O		
La_Push_WA	USA-Washington	47.9133	-124.6367	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360701A	laph	O	O	
Lahaina,Maui	USA-Hawaii	20.8750	-156.6920	PTWC	enc	2	0	LARC	-	LARC0005	laha	O		
LameshurBayStJohnVI	St_John_VI	18.2000	-64.4400	NOS	pwl,bwl	1	6	GOESE	SXXX03	335D10EA	lame	O	O	
Lamu	Kenya	-2.2667	40.9000	UHSLC	prs,rad	1	15	METEOSAT7	SXXX33	16287190	lamu	O	O	O
Langara_Point_BC	Canada-BC	54.2000	-133.1000	NOS	pwl,bwl	1	60	GOESW	SXAK50	15C396A6	lpbc	O	O	
Langkawi	Malaysia	6.4333	99.8667	UHSLC	prs,rad	1	15	METEOSAT5	SXXX32	3276866C	lang	O	O	O
Lapahoehoe,Hawaii	USA-Hawaii	19.9949	-155.2431	PTWC	sps	0	0	ANAL	-	VHF13060	laup	O	O	
Lautoka	Fiji_Islands	-17.6000	177.4300	NTF	prs	1	6	GOESE	SZPS01	99967070	levu	O	O	
Lautoka	Fiji_Islands	-17.6000	177.4300	NTF	paq,baq	6	60	GOESW	SXPS84	99991679	laut	O	O	O
Legaspi	Philippines	13.1611	123.7578	PTWC	sps,spb	1	12	MTSAT	SWPA42	06501C2A	lega	O		O
Legaspi	Philippines	13.1611	123.7578	PTWC	sps,spb	1	12	MTSAT	SWPA42	LEGAA	legaD		O	
Lewes	USA-DE	38.7816	-75.1200	NOS		1			SXXX03	335F2084	ledeA		O	
Lewes	USA-DE	38.7816	-75.1200	NOS		6			SXXX03	335F2084	ledeD		O	
Lewisetta	USA-VA	37.9950	-76.4650	NOS		1			SXXX03	33660644	levaA		O	
Lewisetta	USA-VA	37.9950	-76.4650	NOS		6			SXXX03	33660644	levaD		O	
Limetree_VI	Virgin_islands	17.7000	-64.7500	NOS	pwl,bwl	1	6	GOESE	SXXX03	3364B03E	lime	O	O	

Owenga,Chatham_NZ	New_Zealand	-44.0247	-176.3680	PTWC	sps,spb	2	60	GOESW	SEPS40	932220FC	owen	O	O	
Oyster_Landing	USA-SC	33.3000	-79.2000	NOS		6			SXFL03	334376FA	olscD		O	
Padang	Indonesia	-0.9500	100.3667	UHSLC	sps,rad,enc	1	30	METEOSAT5	SXXX32	12FFB3C8	pada	O	O	O
Pago_Pago_AS	USA-Ter_Am_Samo	-14.2766	-170.6907	NOS	pwl,bwl	1	6	GOESW	SXXX03	3362037E	pago	O	O	
Pago_Pago_AS	USA-Ter_Am_Samo	-14.2766	-170.6907	PTWC	bub	2	60	GOESW	SXTV11	15D6F31E	pago	O		
Panama_City_FL	USA-FL	30.1520	-85.6670	NOS	pwl,bwl	1	6	GOESE	SXXX03	33673124	pcfl	O		
Panama_City_FL	USA-FL	30.1520	-85.6670	NOS	pwl,bwl	1	6	GOESE	SXXX03	3369F052	pcfl		O	
PanamaCityBeach_FL	USA-FL	30.2130	-85.8780	NOS	pwl,bwl	1	6	GOESE	SXXX03	33672252	pbfl	O		
PanamaCityBeach_FL	USA-FL	30.2130	-85.8780	NOS	pwl,bwl	1	6	GOESE	SXXX03	3369D6BE	pbfl		O	
Papeete,Tahiti	Fr._Polynesia	-17.5330	-149.5670	NOS	pwl,bwl	6	180	GOESW	PHPO03	3341D3F6	pape	O		
Papeete,Tahiti	Fr._Polynesia	-17.5330	-149.5670	NOS	pwl,bwl	6	180	GOESW	SXWA03	3341D3F6	pape		O	
Patricia_Bay_BC	CA-BC	48.4000	-123.4000	NOS	pwl,bwl	1	60	GOESW	SXXX03	15C3B04A	pbbc	O		
Patricia_Bay_BC	CA-BC	48.4000	-123.4000	NOS	pwl,bwl	1	60	GOESW	SXAK50	15C3B04A	pbbc		O	
Pemba	Mozambique	-12.9660	40.5500	UHSLC		1	15	METEOSAT5	SXXX32	MZ-NIH1-07	pemb	O	O	O
Penrhyn	Cook_Islands	-9.0011	-158.0511	UHSLC	enc,enb	4	60	GOESW	SEPA40	3540D4C0	penr	O	O	O
Pensacola_FL	USA-FL	30.4030	-87.2120	NOS	pwl,bwl	1	6	GOESE	SXXX03	335E17E4	pnfl	O		
Pensacola_FL	USA-FL	30.4030	-87.2120	NOS	pwl,bwl	1	6	GOESE	SXXX03	33616196	pnfl		O	
Penuelas_PR	Puerto_Rico	17.9667	-66.7619	NOS	pwl,bwl	1	6	GOESE	SXXX03	3366A6BC	penu	O		
Philadelphia	USA-PA	39.9333	-75.1416	NOS		1			SXXX03	33661532	phpaA		O	
Philadelphia	USA-PA	39.9333	-75.1416	NOS		6			SXXX03	33661532	phpaD		O	
Pilots_Station_East	USA-LA	28.8000	-89.4000	NOS		6			SXLA03	335E54DE	pslaD		O	
Platform_Harvest	USA-CA	34.4683	-120.6730	NOS		6			SXCA03	334EC612	phcaD		O	
Pohnpei	Fed_States_Micro	7.0000	158.2181	UHSLC	enc,enb	6	60	GOESW	SXPS40	99991349	pona	O		O
Pohnpei	Fed_States_Micro	7.0000	158.2181	UHSLC	enc,enb	4	60	GOESW	SEPA40	354011DE	ponaF		O	
Pohnpei	Fed_States_Micro	7.0000	158.2181	UHSLC	enc,enb	15	60	GOESW	SEPA40	354011DE	ponaX		O	
Point_Reyes_CA	USA-California	37.9970	-122.9750	NOS	pwl,bwl	6	6	GOESW	SXXX03	3367F43A	ptre	O	O	
Ponta_Delgada_Azor	Azores	37.7300	-25.6800	NOS	pwl,bwl	6	180	GOESW	SXXX03	33537164	pdas	O	O	
Port_Allen,Kauai	USA-Hawaii	21.9030	-159.5920	NOS	pwl,bwl	6	60	GOESW	PHHI03	3342247C	paln	O		
Port_Angeles_WA	USA-Washington	48.1250	-123.4400	NOS	pwl,bwl	1	6	GOESW	SXXX03	336B73B2	pang	O	O	
Port_Chicago_CA	USA-California	38.0567	-122.0383	NOS	pwl,bwl	1	6	GOESW	SXXX03	3362961C	pchi	O	O	
Port_Elizebeth	South_Africa	-33.9666	25.6333			1		METEOSAT7	SXXX33	ZA-PR	prteA		O	
Port_Fourchon	USA-LA	29.1150	-90.2000	NOS		6			SXXX03	334FE204	pflaD		O	
Port_Isabel_TX	USA-TX	26.0600	-97.2150	NOS	pwl,bwl	1	6	GOESW	SXXX03	336950AA	pitx	O	O	
Port_Kemblao_AU	Australia	-34.4739	150.9119	NTF	prs	1	6	GOESE	SZAU01	99960420	pkem	O	O	
Port_La_Rue	Seychelles	-4.6717	55.5283	UHSLC	enc,enb	1	15	METEOSAT5	SXXX32	12FD90D0	laru	O	O	O
Port_Louis	Mauritius	-20.1550	57.4950	UHSLC	enc,enb	1	15	METEOSAT5	SXXX32	165B3038	ptlu	O		O
Port_Louis	Mauritius	-20.1550	57.4950	UHSLC	enc,enb	2	15	METEOSAT5	SXXX32	16590056	ptluA		O	
Port_Louis	Mauritius	-20.1550	57.4950	UHSLC	enc,enb	3	15	METEOSAT5	SXXX32	16590056	ptluE		O	
Port_Louis	Mauritius	-20.1550	57.4950	UHSLC	enc,enb	15	15	METEOSAT5	SXXX32	16590056	ptluX		O	
Port_Orford_OR	USA-Oregon	42.7370	-124.4970	NOS	pwl,bwl	6	60	GOESW	PHOR03	33685250	porf	O		
Port_Orford_OR	USA-Oregon	42.7370	-124.4970	NOS	pwl,bwl	1	60	GOESW	SXXX03	33685250	porfA		O	
Port_Orford_OR	USA-Oregon	42.7370	-124.4970	NOS	pwl,bwl	6	60	GOESW	SXXX03	33685250	porfD		O	
Port_San_Luis_CA	USA-California	35.1680	-120.7530	NOS	pwl,bwl	1	6	GOESW	SXXX03	3362C660	pslu	O	O	
Port_Stanavac_AU	Australia	-35.1086	138.4670	NTF	prs	1	6	GOESE	SZAU01	99961583	pors	O	O	
Port_Townsend_WA	USA-Washington	48.1010	-122.7580	NOS	pwl,bwl	1	1	GOESW	SXXX03	336B9040	ptow	O	O	
Port_Vila	Vanuatu	-17.7500	168.2831	NTF	paq,baq	6	60	GOESW	SXPS85	99991559	porv	O	O	O
Port_Vila	Vanuatu	-17.7500	168.2831	NTF	paq,baq	1	3	GOESW	SZPS01	99991559	porv		O	
Portland_AU	Australia	-38.3434	141.6131	NTF	prs	1	6	GOESE	SZAU01	99961410	porl	O	O	
Portland_ME	USA-ME	43.6600	-70.2500	NOS	pwl,bwl	6	60	GOESE	SXME03	3343658C	ptme	O		
Portland_ME	USA-ME	43.6600	-70.2500	NOS	pwl,bwl	1	60	GOESE	SXXX50	3358B7D2	ptmeA		O	
Portland_ME	USA-ME	43.6600	-70.2500	NOS	pwl,bwl	6	60	GOESE	SXXX50	3358B7D2	ptmeD		O	
Prigi_ID	Prigi	-8.2833	111.7333	UHSLC	prs,rad	1	15	EESA	SXXX33	22E595B6	prig	O		
Providence_RI	USA-RI	41.8100	-71.4000	NOS	pwl,bwl	1	6	GOESW	SXXX03	335F5614	prri	O	O	
Prudence_Island_RI	USA-RI	41.6000	-71.3000	NOS	pwl,bwl	6	6	GOESE	SXXX03	334F6410	blri	O	O	
Prudhoe_Bay_AK	USA-Alaska	70.3880	-148.5100	NOS	pwl,bwl	1	6	GOESW	SXXX03	33611706	prud	O	O	
PTWC_test	USA-Hawaii	21.3040	-157.8670	PTWC	sps,enc	4	180	GOESW	SEHI40	DCAAAF3C	test	O		
Puerto_Montt	Chile	-41.4833	-72.9667	SHOA	sps	2	60	GOESE	SXCH40	ADC063D8	pmon	O	O	O
Puerto_Williams	Chile	-54.9333	-67.6111	SHOA	sps	2	60	GOESE	SXCH40	ADC0935C	pwil	O	O	O
Punta_Carona	Chile	-41.7830	-74.8830	SHOA		2			SXCH40	ADC070AE	pcorB		O	
Quarry_Bay	Hong_Kong	22.2911	114.2133	HK		1	10	NMC	SEHK40	SEHK40	quar			O
Qui_Nhon	Vietnam	13.7750	109.2542	UHSLC	prs,enc,enb	1	15	METEOSAT7	SXXX33	12C65016	quin	O	O	O
Quonset_Point_RI	USA-RI	41.5900	-71.4100	NOS	pwl,bwl	6	180	GOESE	SXXX03	3353A70C	quri	O	O	
Rabaul_PG	Papua_New_Guine	0.0000	152.1750	UHSLC	enc,enb	2	60	GOESW	SRUS40	354084BC	raba	O		
Rarotonga	Cook_Islands	-21.2000	-159.7831	PTWC	enc,enb	4	60	GOESW	SRUS40	93201092	raro	O		
Rarotonga	Cook_Islands	-21.2000	-159.7831	NTF	paq,baq	6	60	GOESW	SXPS83	99991844	raro	O	O	O
Red_Dog_AK	USA-Alaska	67.0650	-164.0650	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360068A	redg	O	O	
Redwood_City_CA	USA-California	37.9280	-122.4000	NOS	pwl,bwl	1	6	GOESW	SXXX03	3362F3FA	rwca	O	O	
Reedy_Point	USA-DE	39.5583	-75.5733	NOS		1			SXXX03	336620A8	rpdeA		O	
Reedy_Point	USA-DE	39.5583	-75.5733	NOS		6			SXXX03	336620A8	rpdeD		O	
Rikitea	French_Polynesia	-23.1333	-134.9500	UHSLC	enc,enb	4	60	GOESW	SEPA40	35411324	riki	O	O	O
Rockport	USA-TX	28.0216	-97.0466	NOS		6			SXTX03	334B04CC	rptxD		O	
Rodrigues	Mauritius	-19.6683	63.4183	UHSLC	enc,enb	1	15	METEOSAT5	SXXX32	16590056	rodr	O	O	O
Rosslyn_Bay_AU	Australia	-23.1611	150.7900	NTF	prs	1	6	GOESE	SZAU01	99959670	ross	O	O	
Sabang	Indonesia	5.8333	95.3333	UHSLC	sps,rad	1	15	METEOSAT5	SXXX32	224AD678	saba	O	O	O
Sabine_Pass_TX	USA-TX	29.7300	-93.8700	NOS	pwl,bwl	1	6	GOESW	SXXX03	33697646	sptx	O	O	
Saipan	USA	15.1833	145.7500	UHSLC		1	15	MTSAT	SWMY40	06506468	saip	O		O

Salalah	Oman	16.9350	54.0067	UHSLC	sps,rad	1	15	METEOSAT7	SXXX33	1605C096	sala	O	O	O
San_Antonio	Chile	-33.5833	-71.6333	SHOA	sps	2	60	GOESE	SXCH40	ADC0063E	sano	O	O	O
San_Diego_CA	USA-California	32.7130	-117.1730	NOS	pwl,bwl	1	6	GOESW	SXXX03	336BC03C	sand	O	O	
San_Felix_CL	Chile	-26.2580	-80.1240	SHOA	bub	2	60	GOESE	SEPO40	93214214	sanf	O	O	
San_Juan_PR	Puerto_Rico	18.4617	-66.1167	NOS	pwl,bwl	1	6	GOESE	SXXX03	335CA19E	sanj	O	O	
San_Pedro	Chile	-47.7167	-74.8833	SHOA		2	60	GOESE	SXCH40	ADC0802A	sanp	O	O	O
Sand_Point_AK	USA-Alaska	55.3367	-160.5017	NOS	pwl,bwl	1	6	GOESW	SXXX03	336093E8	sdpt	O	O	
Sand_Point_AK	USA-Alaska	55.3367	-160.5017	ATWC	pwl	1	0	DREAL	-	ATWC0003	sdpt	O	O	
Sandy_Hook_NJ	USA-NJ	40.4700	-74.0100	NOS	pwl,bwl	1	6	GOESE	SXXX03	33668050	shnj	O	O	
Santa_Barbara_CA	USA-California	34.4080	-119.6850	NOS	pwl,bwl	1	60	GOESW	SXXX03	335F930A	sanb	O	O	
Santa_Monica_CA	USA-California	34.0080	-118.5000	NOS	pwl,bwl	1	6	GOESW	SXXX03	3362D516	sanm	O	O	
Santa_Cruz	Ecuador	-0.7519	-90.3069	PTWC	enc,enb	4	60	GOESE	SEEQ40	932085F0	sant	O	O	O
Seattle	USA-WA	47.6020	-122.3350	NOS		1			SXXX03	3368022C	ellbA		O	
Seattle	USA-WA	47.6020	-122.3350	NOS		6			SXXX03	3368022C	ellbD		O	
Seattle	USA-WA	47.6020	-122.3350	NOS		6			SXXX03	3368022C	ellbZ		O	
Seldovia_AK	USA-Alaska	59.4370	-151.7170	NOS	pwl,bwl	1	60	GOESW	SXXX03	335FD000	seld	O	O	
Severo_Kurilsk	Russia	50.6781	156.1389	PTWC	sps	2	12	NMC	SWRA41	SWRA41	seve	O	O	O
Seward_AK	USA-Alaska	60.1190	-149.4270	NOS	pwl,bwl	1	60	GOESW	SXXX03	335FC376	sewa	O	O	
Sewells_Point_VA	USA-VA	36.9500	-76.3300	NOS	pwl,bwl	1	6	GOESE	SXXX03	3365A1B2	spva	O	O	
Shek_Pik	Hong_Kong	22.2219	113.8944	HK		1	10	NMC	SEHK40	SEHK40	shek			O
Shemya_AK	USA-Alaska	52.7308	174.1031	ATWC	bub	0	0	ANAL	-	ATWC0001	shmy	O	O	
Ship_John_Shoal_NJ	USA-NJ	39.3100	-75.3800	NOS	pwl,bwl	6	60	GOESW	SXXX03	335797AC	jsnj	O	O	
Sibolga	Indonesia	1.7333	98.8000	UHSLC	sps,rad,enb	1	15	METEOSAT5	SXXX32	32BD7124	sibo	O	O	O
Simon's_Town	South_Africa	-34.1833	18.4333			1	15	METEOSAT7	SXXX33	ZA-SITN-06	simo		O	O
Sitka_AK	USA-Alaska	57.0517	-135.3417	ATWC	pwl	1	0	DREAL	-	ATWC0004	sit_	O	O	
Sitka_AK	USA-Alaska	57.0517	-135.3417	NOS	pwl,bwl	1	6	GOESW	SXXX03	33625302	sitk	O	O	
Sittwe	Myannmar	20.1500	92.9000	UHSLC	sps,rad	1	15	METEOSAT7	SXXX33	1227146C	sitt	O		O
Sittwe	Myannmar	20.1500	92.9000	UHSLC	sps,rad	1	15	METEOSAT7	SXXX32	1227146C	sitt		O	
Skagway_AK	USA-Alaska	59.4500	-135.3267	NOS	pwl,bwl	1	6	GOESW	SXXX03	33637714	skag	O	O	
Snug_Harbor,Oahu	USA-Hawaii	21.3180	-157.8850	UHSLC	bub,enc	4	180	GOESW	SEPA40	354271CC	snug	O		
Socorro_Is.	Mexico	18.7169	-110.0169	PTWC	sps,spb	1	15	GOESE	SEMX40	354305A6	soco	O		O
Socorro_Is.	Mexico	18.7169	-110.0169	PTWC	sps,spb	1	15	GOESE	SEPA40	354305A6	socoA		O	
Solomons_Island	USA-MD	38.3166	-76.4516	NOS		1			SXXX03	3367D2D6	simdA		O	
Solomons_Island	USA-MD	38.3166	-76.4516	NOS		6			SXXX03	3367D2D6	simdD		O	
South_Beach_OR	USA-Oregon	44.6250	-124.0430	NOS	pwl,bwl	6	60	GOESW	SXXX03	3368974E	sbea	O	O	
South_Capers_Island	USA-SC	32.9000	-79.7000	NOS		6			SXSE03	334D1774	ciscD		O	
Spring_Bay_AU	Australia	-42.5464	147.9380	NTF	prs	1	6	GOESE	SZAU01	99961170	sprg	O	O	
Springmaid_Pier_SC	USA-SC	33.6550	-78.9180	NOS	pwl,bwl	1	6	GOESE	SXXX03	336620A8	spsc	O		
Springmaid_Pier_SC	USA-SC	33.6550	-78.9180	NOS	pwl,bwl	1	6	GOESE	SXXX03	3367E74C	spscA		O	
Springmaid_Pier_SC	USA-SC	33.6550	-78.9180	NOS	pwl,bwl	6	6	GOESE	SXXX03	3367E74C	spscD		O	
St_Croix_VI	Virgin_islands	17.7419	-64.6922	NOS	pwl,bwl	1	6	GOESE	SXXX03	3365B2C4	stcr	O		
St_Paul_Is	USA-Alaska	57.1250	-170.2750	NOS			6		SXPO03	3345353E	spakD		O	
St_Petersburg_FL	USA-FL	27.7600	-82.6270	NOS	pwl,bwl	1	6	GOESW	SXXX03	3365D722	spfl	O	O	
St_Simons_Is_GA	USA-GA	31.1300	-81.4000	NOS	pwl,bwl	6	180	GOESE	SXXX03	334F87E2	siga	O	O	
Subic_Bay	Philippines	14.8167	120.2833	UHSLC		1	15	METEOSAT7	SXXX33	3226F4BE	subi	O		O
Sunset_Beach	USA-NC	33.9000	-78.5000	NOS		6			SXMD30	335635AE	ssncD		O	
Suva	Fiji_Islands	-18.1369	178.4250	NTF		6	60	GOESW	SXPS92	99991689	suva			O
Suva_Viti_Levu_FJ	Fiji	-18.1342	178.4236	NTF	prs	1	6	GOESE	SZPS01	99967050	viti	O		
Tacoma_WA	USA-Washington	48.1010	-122.7580	NOS	pwl,bwl	6	60	GOESW	PHWA03	3348A33A	taco	O		
Tacoma_WA	USA-Washington	48.1010	-122.7580	NOS	pwl,bwl	1	60	GOESW	SXXX03	33618264	tacoA		O	
Tacoma_WA	USA-Washington	48.1010	-122.7580	NOS	pwl,bwl	6	60	GOESW	SXXX03	33618264	tacoD		O	
TaconyPalmyraBrg_NJ	USA-NJ	40.0500	-75.1000	NOS	pwl,bwl	6	60	GOESE	SXXX03	3357B140	tpnj	O	O	
Takoradi_GA	Ghana	4.1667	-1.7500	UHSLC	rad,prs	0	15	EESA	SXXX33	GA-TA	tako	O	O	
Talcahuano	Chile	-36.6833	-73.1000	SHOA	sps	2	60	GOESE	SXCH40	ADC04534	talc	O	O	O
Tern,Fr._Frigate	USA-Hawaii	23.7831	-166.2169	PTWC	bub	1		GOESW	SXHW11	15D58280	fren	O	O	O
TesoroMarTerminl_LA	USA-LA	29.6700	-91.2400	NOS	pwl,bwl	6	180	GOESE	SXXX03	3352D366	ttla	O	O	
The_Battery	USA-NY	40.7000	-74.0150	NOS		6			SXXX03	336670D4	btnyD		O	
Thevenard_AU	Australia	-32.1489	133.6413	NTF	prs	1	6	GOESE	SZAU01	99962000	thev	O	O	
Tofino_BC	Canada-BC	49.1500	-125.9100	NOS	pwl,bwl	6	60	GOESW	SXAK50	15C3A33C	tfbc	O	O	
Tokai	Japan	33.7700	137.5900	JMA	prs	1	15	NMC	SWJP50	TOKAI	toka	O	O	O
Toke_Point	USA-WA	46.7050	-123.9590	NOS		1			SXXX03	336B30B8	tpwaA		O	
Toke_Point	USA-WA	46.7050	-123.9590	NOS		6			SXXX03	336B30B8	tpwaD		O	
Tolchester_Beach	USA-MD	39.2133	-76.2450	NOS		6			SXMD03	334C5684	tbmdD		O	
Tosashimizu	Japan	32.7800	132.9700	JMA	enc	1	15	NMC	SWJP40	TOSASHIMIZU	shim	O	O	O
Trident_Pier_FL	USA-FL	28.4200	-80.5900	NOS	pwl,bwl	1	6	GOESE	SXXX03	3367722E	tpfl	O	O	
Trinconmalee	Sri_Lanka	8.5636	81.1994	UHSLC	prs,rad	1	15	METEOSAT7	SXXX33	322952D4	trin	O	O	O
Ushuaia	Argentina	-54.8083	-68.3000	NOS		6			SXAG03	334CE50A	ushuD		O	
Ust-Kamchatsk	Russia	56.2000	162.5000	PTWC	sps	2	12	MTSAT	SWRA40	SWRA40	ustk	O	O	O
Vaca_Key_FL	USA-FL	24.7170	-81.1050	NOS	pwl,bwl	1	6	GOESE	SXXX03	336704BE	vkfl	O	O	
Valdez_AK	USA-Alaska	61.1250	-146.3620	NOS	pwl,bwl	1	6	GOESW	SXXX03	335FB5E6	vald	O	O	
Valparaiso_CL	Chile	-33.0330	-71.6170	SHOA	bub,enc	2	60	GOESE	SECH40	932127F2	valp	O	O	
Vanuatu_VU	Vanuatu	-17.7614	168.2931	NTF	prs	1	6	GOESE	SZPS01	99957320	vanu	O		
Vieques_Is1_PR	Puerto_Rico	18.0939	-65.4714	NOS	pwl,bwl	1	6	GOESE	SXXX03	335CC478	vieq	O	O	
Vieques_Is2_PR	Puerto_Rico	18.1500	-65.4438	NOS	pwl,bwl	1	6	GOESE	SXXX03	3366D02C	viqu	O	O	
Vilano_Beach	USA-FL	29.9000	-81.3000	NOS		6					vbflD		O	
Virgina_Key	USA-FL	25.7316	-80.1616	NOS		6			SXFL03	3343006A	vkflD		O	

Wachapreague_VA	USA-VA	37.6000	-75.6000	NOS	pwl,bwl	1	6	GOESE	SXXX03	33659428	wava	O	O	
Waianae,Oahu	USA-Hawaii	21.4400	-158.1700	PTWC	enc	2	0	LARC	-	LARC0008	waia	O		
Waitangi,Chatham_NZ	New_Zealand	-43.9458	-176.5608	PTWC	sps,enc	2	60	GOESW	SEPS40	9321E2EC	wait	O	O	
Wake	USA-Territory	19.2892	166.6214	NOS	pwl,bwl	1	6	GOESW	SXXX03	33638790	wake	O	O	
Wake	USA-Territory	19.2892	166.6214	NOS	pwl,bwl	1	6	GOESW	SXXX03	3361477A	wakx	O	O	
Wake	USA-Territory	19.2892	166.6214	NOS	pwl,bwl	1	6	GOESW	SXHW11	93201F40	waky	O		O
Washington_DC	USA-DC	38.8700	0.0000	NOS	pwl,bwl	1	6	GOESE	SXXX50	335861BA	wsdc	O	O	
Waveland	USA-MS	30.2816	-89.3666	NOS		6			SXOH03	334A63D0	wlmsD		O	
Wells	USA-ME	43.3166	70.5500	NOS		6			SXXX03	335D667A	wellD		O	
West_Bank_LA	USA-LA	29.7800	-90.4200	NOS	pwl,bwl	1	6	GOESE	SXXX03	3368B1A2	wbla	O	O	
Westport,WA	USA-Washington	46.9083	-124.1100	NOS	pwl,bwl	1	6	GOESW	SXXX03	33632768	wpwa	O	O	
Willapa_Bay,Toke_Pt	USA-Washington	46.7050	-123.9590	NOS	pwl,bwl	1	6	GOESW	SXXX03	336B30B8	wilb	O		
Wilmington_NC	USA-NC	34.2270	-77.9530	NOS	pwl,bwl	1	6	GOESE	SXXX03	3364362A	winc	O	O	
Windmill_Point_VA	USA-VA	37.6200	-76.2900	NOS	pwl,bwl	1	6	GOESW	SXXX03	335D3606	wpva	O	O	
Winter_Harbour_BC	Canada-BC	50.7000	-128.3000	NOS	pwl,bwl	6	60	GOESW	SXAK50	15C385D0	whbc	O	O	
Woods_Hole	USA-MA	41.5233	-70.6666	NOS		6			SXMA03	3340C27A	womaD		O	
Wright_Beach_NC	USA-NC	34.2100	-77.7950	NOS	pwl,bwl	1	60	GOESE	SXXX03	335E7202	wbnc	O		
Wright_Beach_NC	USA-NC	34.2100	-77.7950	NOS	pwl,bwl	1	60	GOESE	SXNC03	335E7202	wbncA		O	
Wright_Beach_NC	USA-NC	34.2100	-77.7950	NOS	pwl,bwl	6	60	GOESE	SXNC03	335E7202	wbncD		O	
Yabucoa_PR	Puerto_Rico	18.0501	-65.8330	NOS	pwl,bwl	1	6	GOESE	SXXX03	3366B5CA	yabu	O		
Yakutat_AK	USA-Alaska	59.5480	-139.7350	NOS	pwl,bwl	1	6	GOESW	SXXX03	3360E578	yaku	O	O	
Yap	Fed_States_Micro	9.5142	138.1247	PTWC	enc,enb	1	12	MTSAT	SWPA41	065012F8	yapi	O	O	O
Yorktown	USA-VA	37.2266	-76.4783	NOS		6			SXVA03	335E6174	ytvaD		O	
Zanzibar	Tanzania	-6.1500	39.1833	UHSLC	prs,rad	1	15	METEOSAT7	SXXX33	1605D3E0	zanz	O	O	O

enc --- an encoder measuring sea level in a stilling well
enb --- a second encoder at the same site
prs --- a pressure sensor
pr2 --- a second pressure sensor at the same site
rad --- a radar sensor

(*) The above table includes stations outside the Pacific region.
(**) Stations occasionally stop thir operation as well as there are often found missing data. Therefore, it is not always guaranteed that all stations' data will be appered on the tsunami bulletins issued by the international centers.
(***) The 4-letters codes appear on the PDC google-Earth based station metadata tool: http://www.pdc.org/pride/ptwc/stations.kml.

SECTION 4 - PACIFIC TSUNAMI WARNING CENTER (PTWC)

4.1 INTRODUCTION

The Pacific Tsunami Warning Center (PTWC) located in Ewa Beach, Hawaii, is operated by the Pacific Region of the U.S. National Weather Service and is a part of the U.S. National Oceanic and Atmospheric Administration (NOAA). The PTWC serves as the operational center for the PTWS. It continuously receives, processes, and evaluates seismic and sea level data from within and surrounding the Pacific region. Based on that information it creates and issues text and other products to PTWS participants as well as to other nations, states or dependencies within and bordering the Pacific Ocean basin regarding the occurrence of a major earthquake and the threat from possible or confirmed tsunami waves. PTWC also serves as a backup to WC/ATWC and would its products, including those to Canada, should WC/ATWC ever become disabled.

4.2 AREA OF RESPONSIBILITY

PTWC's area of responsibility (AOR) for issuing PTWS warnings and other messages includes all coasts in the Pacific Ocean except those covered by WC/ATWC (Alaska, British Columbia, Washington, Oregon, and California). It also includes the Russian coast of the Bering Sea, and all coasts in the South China Sea, Sulu Sea, Celebes Sea, Philippine Sea, Bismarck Sea, Solomon Sea, Coral Sea, and Tasman Sea. It does not include coasts in the Sea of Okhotsk, Sea of Japan or East Sea, East China Sea, Molucca Sea, and Banda Sea although an informational bulletin would still be issued following any large earthquake that occurs within or near those regions. Outside the Pacific, PTWC's AOR currently includes all coasts in the Indian Ocean, as well as all coasts in the Caribbean except those covered by WC/ATWC (Puerto Rico and the U.S. and British Virgin Islands). PTWC's Indian Ocean and Caribbean responsibilities are on an interim basis.

4.3 OPERATIONAL PROCEDURES

4.3.1 Response and Analysis

Functioning of the system begins with the detection of an earthquake of sufficient size to trigger an alarm at PTWC. Generally, this will occur within a few minutes of the occurrence of any earthquake in the Pacific region with a magnitude above about 5.7. Duty personnel respond immediately and begin their analysis of the event. PTWC is staffed on a 24x7 basis to be able to respond immediately. The analysis includes automatic and interactive processes for determining the earthquake's epicenter, depth, and origin time, as well as its magnitude. Using criteria based on this analysis, PTWC issues appropriate initial messages. If a warning was issued or if there is otherwise the possibility that a tsunami may have been generated, PTWC will examine records from nearby coastal and deep ocean sea level gauges. From the seismic and sea level data, as well as any other reports, it will be determined whether a tsunami was generated, and if so its characteristics. Then, from historical and numerical model forecasts, the level of threat it represents will be estimated. If necessary, addition messages will be issued appropriately reflecting the estimated level of threat.

The PTWC staff level was increased in 2005 and 2006 so that it could operate 24 hours every day with two watchstanders always on duty. The center began 24x7 shift operations on April 26, 2006.

4.3.2 Message Types and Criteria

For most alarm earthquakes an informal ***Observatory Message*** is issued to a limited number of recipients that contains PTWC's preliminary reviewed earthquake parameters. These earthquake parameters may be further refined before any additional products are issued.

Based on the evolving earthquake parameters, a decision is made concerning further action. If the earthquake is within or near the Pacific Ocean basin and its moment magnitude is greater than 6.5, but less than or equal to 7.5, or if it has a larger magnitude but is more than 100 km below the surface of the earth, or if it is located well inland, then a ***Tsunami Information Bulletin*** is issued to the PTWS participants. The bulletin indicates no threat of a widespread tsunami, but that in some cases a local tsunami may occur. A ***Regional Fixed Tsunami Warning*** is issued to PTWS participants for earthquakes with a moment magnitude of 7.6 to 7.8, alerting them to the possibility that a local or regional tsunami has been generated that could affect coasts located within 1000 km of the epicenter. Subsequent bulletins, issued at least hourly, do not expand the warning area but provide additional data and evaluations until the warning is cancelled or upgraded. A ***Regional Expanding Tsunami Warning and Watch*** is issued for earthquakes with a moment magnitude of 7.9 and greater. Areas within 3 hours of the estimated arrival time of the first tsunami wave are put in a Warning and areas within 3 to 6 hours are put into a Watch. Subsequent bulletins are issued at least hourly that provide additional information and, because the tsunami is propagating outward from the epicenter, appropriately expand the Warning and Watch areas. If a tsunami is confirmed with widespread destructive potential then a ***Pacific-Wide Warning*** is issued to cover the entire Pacific within PTWC's area of responsibility. Subsequent bulletins are issued at least hourly to provide additional observations and evaluations until the threat has largely passed and final bulletin is issued.

The criteria used for the issuance of each of these types of products are based primarily on an analysis of historical data (IOC/ITSU-XVIII/12) and are summarized in the following table.

Earthquake Moment Magnitude	Earthquake Depth	Epicenter on Land or at Sea	Product Type
~5.7 and greater	-	-	Observatory Message
6.5 to 7.5	-	-	Tsunami Information Bulletin
7.6 and greater	≥ 100 km	-	
7.6 and greater	-	Inland	
7.6 to 7.8	< 100 km	Near Shore or Offshore	Regional Fixed Tsunami Warning
7.9 and greater	< 100 km	Near Shore or Offshore	Regional Expanding Warning and Watch
Confirmed tsunami with widespread destructive potential			Pacific-Wide Warning

Whenever any kind of Warning is issued, as well as for near-warning-level events, PTWC continuously monitors water level data from the sea level stations located near the epicenter for evidence of a tsunami. Based on these data and on any credible reports of tsunami wave activity from national agencies or the media, and using historical data and numerical forecast model outputs for decision guidance, an evaluation of the threat is made. If a tsunami has been generated that poses a continuing threat, the current level of alert will continue or be upgraded until there is no longer the threat of a destructive tsunami. In response to a PTWC Warning or Watch, national or regional authorities must implement their own pre-determined procedures that can include issuing evacuation instructions to coastal areas when appropriate. If sea level and all other data indicate, however, that a destructive tsunami has not been generated or that there is no further threat then PTWC issues a cancellation of its previously disseminated Warning. This is most often the case since most large earthquakes with the potential to generate a destructive tsunami do not actually do so.

Initial products from PTWC for the Pacific are typically issued within 10-20 minutes of the earthquake depending upon the spatial density of nearby seismic stations. This density is insufficient to produce the more rapid warnings required for local tsunamis. In areas threatened by local tsunamis, at-risk populations need to be educated about natural warning signs such as strong shaking from the earthquake or a withdrawal of the sea, and be ready to immediately evacuate when such signs occur. Local warning systems that utilize higher density seismic and sea level networks in order to respond more quickly with an official warning can also be implemented.

In a warning situation, bulletins are issued by PTWC at least hourly or sooner if the situation warrants, until the threat has passed.

4.4 OPERATIONAL LIMITATIONS

The science of rapidly and accurately forecasting tsunamis has made important strides in recent years but challenges remain. Limitations of PTWC's operational warnings should be known and understood in order to best plan for and execute an appropriate response.

4.4.1 Earthquake Parameters

Earthquake parameters provide the earliest indication of a potential tsunami because seismic waves travel much faster around the earth than tsunami waves. Consequently, the fastest initial tsunami warnings are based entirely on the preliminary earthquake parameters. However, most large earthquakes with the potential to generate a widespread destructive tsunami actually do not do so, and consequently most warnings based on the preliminary earthquake parameters are eventually cancelled later when significant tsunami waves are not observed. A number of factors contribute to this limitation including: 1) the tsunami is generated primarily by earthquake induced vertical seafloor displacements and this phenomenon is not directly measured with the seismic waves, 2) the magnitude threshold for warnings is set at a conservative level to ensure a significant tsunami is not missed, 3) the magnitude threshold is further set at a conservative level to take into account uncertainties in the preliminary magnitude, and 4) there are many more earthquakes with magnitudes near the conservative threshold than ones far above it where a destructive tsunami is more certain.

4.4.2 Initial Estimated Arrival Times

PTWC's initial estimated arrival times are typically computed from the epicenter of the earthquake to each forecast point using the physics principle that a wave will travel from point A to point B over whatever path in space (the ocean in this case) gets it there the fastest. There are two limitations to this method. The first is the inaccuracy of representing the tsunami source by a point located at the epicenter. For great earthquakes, the ones most likely to produce a tsunami, the earthquake rupture will start at the epicenter but it can extend for tens or even hundreds of kilometers away from the epicenter. As a consequence, the tsunami source may not be like a point and it may not be located at the epicenter. The second limitation is that the fastest path from the epicenter to the forecast point may not a path over which much energy has traveled. Consequently, the first arriving tsunami waves may be small compared to later arriving waves. The net result of both limitations is that significant tsunami waves may arrive tens of minutes sooner or later than the predicted arrival time and that such errors may be largest in the biggest events. At present it is not possible to quickly know the precise dimensions or location of the tsunami source. These parameters may only become available once the tsunami forecast model is sufficiently constrained with sea level readings, and this methodology is still untested for major events and is in its implementation stage. Consequently, for now, estimated tsunami arrival times must be used cautiously and conservatively, expecting that tsunami impact could be sooner or later than predicted.

4.4.3 Area of Warnings and Watches

PTWC puts any particular coastal area in the Pacific into a warning or watch based only on whether either 1) the area is within a thousand kilometers of the source of a potentially destructive tsunami (under a Regional Fixed Tsunami Warning), 2) the area is within six hours travel time of a potentially destructive tsunami (under a Regional Expanding Tsunami Warning and Watch), or 3) the area is in PTWC's Pacific area of responsibility (under a Pacific-Wide Tsunami Warning). Historical data and numerical model outputs show that tsunamis do not affect all areas equally. Significant differences can be due to directionality associated with the source, focusing and defocusing by bathymetry, attenuation by spreading and friction, and blockage by land masses. Consequently, some areas currently put into warning or watch status may not actually be threatened. As the forecasting capabilities of the PTWC become quicker and more accurate in coming years due to improved earthquake analyses, more deep ocean data, and improved numerical forecast models, then warnings can be based on expected tsunami amplitudes instead of expected arrival times or distances from the epicenter. For now, this more conservative and simplified approach remains in place.

4.5 TYPES OF PTWC MESSAGES

As mentioned above, PTWC issues four basic categories of bulletins in response to large earthquakes or other potential tsunami events. A fifth category of bulletin is issued between events to test communication links.

4.5.1 Tsunami Information Bulletin

A message issued to advise PTWS participants of the occurrence of a major earthquake in or near the Pacific, with an evaluation that there is either: a) no widespread tsunami threat but the small possibility of a local tsunami or b) there is no tsunami threat at all because the earthquake is located inland or deep inside the earth. A supplement or higher level of alert will be issued if tsunami waves are observed on nearby sea level gauges.

4.5.2 Regional Fixed Tsunami Warning Bulletin

A message based initially on only seismic information that alerts all PTWS participants of the possibility of a regional tsunami. It advises that a tsunami investigation is underway. The area placed in Tsunami Warning status encompasses coastal regions within 1000-km of the earthquake epicenter. A Regional Fixed Tsunami Warning will be followed by additional bulletins at least once an hour until the warning is either upgraded or canceled. The fixed regional warning will not expand, unless conditions warrant an upgraded status. Responsible agencies in each area under a warning should evaluate the probability of a tsunami impacting their area and carry out appropriate actions according to their predetermined standard operating procedures.

4.5.3 Regional Expanding Tsunami Warning and Watch Bulletin

A message based initially on only seismic information that alerts all PTWS participants of the possibility of a widely destructive tsunami. It advises that a tsunami investigation is underway. Warning status will encompass regions having less than 3 hours until the estimated time of tsunami arrival. Those areas having 3 to 6 hours will be placed in a Watch status. Additional bulletins will be issued hourly or sooner until either a Pacific-wide tsunami is confirmed or no further tsunami threat exists. If there is no cancellation, the warning and watch regions will continue to expand outward from the earthquake epicenter in an hourly rate. Responsible agencies in each area under a warning should evaluate the probability of a tsunami impacting their area and carry out appropriate actions according to their predetermined standard operating procedures.

4.5.4 Pacific-Wide Tsunami Warning Bulletin

A warning issued to all PTWS participants after there is confirmation of tsunami waves capable of causing destruction beyond the local area. Such waves may pose a threat to coastal populations in part or all of the Pacific Basin. Updated information will be issued at least once an hour until the Pacific-Wide Tsunami Warning is canceled or a final bulletin is issued. Responsible agencies in all areas should evaluate the probability of a tsunami impacting their area and carry out appropriate actions according to their predetermined standard operating procedures.

4.5.5 Communication Test

A test message issued by PTWC, usually at unannounced times to determine delays in disseminating tsunami bulletins, to test the operation of the warning system by requiring a response, and to keep PTWS operations personnel familiar with the procedures for handling tsunami message traffic. Communication tests will take place approximately four times per year, and may be issued by WC/ATWC to exercise their backup role. Results of communication tests will be provided to ITIC to help facilitate its performance monitoring of the PTWS.

4.6 PTWC ALERT STATUS DEFINITIONS

4.6.1 Tsunami Warning

A tsunami warning is issued by PTWC 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 arrival of the initial wave. Warnings also 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.

4.6.2 Tsunami 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 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.

4.6.3 Tsunami Advisory

Advisories are issued to coastal populations within areas not currently in either warning or watch status when a tsunami warning has been issued for another region of the same ocean. An Advisory indicates that an area is either outside the current warning and watch regions or that the tsunami poses no danger to that area. PTWC will continue to monitor the event, issuing updates at least hourly. As conditions warrant, the Advisory will either be continued, upgraded to a watch or warning, or ended.

4.6.4 Tsunami Information

Tsunami information, issued in a Tsunami Information Bulletin, is to inform that an earthquake has occurred and to advise regarding its potential to generate a tsunami. In most cases there is no threat of a destructive tsunami, and the information is used to prevent unnecessary evacuations as the earthquake may have been strongly felt in coastal areas. The information may, in appropriate situations, caution about the possibility of a destructive local tsunami for coasts located near an earthquake epicenter (usually within 100 km). Because it takes 10-20 minutes for PTWC initial bulletins to be issued, they are typically not effective for a local tsunami that can be onshore in just minutes. In such situations, however, the information can be useful to local authorities so they can at least investigate if a tsunami has occurred and if so quickly initiate recovery procedures. A Supplemental tsunami information may be issued if, for example, a sea level reading showing a tsunami signal is received.

4.6.5 Warning Cancellation

A cancellation indicates 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. A cancellation will also be issued following a destructive tsunami when sea level readings indicate that the tsunami is below destructive levels and subsiding in most locations that can be monitored by PTWC.

4.7 ALL CLEAR DETERMINATION

An “All Clear”, or its equivalent, is usually issued by local authorities following any type of near or actual disaster to inform the public that it is safe to re-enter evacuated areas and resume normal activities. Following a destructive tsunami, PTWC will issue a warning cancellation. PTWC does not, however, receive enough data to determine when the danger has passed in all coastal areas. Local conditions can cause wide variations in tsunami wave action and additional hazards such as fires, chemical spills, or downed power lines may exist following a destructive tsunami. Consequently, “All Clear” determinations must be made by local authorities and not by PTWC. In general, local authorities can assume the tsunami danger has passed when their area is free from damaging waves for at least 2 hours after the last destructive wave or if no destructive waves have occurred for at least two hours after the expected tsunami arrival time. Local conditions including seiching in bays and harbors, wave resonance along continental shelves, and strong currents in channels and harbors can persist for many hours and delay the “All Clear”.

4.8 PTWC TEXT PRODUCT FORMAT AND CONTENT

PTWC text products are composed of the following key elements:

4.8.1 Product Header (PH)

The Product Header has just three lines. The first line indicates that this is tsunami bulletin and it shows the number of the bulletin. Bulletins are numbered starting with 1 for each event and continue in sequence. Numbers continue to increment in sequence, even if the status changes from one type of bulletin (e.g., a Tsunami Information Bulletin) to another (e.g., a Regional Fixed Warning). The second line indicates the issuing office, the Pacific Tsunami Warning Center. Note that this line would remain the same even in the case of WC/ATWC issuing the product as a backup for PTWC. The third line indicates the date and time that the bulletin was issued.

Sample Product Header

```
TSUNAMI BULLETIN NUMBER 002
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 2232Z 24 JUN 2007
```

4.8.2 Coverage Area (AC)

Immediately following the Product Header is a statement regarding the area that the bulletin is intended to cover. PTWC bulletins for the PTWS apply to the entire Pacific and its adjacent seas, except for the Pacific area covered by WC/ATWC that is Alaska, British Columbia, and the U.S. West Coast.

Coverage Area

```
THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.
```

4.8.3 Headline (HL)

Following the Coverage Statement is the Headline. It is a single line to describe the current situation, with an ellipsis at each end.

Sample Headlines

```
... TSUNAMI INFORMATION BULLETIN ...
... A TSUNAMI WARNING AND WATCH ARE IN EFFECT ...
... TSUNAMI WARNING CANCELLATION ...
```

4.8.4 Authority Statement (AS)

Following the Headline is the Authority Statement. It indicates that the PTWC bulletin is issued as advice only and that the condition of alert in each area is up to national or local authorities.

Sample Authority Statement

```
THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES.  ONLY
NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND
ANY ACTIONS TO BE TAKEN IN RESPONSE.
```

4.8.5 Earthquake Parameters (EP)

Following the Authority Statement are the Earthquake Parameters. These are preliminary parameters determined quickly for tsunami purposes. They may be revised following the initial bulletin as more data are received. Small differences between these parameters and those that may be issued by other agencies are normal.

Sample Earthquake Parameters

```
AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  2134Z 24 JUN 2007
 COORDINATES -  23.7 SOUTH   71.2 WEST
 DEPTH       -  42 KM
```

```
LOCATION    -  OFF COAST OF NORTHERN CHILE
MAGNITUDE   -  6.6
```

4.8.6 Tsunami Wave Measurements (TM)

When such data become available, usually after an initial bulletin, PTWC will report tsunami wave measurements from key coastal and deep ocean gauges. Each measurement includes the name of the gauge, the coordinates of the gauge, the time of the measurement, the amplitude of the wave in meters and feet, and the period of the wave cycle in minutes. These measurements, while generally indicative of whether a tsunami has been generated and the size of the tsunami, should only be further interpreted by experts. The character of tsunami waves in the deep ocean and at the shore is outside normal human experience and is non-intuitive. For example, a tsunami measuring only a few centimeters or inches on a deep ocean gauge can create flooding at the shore. In addition, because readings are evolving, values reported for a particular gauge may change significantly from one bulletin to the next or when reported by different Centers.

Sample Tsunami Wave Measurements

```
MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

 GAUGE LOCATION       LAT   LON    TIME       AMPL        PER
 -------------------  ----- ------  -----  ---------------  -----
 CALDERA CL          27.1S  70.8W  2205Z   0.44M /  1.5FT  54MIN
 ANTOFAGASTA CL       23.6S  70.4W  2251Z   0.25M /  0.8FT  24MIN
 IQUIQUE CL          20.2S  70.2W  2245Z   0.23M /  0.7FT  34MIN

 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.
```

4.8.7 Evaluation Statement (ES)

All bulletins contain an evaluation statement. This is a general statement of the current situation along with an assessment of the tsunami threat. It may also contain advice regarding the appropriate response actions.

Sample Evaluation Statement

```
EVALUATION

 SEA LEVEL READINGS INDICATE A TSUNAMI WAS GENERATED. IT MAY HAVE
 BEEN DESTRUCTIVE ALONG COASTS NEAR THE EARTHQUAKE EPICENTER. FOR
 THOSE AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS
 AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT
 OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME
 THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN
 CONTINUE FOR SEVERAL HOURS DUE TO THE CONTINUING SEA LEVEL
 CHANGES AND RAPID CURRENTS.  AS LOCAL CONDITIONS CAN CAUSE A WIDE
 VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST
 BE MADE BY LOCAL AUTHORITIES.
```

NO TSUNAMI THREAT EXISTS FOR OTHER COASTAL AREAS IN THE PACIFIC ALTHOUGH SOME OTHER AREAS MAY EXPERIENCE SMALL NON-DESTRUCTIVE SEA LEVEL CHANGES LASTING UP TO SEVERAL HOURS.

4.8.8 Estimated Arrival Times (AT)

Following the Headline is the Authority Statement. It indicates that the PTWC bulletin is issued as advice only and that the condition of alert in each area is up to national or local authorities.

Sample Estimated Arrival Times

ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES AT FORECAST POINTS WITHIN THE WARNING AREA ARE GIVEN BELOW. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN SUCCESSIVE WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION	FORECAST POINT	COORDINATES	ARRIVAL TIME
CHILE	ANTOFAGASTA	23.5S 70.5W	2142Z 24 JUN
	CALDERA	27.0S 70.8W	2205Z 24 JUN
	IQUIQUE	20.2S 70.1W	2211Z 24 JUN
	ARICA	18.5S 70.3W	2228Z 24 JUN
	COQUIMBO	29.8S 71.3W	2230Z 24 JUN
	VALPARAISO	33.0S 71.6W	2254Z 24 JUN
PERU	MOLLENDO	17.2S 72.0W	2233Z 24 JUN
	SAN JUAN	15.3S 75.2W	2254Z 24 JUN

4.8.9 Product Schedule (PS)

Near the end of the bulletin is a statement regarding future bulletins. Warning products are issued on an hourly schedule unless significant new information is received or the PTWC warning is entirely cancelled.

Sample Product Schedule Statement

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT. THE TSUNAMI WARNING WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE.

4.8.10 Other Centers' Actions (OC)

At the very end of the bulletin is a statement regarding products that may be issued by other TWCs. During major events .

Sample Statement regarding Other Centers' Actions

THE JAPAN METEOROLOGICAL AGENCY MAY ALSO ISSUE TSUNAMI MESSAGES FOR THIS EVENT TO COUNTRIES IN THE NORTHWEST PACIFIC AND SOUTH CHINA SEA REGION. IN CASE OF CONFLICTING INFORMATION... THE MORE CONSERVATIVE INFORMATION SHOULD BE USED FOR SAFETY.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.

4.8.11 Table of Product Content

The following table shows which of these elements normally appear in each type of PTWC bulletin.

Bulletin Type	Sequence	Bulletin Element									
		PH	CA	HL	AS	EP	TM	ES	AT	PS	OC
Tsunami Information Bulletin	Initial	Y	Y	Y	Y	Y	N	Y	N	Y	Y
	Supplement	Y	Y	Y	Y	Y	O	Y	N	Y	Y
Regional Fixed Tsunami Warning	Initial	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Supplement	Y	Y	Y	Y	Y	O	Y	Y	Y	Y
	Cancellation	Y	Y	Y	Y	Y	O	Y	N	Y	Y
Regional Expanding Tsunami Warning and Watch	Initial	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Supplement	Y	Y	Y	Y	Y	O	Y	Y	Y	Y
	Cancellation	Y	Y	Y	Y	Y	O	Y	N	Y	Y
Pacific-Wide Tsunami Warning	Initial	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Supplement	Y	Y	Y	Y	Y	O	Y	O	Y	Y
	Cancellation	Y	Y	Y	Y	Y	O	Y	N	Y	Y

Y=yes, N=no, O=optional

4.9 FORECAST POINTS

For each country or other entity in PTWC's area of responsibility one or more coastal forecast points have been assigned, as shown in the table below. For a Fixed Regional Tsunami Warning, if any forecast point of a country is within 1000 km of the earthquake epicenter then that country is named in the warning. For a Regional Expanding Tsunami Warning and Watch, if any forecast point of a country has less than three hours to its estimated tsunami arrival time then that country is named in the warning, and if three to six hours then it is named in the watch if not already in a warning. In the bulletins, only forecast points that meet the warning or watch criteria are listed with their estimated tsunami arrival times. In the case of a Pacific-Wide Tsunami Warning, all forecast points are listed.

Most of the forecast points have been unilaterally designated by PTWC to provide an even spatial sampling and a list that is not too lengthy for bulletins. However, forecast points may also be requested of PTWC by Member States through their National Contact to meet their particular needs.

Table of PTWC Tsunami Forecast Points

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
AMERICAN SAMOA	PAGO PAGO	-14.300	-170.700
ANTARCTICA	THURSTON IS.	-72.000	-100.000
	CAPE ADARE	-71.000	170.000
AUSTRALIA	HOBART	-43.270	147.650
	SYDNEY	-33.860	151.450
	BRISBANE	-27.220	153.300
	GLADSTONE	-23.820	151.440
	MACKAY	-21.060	149.270
	CAIRNS	-16.740	145.790
BELAU	MALAKAL	7.300	134.500
BRUNEI	MUARA	5.000	115.100
CAMBODIA	SIHANOUKVILLE	10.600	103.600

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
COLOMBIA	TUMACO	1.820	-78.860
	BUENAVENTURA	3.800	-77.200
	BAHIA SOLANO	6.300	-77.400
COOK ISLANDS	RAROTONGA	-21.200	-159.800
	PUKAPUKA IS.	-10.800	-165.860
	PENRYN IS.	-8.880	-157.840
COSTA RICA	CABO MATAPALO	8.350	-83.290
	PUERTO QUEPOS	9.400	-84.200
	CABO SAN ELENA	10.850	-86.040
CHILE	PUERTO WILLIAMS	-54.800	-68.200
	PUNTA ARENAS	-53.200	-70.900
	GOLFO DE PENAS	-47.100	-74.890
	PUERTO MONTT	-41.500	-73.000
	CORRAL	-39.770	-73.540
	TALCAHUANO	-36.700	-73.100
	VALPARAISO	-33.000	-71.600
	COQUIMBO	-29.930	-71.350
	EASTER IS.	-27.150	-109.450
	CALDERA	-27.100	-70.800
	ANTOFAGASTA	-23.320	-70.430
	IQUIQUE	-20.200	-70.100
	ARICA	-18.500	-70.300
CHINA	HONG KONG	22.300	114.200
	HONG KONG	22.300	114.200
CHUUK	CHUUK IS.	7.445	151.845
ECUADOR	LA LIBERTAD	-2.190	-81.230
	BALTRA IS.	-0.500	-90.300
	ESMERELDAS	1.170	-79.790
EL SALVADOR	ACAJUTLA	13.600	-89.800
FIJI	SUVA	-18.137	178.425
FR. POLYNESIA	RIKITEA	-23.100	-135.000
	PAPEETE	-17.533	-149.567
	HIVA OA	-10.000	-139.000
GUAM	GUAM	13.436	144.652
GUATEMALA	SIPICATE	13.900	-91.230
HAWAII	HILO	19.700	-155.100
	HONOLULU	21.300	-157.900
	NAWILIWILI	21.957	-159.360
HONDURAS	AMAPALA	13.230	-87.640
HOWLAND-BAKER	HOWLAND IS.	0.550	-176.620
INDONESIA	JAYAPURA	-2.410	140.760
	PANGKALPINANG	-2.100	106.100
	MANOKWARI	-0.810	134.210
	SORONG	-0.810	131.130
	WARSA	-0.620	135.790
	PATANI	0.430	128.760
	SINGKAWANG	1.000	109.000
	MANADO	1.600	124.900
	BEREBERE	2.460	128.690
	TARAKAN	3.300	117.600
	GEME	4.590	126.800

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
JAPAN	OKINAWA	26.200	127.800
	SHIMIZU	32.800	133.000
	KATSUURA	35.110	140.330
	HACHINOHE	40.500	141.500
	KUSHIRO	42.900	144.330
JARVIS IS.	JARVIS IS.	-0.370	-160.050
JOHNSTON IS.	JOHNSTON IS.	16.738	-169.525
KERMADEC IS	RAOUL IS.	-29.210	-177.940
KIRIBATI	FLINT IS.	-11.400	-151.820
	MALDEN IS.	-3.940	-154.900
	KANTON IS.	-2.820	-171.670
	TARAWA IS.	1.500	173.000
	CHRISTMAS IS.	1.980	-157.480
KOSRAE	KOSRAE IS.	5.500	163.000
MALAYSIA	BINTULU	3.200	113.000
	K TERENGGANU	5.300	103.200
	SANDAKAN	5.900	118.100
MARCUS IS.	MARCUS IS.	24.300	154.000
MARSHALL IS.	MAJURO	7.117	171.370
	KWAJALEIN	8.700	167.700
	ENIWETOK	11.400	162.300
MEXICO	PUERTO MADERO	14.790	-92.530
	ACAPULCO	16.900	-99.900
	SOCORRO	18.800	-111.000
	MANZANILLO	19.100	-104.300
	CABO SAN LUCAS	22.840	-109.980
	MAZATLAN	23.170	-106.440
	PUNTA ABREOJOS	26.680	-113.620
	ENSENADA	31.830	-116.780
MIDWAY IS.	MIDWAY IS.	28.200	-177.400
N. MARIANAS	SAIPAN	15.300	145.800
NAURU	NAURU	-0.518	166.900
NEW CALEDONIA	NOUMEA	-22.300	166.500
NEW ZEALAND	BLUFF	-46.566	168.333
	DUNEDIN	-45.883	170.514
	MILFORD SOUND	-44.626	167.877
	LYTTELTON	-43.617	172.717
	WESTPORT	-41.752	171.583
	WELLINGTON	-41.270	174.837
	NELSON	-41.260	173.266
	NAPIER	-39.474	176.910
	NEW PLYMOUTH	-39.053	174.069
	GISBORNE	-38.052	176.446
	AUCKLAND(W)	-37.100	174.200
	AUCKLAND(E)	-36.700	175.000
	EAST CAPE	-36.231	175.105
	NORTH CAPE	-34.400	173.300
NICARAGUA	SAN JUAN DL SUR	11.200	-85.900
	PUERTO SANDINO	12.200	-86.800
	CORINTO	12.500	-87.200

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
NIUE	NIUE IS.	-19.000	-170.000
PALMYRA IS.	PALMYRA IS.	6.340	-162.450
PANAMA	PUERTO PINA	7.390	-78.050
	PUNTA MALA	7.480	-79.950
	PUNTA BURICA	8.020	-82.850
	BALBOA HTS.	9.000	-79.600
PAPUA NEW GUINEA	PORT MORESBY	-9.340	146.940
	LAE	-6.760	147.030
	KIETA	-6.070	155.630
	AMUN	-5.960	154.690
	MADANG	-5.170	145.840
	RABAUL	-4.180	152.270
	WEWAK	-3.520	143.650
	VANIMO	-2.580	141.340
	KAVIENG	-2.530	150.690
	MANUS IS.	-2.030	147.490
PERU	MOLLENDO	-17.080	-72.000
	SAN JUAN	-15.330	-75.240
	LA PUNTA	-12.100	-77.200
	CHIMBOTE	-9.000	-78.830
	PIMENTAL	-6.900	-80.020
	TALARA	-4.630	-81.470
PHILIPPINES	DAVAO	6.850	125.650
	ZAMBOANGA	6.900	122.100
	PUERTO PRINCESA	9.800	118.800
	ILOILO	10.700	122.500
	LEGASPI	13.200	123.800
	MANILA	14.600	121.000
	SAN FERNANDO	16.600	120.300
	PALANAN	17.150	122.610
	LAOAG	18.200	120.600
PITCAIRN	PITCAIRN IS.	-25.080	-130.080
POHNPEI	POHNPEI IS.	7.000	158.218
RUSSIA	URUP IS	46.120	150.540
	SEVERO KURILSK	50.830	156.070
	PETROPAVLOVSK K	53.230	159.580
	MEDNNY IS	54.720	167.430
	UST KAMCHATSK	56.120	162.580
SAMOA	APIA	-13.800	-171.800
SINGAPORE	SINGAPORE	1.200	103.800
SOLOMON IS.	KIRAKIRA	-10.360	161.940
	HONIARA	-9.290	159.960
	AUKI	-8.750	160.620
	MUNDA	-8.380	157.210
	GHATERE	-7.770	159.170
	FALAMAE	-7.360	155.560
	PANGGOE	-6.870	157.160
TAIWAN	HUALIEN	24.000	121.600
THAILAND	NK SI THAMMARAT	8.400	100.000
	PRA KHIRI KHAN	11.800	99.800

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
TOKELAU	NUKUNONU IS.	-9.160	-171.830
TONGA	NUKUALOFA	-21.020	-175.230
TUVALU	FUNAFUTI IS.	-7.880	178.500
VANUATU	ANATOM IS.	-20.160	169.850
	ESPERITU SANTO	-15.110	167.290
VIETNAM	BAC LIEU	9.300	105.800
	QUI NHON	13.700	109.200
	VINH	18.600	105.700
WAKE IS.	WAKE IS.	19.300	166.600
WALLIS-FUTUNA	WALLIS IS.	-13.250	-176.250
YAP	YAP IS.	9.500	138.100

4.10 PTWC PRODUCT IDENTIFIERS AND DISSEMINATION

PTWC utilizes the following communications services to disseminate its text products:

	Service	Communication Link	User Audience
International	GTS	Dedicated GTS Circuit	U.S. and International Meteorological Service Offices
	AFTN	Dedicated AFTN Circuit	Designated U.S. and International Airfield Facilities
	EMWIN	GOES Satellite	Openly Available
	FAX	Standard Telephone Line	Many international and domestic government agencies
	EMAIL	Standard Internet Connection	Designated international and domestic government agencies
	WEB	Standard Internet Connection	Available to all PTWS Users
U.S. Domestic	AWIPS	Dedicated AWIPS Circuit	U.S. Weather Forecast Offices Only
	NWW	Commercial Satellite	NOAA Weather Wire Subscribers
	NAWAS	Dedicated NAWAS Circuit	U.S. Emergency Management Agencies.
	HAWAS	Dedicated HAWAS Circuit	State of Hawaii Civil Defense Offices
	IDN	Private TCP/IP Circuit	State of Hawaii Civil Defense Offices

4.10.1 GTS

The Global Telecommunications System (GTS) is operated by the World Meteorological Organization (WMO) primarily to exchange weather information between countries around the globe (see http://www.wmo.ch/pages/prog/www/TEM/gts.html). It consists of an integrated network of point-to-point circuits, and multi-point circuits that interconnect meteorological telecommunication centers. It is a "store and forward" type messaging system with 18 central hubs and with spokes attached to those hubs that connect primarily to the National Meteorological and Hydrometerorological Service (NMHS) of each participating country. The NHMSs and other participants subscribe to products they wish to receive based on each product's WMO identifier. PTWC products disseminated on the GTS have a WMO product identifier that is shown in the following table. Because messages usually flow through the GTS within a few minutes, and because the GTS has 24x7 support and a high reliability record, it is a preferred method for receiving PTWC products.

Area of Coverage	WMO ID	AWIPS ID	Product Explanation
Pacific	WEPA40 PHEB	TSUPAC	Tsunami Warnings and Watches [Pacific Earthquake, Mw > 7.5]; Test
	WEPA42 PHEB	TIBPAC	Tsunami Information Bulletin [Pacific Earthquake, Mw = 6.5 to 7.5]
Hawaii	WEHW40 PHEB	TSUHWX	Tsunami Warning, Watch, or Advisory for Hawaii [Hawaii Earthquake, Mw ≥ M6.9; Pacific Earthquake, Mw > 7.5]
	WEHW42 PHEB	TIBHWX	Tsunami Information Statement for Hawaii [Pacific, Mw = 6.5 to 7.5]
	SEHW70 PHEB	EQIHWX	Earthquake Information Statement [Hawaii Earthquake, M = 4.0 to 6.8]
	WEHW50 PHEB	TSUHW1	Public Tsunami Warnings [Hawaii, Mw > 6.8]

4.10.2 AFTN

The Aeronautical Fixed Telecommunications Network (AFTN) is a world-wide system of circuits operated by the International Civil Aviation Organization (ICAO) for the exchange of messages and/or digital data primarily for the safety of air navigation and for the regular, efficient and economical operation of air services. Since many flight service facilities must operate on a 7X24 basis they are logical contact points for tsunami messages that can require an immediate response. PTWC products are put into AFTN through a dedicated circuit. PTWC products on AFTN are addressed to specific offices with AFTN addresses that are designated by PTWS Member States. Because messages usually flow through the AFTN within a few minutes, and because the AFTN has 24x7 support and a high reliability record, it is a preferred method for receiving PTWC products.

4.10.3 EMWIN

The Emergency Managers Weather Information Network (EMWIN) is a US service that allows users to obtain PTWC Tsunami Bulletins as well as weather forecasts, warnings, and other information directly from the U.S. National Weather Service (NWS) through satellite broadcast on the NOAA GOES-East and West satellites which cover the USA, the Caribbean, and South and Central America, and most of the Pacific Ocean. It is intended to be used primarily by emergency managers and public safety officials who need this timely information to make critical decisions. The EMWIN live stream of weather and other critical emergency information can be received via broadcasts from U.S. geostationary weather satellites (GOES) using only a personal computer with an inexpensive receiver and satellite dish. For this reason, EMWIN is used by many Pacific Island States that do not have practical access to other types of circuits. EMWIN is also available via the public internet and certain radio links. Because tsunami messages have a very high priority and usually flow through the EMWIN within a few minutes, and because the EMWIN has 24x7 support and a high reliability record, it is a preferred method for receiving PTWC products.

4.10.4 FAX

Designated agencies may receive PTWC bulletins over standard telephone lines using a telefax machine. To ensure rapid distribution to multiple fax numbers, a commercial service with many outgoing lines is utilized. Multiple attempts to send will be made when, for example, the line is busy with another fax. Telefax should only be used as a primary method of receipt for agencies that do not have access to the other preferred communication services. Otherwise, telefax should be considered as a backup method of receipt.

4.10.5 EMAIL

PTWC sends its messages by email over the public internet to a long list of designated recipients. However, email should only be used as a primary method of receipt for agencies that do not have access to the preferred communication services. Otherwise, email should be considered as a backup method of receipt.

4.10.6 WEB

PTWC posts it messages, along with other relevant information such as location maps, on its website that can be accessed through the tsunami portal at: http://tsunami.gov

4.10.7 AWIPS

The Advanced Weather Information Processing System (AWIPS) is operated by the U.S. National Weather Service (NWS) to exchange weather information and products between its offices throughout the country. PTWCs products are entered into AWIPS through the U.S. National Weather Service Telecommunications Gateway (NWSTG) in Silver Spring Maryland. They have AWIPS product identifiers as shown in the table above. NWS Weather Forecast Offices that play an important role in the timely dissemination of tsunami products to local communities receive U.S. TWC products via AWIPS.

4.10.8 NWW

The NOAA Weather Wire is a satellite broadcast service maintained by the NWS to disseminate weather products domestically in the U.S. PTWC has both uplink and downlink capabilities on the NWW system. Users of the NWW system are primarily Weather Service Offices and emergency management agencies. The NWW also feeds the NWS Family of Services that is subscribed to by various news organizations.

4.10.9 NAWAS

The National Warning System is a nationwide dedicated voice telephone system connecting selected national defense, emergency management, and Coast Guard agencies. The circuit is supported by the Federal Emergency Management Agency (FEMA). Control over transmissions on the circuit is maintained by the National Warning Center at the Cheyenne Mountain Complex in Colorado. PTWC uses NAWAS only when it is acting as a backup for WC/ATWC.

4.10.10 HAWAS

The Hawaii Warning System is a statewide dedicated voice telephone system connecting selected State Civil Defense, National Guard, Law Enforcement and NWS Offices. The circuit is supported by FEMA and Hawaii State Civil Defense. Control over transmissions on the circuit is maintained by the State Warning Point. PTWC reads the text of its Hawaii bulletins over this circuit as soon as they are generated.

4.10.11 IDN

Hawaii State Civil Defense maintains the Interisland Data Network, an email service utilizing a private TCP/IP circuit, that connects PTWC with all Hawaii State and County Civil Defense offices. Products are disseminated simultaneously to all IDN participants.

4.11 SAMPLE BULLETINS

4.11.1 Tsunami Information Bulletin (WEPA42 PHEB)

```
TSUNAMI BULLETIN NUMBER 001
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0316Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

... TSUNAMI INFORMATION BULLETIN ...

THIS BULLETIN IS FOR INFORMATION ONLY.

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES.  ONLY
NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND
ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  0301Z 31 AUG 2007
 COORDINATES -   1.8 SOUTH   81.4 WEST
 DEPTH       -   20 KM
 LOCATION    -  OFF COAST OF ECUADOR
 MAGNITUDE   -  6.7

EVALUATION

 NO DESTRUCTIVE WIDESPREAD TSUNAMI THREAT EXISTS BASED ON
 HISTORICAL EARTHQUAKE AND TSUNAMI DATA.

 HOWEVER - EARTHQUAKES OF THIS SIZE SOMETIMES GENERATE LOCAL
 TSUNAMIS THAT CAN BE DESTRUCTIVE ALONG COASTS LOCATED WITHIN
 A HUNDRED KILOMETERS OF THE EARTHQUAKE EPICENTER. AUTHORITIES
 IN THE REGION OF THE EPICENTER SHOULD BE AWARE OF THIS
 POSSIBILITY AND TAKE APPROPRIATE ACTION.

THIS WILL BE THE ONLY BULLETIN ISSUED FOR THIS EVENT UNLESS
ADDITIONAL INFORMATION BECOMES AVAILABLE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
```

4.11.2 Tsunami Information Bulletin – Supplement (WEPA42 PHEB)

```
TSUNAMI BULLETIN NUMBER 001
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0330Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

... TSUNAMI INFORMATION BULLETIN ...

THIS BULLETIN IS FOR INFORMATION ONLY.

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES.  ONLY
NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND
ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  0301Z 31 AUG 2007
 COORDINATES -   1.8 SOUTH   81.4 WEST
 DEPTH       -   20 KM
 LOCATION    -  OFF COAST OF ECUADOR
 MAGNITUDE   -  6.7

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

 GAUGE LOCATION       LAT   LON    TIME       AMPL        PER
 ------------------  ----- ------  -----  --------------  -----
 LA LIBERTAD EC       2.2S  80.9W  0322Z   0.24M /  0.8FT  16MIN

 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.

EVALUATION

 SEA LEVEL READINGS INDICATE A TSUNAMI WAS GENERATED. IT MAY HAVE
 BEEN DESTRUCTIVE ALONG COASTS NEAR THE EARTHQUAKE EPICENTER. FOR
 THOSE AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS
 AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT
 OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME
 THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN
 CONTINUE FOR SEVERAL HOURS DUE TO THE CONTINUING SEA LEVEL
 CHANGES AND RAPID CURRENTS.  AS LOCAL CONDITIONS CAN CAUSE A WIDE
 VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST
 BE MADE BY LOCAL AUTHORITIES.

 NO TSUNAMI THREAT EXISTS FOR OTHER COASTAL AREAS IN THE PACIFIC
```

ALTHOUGH SOME OTHER AREAS MAY EXPERIENCE SMALL NON-DESTRUCTIVE SEA LEVEL CHANGES LASTING UP TO SEVERAL HOURS.

THIS WILL BE THE FINAL BULLETIN ISSUED FOR THIS EVENT UNLESS ADDITIONAL INFORMATION BECOMES AVAILABLE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.

4.11.3 Regional Fixed Tsunami Warning – Initial (WEPA40 PHEB)

TSUNAMI BULLETIN NUMBER 001
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0317Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA... WASHINGTON...OREGON AND CALIFORNIA.

... A TSUNAMI WARNING IS IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR

ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA

FOR ALL OTHER AREAS COVERED BY THIS BULLETIN... IT IS FOR INFORMATION ONLY AT THIS TIME.

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND ANY ACTIONS TO BE TAKEN IN RESPONSE.
AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 0301Z 31 AUG 2007
COORDINATES - 1.8 SOUTH 81.4 WEST
DEPTH - 20 KM
LOCATION - OFF COAST OF ECUADOR
MAGNITUDE - 7.7

EVALUATION

IT IS NOT KNOWN THAT A TSUNAMI WAS GENERATED. THIS WARNING IS BASED ONLY ON THE EARTHQUAKE EVALUATION. AN EARTHQUAKE OF THIS SIZE HAS THE POTENTIAL TO GENERATE A DESTRUCTIVE TSUNAMI THAT CAN STRIKE COASTLINES IN THE REGION NEAR THE EPICENTER WITHIN MINUTES TO HOURS. AUTHORITIES IN THE REGION SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTER WILL MONITOR SEA LEVEL GAUGES NEAREST THE REGION AND REPORT IF ANY TSUNAMI WAVE ACTIVITY IS OBSERVED. THE WARNING WILL NOT EXPAND TO OTHER AREAS OF THE PACIFIC UNLESS ADDITIONAL DATA ARE RECEIVED TO WARRANT SUCH AN EXPANSION.
ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES AT FORECAST POINTS

WITHIN THE WARNING AND WATCH AREAS ARE GIVEN BELOW. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN SUCCESSIVE WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION	FORECAST POINT	COORDINATES	ARRIVAL TIME
ECUADOR	LA LIBERTAD	2.2S 81.2W	0308Z 31 AUG
	ESMERELDAS	1.2N 79.8W	0349Z 31 AUG
	BALTRA IS.	0.5S 90.5W	0508Z 31 AUG
PERU	TALARA	4.6S 81.5W	0332Z 31 AUG
	PIMENTAL	6.9S 80.0W	0459Z 31 AUG
	CHIMBOTE	9.0S 78.8W	0510Z 31 AUG
COLOMBIA	TUMACO	1.8N 79.0W	0403Z 31 AUG
	BAHIA SOLANO	6.3N 77.4W	0437Z 31 AUG
	BUENAVENTURA	3.8N 77.2W	0440Z 31 AUG
PANAMA	PUERTO PINA	7.2N 78.0W	0444Z 31 AUG
	PUNTA MALA	7.5N 79.8W	0448Z 31 AUG
	PUNTA BURICA	8.0N 82.8W	0454Z 31 AUG
	BALBOA HTS.	8.8N 79.5W	0600Z 31 AUG
COSTA RICA	CABO MATAPALO	8.4N 83.3W	0459Z 31 AUG

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT. THE TSUNAMI WARNING WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.

4.11.4 Regional Fixed Tsunami Warning - Supplement (WEPA40 PHEB)

TSUNAMI BULLETIN NUMBER 003
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0517Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA... WASHINGTON...OREGON AND CALIFORNIA.

... A TSUNAMI WARNING IS IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR

ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA

FOR ALL OTHER AREAS COVERED BY THIS BULLETIN... IT IS FOR INFORMATION ONLY AT THIS TIME.

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 0301Z 31 AUG 2007
COORDINATES - 1.8 SOUTH 81.4 WEST
DEPTH - 20 KM
LOCATION - OFF COAST OF ECUADOR
MAGNITUDE - 7.7

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

GAUGE LOCATION	LAT	LON	TIME	AMPL	PER
LA LIBERTAD EC	2.2S	80.9W	0322Z	0.24M / 0.8FT	16MIN
LOBOS DE AFUERA PE	6.9S	80.7W	0420Z	0.13M / 0.4FT	21MIN

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.

EVALUATION

SEA LEVEL READINGS CONFIRM THAT A TSUNAMI WAS GENERATED. THIS TSUNAMI MAY HAVE BEEN DESTRUCTIVE ALONG COASTLINES OF THE REGION NEAR THE EARTHQUAKE EPICENTER. AUTHORITIES IN THE REGION SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTER WILL CONTINUE TO MONITOR SEA LEVEL GAUGES NEAREST THE REGION AND REPORT IF ANY ADDITIONAL TSUNAMI WAVE ACTIVITY. THE WARNING WILL NOT EXPAND TO OTHER AREAS OF THE PACIFIC UNLESS ADDITIONAL DATA ARE RECEIVED TO WARRANT SUCH AN EXPANSION.

FOR AFFECTED AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES AT FORECAST POINTS WITHIN THE WARNING AND WATCH AREAS ARE GIVEN BELOW. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN SUCCESSIVE WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION	FORECAST POINT	COORDINATES	ARRIVAL TIME
ECUADOR	LA LIBERTAD	2.2S 81.2W	0308Z 31 AUG
	ESMERELDAS	1.2N 79.8W	0349Z 31 AUG
	BALTRA IS.	0.5S 90.5W	0508Z 31 AUG
PERU	TALARA	4.6S 81.5W	0332Z 31 AUG
	PIMENTAL	6.9S 80.0W	0459Z 31 AUG
	CHIMBOTE	9.0S 78.8W	0510Z 31 AUG
COLOMBIA	TUMACO	1.8N 79.0W	0403Z 31 AUG

```
              BAHIA SOLANO       6.3N  77.4W    0437Z 31 AUG
              BUENAVENTURA       3.8N  77.2W    0440Z 31 AUG
 PANAMA          PUERTO PINA        7.2N  78.0W    0444Z 31 AUG
              PUNTA MALA         7.5N  79.8W    0448Z 31 AUG
              PUNTA BURICA       8.0N  82.8W    0454Z 31 AUG
              BALBOA HTS.        8.8N  79.5W    0600Z 31 AUG
 COSTA RICA      CABO MATAPALO      8.4N  83.3W    0459Z 31 AUG

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT.
THE TSUNAMI WARNING WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
```

4.11.5 Regional Fixed Tsunami Warning - Cancellation (WEPA40 PHEB)

```
TSUNAMI BULLETIN NUMBER 004
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0540Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.
... TSUNAMI WARNING CANCELLATION ...

THE TSUNAMI WARNING AND/OR WATCH ISSUED BY THE PACIFIC TSUNAMI
WARNING CENTER IS NOW CANCELLED FOR

 ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES.  ONLY
NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND
ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  0301Z 31 AUG 2007
 COORDINATES -   1.8 SOUTH   81.4 WEST
 DEPTH       -   20 KM
 LOCATION    -  OFF COAST OF ECUADOR
 MAGNITUDE   -  7.7

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

 GAUGE LOCATION        LAT   LON    TIME       AMPL        PER
 ------------------- ----- ------ ----- --------------- -----
 LA LIBERTAD EC        2.2S  80.9W  0322Z  0.24M /  0.8FT  16MIN
 LOBOS DE AFUERA PE    6.9S  80.7W  0420Z  0.13M /  0.4FT  21MIN
 BALTRA GALAPAGOS EC   0.3S  90.3W  0508Z  0.08M /  0.3FT  18MIN
 SANTA CRUZ GALAP EC   0.8S  90.3W  0513Z  0.05M /  0.2FT  16MIN
 DART PANAMA 32411     4.9N  90.7W  0521Z  0.02M /  0.1FT  16MIN
```

```
 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.

EVALUATION

 SEA LEVEL READINGS INDICATE A TSUNAMI WAS GENERATED. IT MAY HAVE
 BEEN DESTRUCTIVE ALONG COASTS NEAR THE EARTHQUAKE EPICENTER. FOR
 THOSE AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS
 AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT
 OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME
 THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN
 CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL
 CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE
 ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

 NO TSUNAMI THREAT EXISTS FOR OTHER COASTAL AREAS IN THE PACIFIC
 ALTHOUGH SOME OTHER AREAS MAY EXPERIENCE SMALL SEA LEVEL CHANGES.
 THE TSUNAMI WARNING IS NOW CANCELLED FOR ALL AREAS COVERED BY
 THIS CENTER.

THIS WILL BE THE FINAL BULLETIN ISSUED FOR THIS EVENT UNLESS
ADDITIONAL INFORMATION BECOMES AVAILABLE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
```

4.11.6 Regional Expanding Tsunami Warning - Initial (WEPA40 PHEB)

```
TSUNAMI BULLETIN NUMBER 001
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0315Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

... A TSUNAMI WARNING AND WATCH ARE IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR

 ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA / NICARAGUA /
 CHILE

A TSUNAMI WATCH IS IN EFFECT FOR

 GUATEMALA / EL SALVADOR / HONDURAS / MEXICO

FOR ALL OTHER AREAS COVERED BY THIS BULLETIN... IT IS FOR
```

INFORMATION ONLY AT THIS TIME.

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 0301Z 31 AUG 2007
COORDINATES - 1.8 SOUTH 81.4 WEST
DEPTH - 20 KM
LOCATION - OFF COAST OF ECUADOR
MAGNITUDE - 8.2

EVALUATION

IT IS NOT KNOWN THAT A TSUNAMI WAS GENERATED. THIS WARNING IS BASED ONLY ON THE EARTHQUAKE EVALUATION. AN EARTHQUAKE OF THIS SIZE HAS THE POTENTIAL TO GENERATE A DESTRUCTIVE TSUNAMI THAT CAN STRIKE COASTLINES NEAR THE EPICENTER WITHIN MINUTES AND MORE DISTANT COASTLINES WITHIN HOURS. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTER WILL MONITOR SEA LEVEL DATA FROM GAUGES NEAR THE EARTHQUAKE TO DETERMINE IF A TSUNAMI WAS GENERATED AND ESTIMATE THE SEVERITY OF THE THREAT.

ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES AT FORECAST POINTS WITHIN THE WARNING AND WATCH AREAS ARE GIVEN BELOW. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN SUCCESSIVE WAVES CAN BE FIVE MINUTES TO ONE HOUR.

LOCATION	FORECAST POINT	COORDINATES	ARRIVAL TIME
ECUADOR	LA LIBERTAD	2.2S 81.2W	0308Z 31 AUG
	ESMERELDAS	1.2N 79.8W	0349Z 31 AUG
	BALTRA IS.	0.5S 90.5W	0508Z 31 AUG
PERU	TALARA	4.6S 81.5W	0332Z 31 AUG
	PIMENTAL	6.9S 80.0W	0459Z 31 AUG
	LA PUNTA	12.1S 77.2W	0508Z 31 AUG
	CHIMBOTE	9.0S 78.8W	0510Z 31 AUG
	SAN JUAN	15.3S 75.2W	0525Z 31 AUG
	MOLLENDO	17.2S 72.0W	0555Z 31 AUG
COLOMBIA	TUMACO	1.8N 79.0W	0403Z 31 AUG
	BAHIA SOLANO	6.3N 77.4W	0437Z 31 AUG
	BUENAVENTURA	3.8N 77.2W	0440Z 31 AUG
PANAMA	PUERTO PINA	7.2N 78.0W	0444Z 31 AUG
	PUNTA MALA	7.5N 79.8W	0448Z 31 AUG
	PUNTA BURICA	8.0N 82.8W	0454Z 31 AUG
	BALBOA HTS.	8.8N 79.5W	0600Z 31 AUG
COSTA RICA	CABO MATAPALO	8.4N 83.3W	0459Z 31 AUG
	PUERTO QUEPOS	9.2N 84.2W	0525Z 31 AUG
	CABO SAN ELENA	10.9N 86.0W	0548Z 31 AUG
NICARAGUA	SAN JUAN DL SUR	11.2N 85.9W	0605Z 31 AUG

```
             PUERTO SANDINO     12.2N  87.0W    0621Z 31 AUG
             CORINTO            12.5N  87.2W    0623Z 31 AUG
 CHILE       ARICA              18.5S  70.5W    0611Z 31 AUG
             IQUIQUE            20.2S  70.2W    0614Z 31 AUG
             ANTOFAGASTA        23.5S  70.5W    0632Z 31 AUG
             CALDERA            27.0S  71.0W    0654Z 31 AUG
             COQUIMBO           30.0S  71.5W    0722Z 31 AUG
             VALPARAISO         33.0S  71.8W    0746Z 31 AUG
             TALCAHUANO         36.8S  73.2W    0829Z 31 AUG
             EASTER IS.         27.1S 109.4W    0849Z 31 AUG
             CORRAL             39.8S  73.5W    0905Z 31 AUG
 GUATEMALA   SIPICATE           13.8N  91.2W    0638Z 31 AUG
 EL SALVADOR ACAJUTLA           13.6N  89.8W    0639Z 31 AUG
 HONDURAS    AMAPALA            13.2N  87.6W    0702Z 31 AUG
 MEXICO      PUERTO MADERO      14.8N  92.5W    0707Z 31 AUG
             ACAPULCO           16.8N 100.0W    0736Z 31 AUG
             MANZANILLO         19.0N 104.5W    0823Z 31 AUG
             SOCORRO            18.8N 111.0W    0915Z 31 AUG

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT.
THE TSUNAMI WARNING AND WATCH WILL REMAIN IN EFFECT UNTIL
FURTHER NOTICE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
```

4.11.7 Regional Expanding Tsunami Warning - Supplement (WEPA40 PHEB)

```
TSUNAMI BULLETIN NUMBER 003
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0515Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

... A TSUNAMI WARNING AND WATCH ARE IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR

 ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA / NICARAGUA /
 CHILE / GUATEMALA / EL SALVADOR / HONDURAS / MEXICO

A TSUNAMI WATCH IS IN EFFECT FOR

 PITCAIRN / FR. POLYNESIA

FOR ALL OTHER AREAS COVERED BY THIS BULLETIN... IT IS FOR
INFORMATION ONLY AT THIS TIME.

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES.  ONLY
NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND
```

```
ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  0301Z 31 AUG 2007
 COORDINATES -   1.8 SOUTH   81.4 WEST
 DEPTH       -   20 KM
 LOCATION    -  OFF COAST OF ECUADOR
 MAGNITUDE   -  8.2

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

 GAUGE LOCATION       LAT   LON    TIME       AMPL         PER
 ------------------  ----- ------  -----  --------------  -----
 LA LIBERTAD EC       2.2S  80.9W  0322Z   0.24M /  0.8FT  16MIN
 LOBOS DE AFUERA PE   6.9S  80.7W  0420Z   0.13M /  0.4FT  21MIN

 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.

EVALUATION

 SEA LEVEL READINGS INDICATE A TSUNAMI WAS GENERATED. IT MAY HAVE
 BEEN DESTRUCTIVE ALONG COASTS NEAR THE EARTHQUAKE EPICENTER AND
 COULD ALSO BE A THREAT TO MORE DISTANT COASTS. AUTHORITIES SHOULD
 TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS
 CENTER WILL CONTINUE TO MONITOR SEA LEVEL DATA TO DETERMINE THE
 EXTENT AND SEVERITY OF THE THREAT.

 FOR ALL AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS
 AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT
 OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME
 THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN
 CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL
 CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE
 ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES AT FORECAST POINTS
WITHIN THE WARNING AND WATCH AREAS ARE GIVEN BELOW. ACTUAL
ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE
LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN
SUCCESSIVE WAVES CAN BE FIVE MINUTES TO ONE HOUR.

 LOCATION        FORECAST POINT     COORDINATES     ARRIVAL TIME
 ------------------------------    ------------    ------------
 ECUADOR         LA LIBERTAD        2.2S  81.2W    0308Z 31 AUG
                 ESMERELDAS         1.2N  79.8W    0349Z 31 AUG
                 BALTRA IS.         0.5S  90.5W    0508Z 31 AUG
 PERU            TALARA             4.6S  81.5W    0332Z 31 AUG
                 PIMENTAL           6.9S  80.0W    0459Z 31 AUG
```

	LA PUNTA	12.1S	77.2W	0508Z 31 AUG
	CHIMBOTE	9.0S	78.8W	0510Z 31 AUG
	SAN JUAN	15.3S	75.2W	0525Z 31 AUG
	MOLLENDO	17.2S	72.0W	0555Z 31 AUG
COLOMBIA	TUMACO	1.8N	79.0W	0403Z 31 AUG
	BAHIA SOLANO	6.3N	77.4W	0437Z 31 AUG
	BUENAVENTURA	3.8N	77.2W	0440Z 31 AUG
PANAMA	PUERTO PINA	7.2N	78.0W	0444Z 31 AUG
	PUNTA MALA	7.5N	79.8W	0448Z 31 AUG
	PUNTA BURICA	8.0N	82.8W	0454Z 31 AUG
	BALBOA HTS.	8.8N	79.5W	0600Z 31 AUG
COSTA RICA	CABO MATAPALO	8.4N	83.3W	0459Z 31 AUG
	PUERTO QUEPOS	9.2N	84.2W	0525Z 31 AUG
	CABO SAN ELENA	10.9N	86.0W	0548Z 31 AUG
NICARAGUA	SAN JUAN DL SUR	11.2N	85.9W	0605Z 31 AUG
	PUERTO SANDINO	12.2N	87.0W	0621Z 31 AUG
	CORINTO	12.5N	87.2W	0623Z 31 AUG
CHILE	ARICA	18.5S	70.5W	0611Z 31 AUG
	IQUIQUE	20.2S	70.2W	0614Z 31 AUG
	ANTOFAGASTA	23.5S	70.5W	0632Z 31 AUG
	CALDERA	27.0S	71.0W	0654Z 31 AUG
	COQUIMBO	30.0S	71.5W	0722Z 31 AUG
	VALPARAISO	33.0S	71.8W	0746Z 31 AUG
	TALCAHUANO	36.8S	73.2W	0829Z 31 AUG
	EASTER IS.	27.1S	109.4W	0849Z 31 AUG
	CORRAL	39.8S	73.5W	0905Z 31 AUG
	GOLFO DE PENAS	47.1S	74.9W	1021Z 31 AUG
	PUERTO MONTT	41.8S	73.0W	1035Z 31 AUG
GUATEMALA	SIPICATE	13.8N	91.2W	0638Z 31 AUG
EL SALVADOR	ACAJUTLA	13.6N	89.8W	0639Z 31 AUG
HONDURAS	AMAPALA	13.2N	87.6W	0702Z 31 AUG
MEXICO	PUERTO MADERO	14.8N	92.5W	0707Z 31 AUG
	ACAPULCO	16.8N	100.0W	0736Z 31 AUG
	MANZANILLO	19.0N	104.5W	0823Z 31 AUG
	SOCORRO	18.8N	111.0W	0915Z 31 AUG
	CABO SAN LUCAS	22.8N	110.0W	0922Z 31 AUG
	MAZATLAN	23.2N	106.4W	0925Z 31 AUG
	PUNTA ABREOJOS	26.7N	113.6W	1037Z 31 AUG
	ENSENADA	31.8N	116.8W	1130Z 31 AUG
PITCAIRN	PITCAIRN IS.	25.1S	130.1W	1129Z 31 AUG
FR. POLYNESIA	RIKITEA	23.1S	135.0W	1203Z 31 AUG
	HIVA OA	10.0S	139.0W	1210Z 31 AUG

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT. THE TSUNAMI WARNING AND WATCH WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.

4.11.8 Regional Expanding Tsunami Warning - Cancellation (WEPA40 PHEB)

```
TSUNAMI BULLETIN NUMBER 004
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0605Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

... TSUNAMI WARNING AND WATCH CANCELLATION ...

THE TSUNAMI WARNING AND/OR WATCH ISSUED BY THE PACIFIC TSUNAMI
WARNING CENTER IS NOW CANCELLED FOR

 ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA / NICARAGUA /
 CHILE / GUATEMALA / EL SALVADOR / HONDURAS / MEXICO / PITCAIRN /
 FR. POLYNESIA

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES.  ONLY
NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND
ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  0301Z 31 AUG 2007
 COORDINATES -   1.8 SOUTH   81.4 WEST
 DEPTH       -   20 KM
 LOCATION    -  OFF COAST OF ECUADOR
 MAGNITUDE   -  8.2
MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

 GAUGE LOCATION        LAT   LON    TIME       AMPL        PER
 ------------------  ----- ------  -----  --------------  -----
 LA LIBERTAD EC        2.2S  80.9W  0322Z  0.24M /  0.8FT  16MIN
 LOBOS DE AFUERA PE    6.9S  80.7W  0420Z  0.13M /  0.4FT  21MIN
 BALTRA GALAPAGOS EC   0.3S  90.3W  0508Z  0.08M /  0.3FT  18MIN
 SANTA CRUZ GALAP EC   0.8S  90.3W  0513Z  0.05M /  0.2FT  16MIN
 DART PANAMA 32411     4.9N  90.7W  0521Z  0.02M /  0.1FT  16MIN

 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.

EVALUATION

 SEA LEVEL READINGS INDICATE A TSUNAMI WAS GENERATED. IT MAY HAVE
 BEEN DESTRUCTIVE ALONG COASTS NEAR THE EARTHQUAKE EPICENTER. FOR
 THOSE AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS
```

AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

NO TSUNAMI THREAT EXISTS FOR OTHER COASTAL AREAS ALTHOUGH SOME MAY EXPERIENCE SMALL SEA LEVEL CHANGES. FOR ALL AREAS COVERED BY THIS CENTER...THE TSUNAMI WARNING AND WATCH ARE CANCELLED.

THIS WILL BE THE FINAL BULLETIN ISSUED FOR THIS EVENT UNLESS ADDITIONAL INFORMATION BECOMES AVAILABLE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.

4.11.9 Pacific-Wide Tsunami Warning - Initial (WEPA40 PHEB)

TSUNAMI BULLETIN NUMBER 005
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0534Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA... WASHINGTON...OREGON AND CALIFORNIA.

... A WIDESPREAD TSUNAMI WARNING IS IN EFFECT ...
A TSUNAMI WARNING IS IN EFFECT FOR

ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA / NICARAGUA /
CHILE / GUATEMALA / EL SALVADOR / HONDURAS / MEXICO / PITCAIRN /
FR. POLYNESIA / ANTARCTICA / KIRIBATI / HAWAII / COOK ISLANDS /
JARVIS IS. / PALMYRA IS. / JOHNSTON IS. / NIUE /
AMERICAN SAMOA / SAMOA / TOKELAU / HOWLAND-BAKER /
WALLIS-FUTUNA / TONGA / KERMADEC IS / MIDWAY IS. / NEW ZEALAND /
TUVALU / FIJI / MARSHALL IS. / RUSSIA / NAURU / WAKE IS. /
VANUATU / KOSRAE / SOLOMON IS. / NEW CALEDONIA / POHNPEI /
MARCUS IS. / AUSTRALIA / JAPAN / PAPUA NEW GUINEA / CHUUK /
N. MARIANAS / GUAM / YAP / BELAU / INDONESIA / CHINESE TAIPEI /
TAIWAN / PHILIPPINES

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 0301Z 31 AUG 2007
COORDINATES - 1.8 SOUTH 81.4 WEST
DEPTH - 20 KM
LOCATION - OFF COAST OF ECUADOR

MAGNITUDE - 8.7

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

```
GAUGE LOCATION        LAT   LON    TIME       AMPL          PER
------------------  ----- ------  -----  --------------  -----
LA LIBERTAD EC        2.2S  80.9W  0322Z  2.40M /  7.8FT  26MIN
LOBOS DE AFUERA PE    6.9S  80.7W  0420Z  1.29M /  4.2FT  24MIN
BALTRA GALAPAGOS EC   0.3S  90.3W  0508Z  1.23M /  4.0FT  28MIN
SANTA CRUZ GALAP EC   0.8S  90.3W  0513Z  0.95M /  3.1FT  26MIN
DART PANAMA 32411     4.9N  90.7W  0521Z  0.20M /  0.6FT  31MIN
```

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.

EVALUATION

SEA LEVEL READINGS CONFIRM THAT A TSUNAMI HAS BEEN GENERATED WHICH COULD CAUSE WIDESPREAD DAMAGE. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS THREAT. THIS CENTER WILL CONTINUE TO MONITOR SEA LEVEL DATA TO DETERMINE THE EXTENT AND SEVERITY OF THE THREAT.

A TSUNAMI IS A SERIES OF WAVES AND THE FIRST WAVE MAY NOT BE THE LARGEST. TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND CAN VARY SIGNIFICANTLY ALONG A COAST DUE TO LOCAL EFFECTS. THE TIME FROM ONE TSUNAMI WAVE TO THE NEXT CAN BE FIVE MINUTES TO AN HOUR, AND THE THREAT CAN CONTINUE FOR MANY HOURS AS MULTIPLE WAVES ARRIVE.

FOR ALL AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

ESTIMATED INITIAL TSUNAMI WAVE ARRIVAL TIMES AT FORECAST POINTS WITHIN THE WARNING AND WATCH AREAS ARE GIVEN BELOW. ACTUAL ARRIVAL TIMES MAY DIFFER AND THE INITIAL WAVE MAY NOT BE THE LARGEST. A TSUNAMI IS A SERIES OF WAVES AND THE TIME BETWEEN SUCCESSIVE WAVES CAN BE FIVE MINUTES TO ONE HOUR.

```
LOCATION        FORECAST POINT     COORDINATES     ARRIVAL TIME
--------------------------------  ------------  ------------
ECUADOR         LA LIBERTAD        2.2S  81.2W    0308Z 31 AUG
                ESMERELDAS         1.2N  79.8W    0349Z 31 AUG
                BALTRA IS.         0.5S  90.5W    0508Z 31 AUG
PERU            TALARA             4.6S  81.5W    0332Z 31 AUG
                PIMENTAL           6.9S  80.0W    0459Z 31 AUG
```

	LA PUNTA	12.1S	77.2W	0508Z 31 AUG
	CHIMBOTE	9.0S	78.8W	0510Z 31 AUG
	SAN JUAN	15.3S	75.2W	0525Z 31 AUG
	MOLLENDO	17.2S	72.0W	0555Z 31 AUG
COLOMBIA	TUMACO	1.8N	79.0W	0403Z 31 AUG
	BAHIA SOLANO	6.3N	77.4W	0437Z 31 AUG
	BUENAVENTURA	3.8N	77.2W	0440Z 31 AUG
PANAMA	PUERTO PINA	7.2N	78.0W	0444Z 31 AUG
	PUNTA MALA	7.5N	79.8W	0448Z 31 AUG
	PUNTA BURICA	8.0N	82.8W	0454Z 31 AUG
	BALBOA HTS.	8.8N	79.5W	0600Z 31 AUG
COSTA RICA	CABO MATAPALO	8.4N	83.3W	0459Z 31 AUG
	PUERTO QUEPOS	9.2N	84.2W	0525Z 31 AUG
	CABO SAN ELENA	10.9N	86.0W	0548Z 31 AUG
NICARAGUA	SAN JUAN DL SUR	11.2N	85.9W	0605Z 31 AUG
	PUERTO SANDINO	12.2N	87.0W	0621Z 31 AUG
	CORINTO	12.5N	87.2W	0623Z 31 AUG
CHILE	ARICA	18.5S	70.5W	0611Z 31 AUG
	IQUIQUE	20.2S	70.2W	0614Z 31 AUG
	ANTOFAGASTA	23.5S	70.5W	0632Z 31 AUG
	CALDERA	27.0S	71.0W	0654Z 31 AUG
	COQUIMBO	30.0S	71.5W	0722Z 31 AUG
	VALPARAISO	33.0S	71.8W	0746Z 31 AUG
	TALCAHUANO	36.8S	73.2W	0829Z 31 AUG
	EASTER IS.	27.1S	109.4W	0849Z 31 AUG
	CORRAL	39.8S	73.5W	0905Z 31 AUG
	GOLFO DE PENAS	47.1S	74.9W	1021Z 31 AUG
	PUERTO MONTT	41.8S	73.0W	1035Z 31 AUG
	PUNTA ARENAS	54.2S	72.0W	1220Z 31 AUG
	PUERTO WILLIAMS	55.0S	68.2W	1320Z 31 AUG
GUATEMALA	SIPICATE	13.8N	91.2W	0638Z 31 AUG
EL SALVADOR	ACAJUTLA	13.6N	89.8W	0639Z 31 AUG
HONDURAS	AMAPALA	13.2N	87.6W	0702Z 31 AUG
MEXICO	PUERTO MADERO	14.8N	92.5W	0707Z 31 AUG
	ACAPULCO	16.8N	100.0W	0736Z 31 AUG
	MANZANILLO	19.0N	104.5W	0823Z 31 AUG
	SOCORRO	18.8N	111.0W	0915Z 31 AUG
	CABO SAN LUCAS	22.8N	110.0W	0922Z 31 AUG
	MAZATLAN	23.2N	106.4W	0925Z 31 AUG
	PUNTA ABREOJOS	26.7N	113.6W	1037Z 31 AUG
	ENSENADA	31.8N	116.8W	1130Z 31 AUG
PITCAIRN	PITCAIRN IS.	25.1S	130.1W	1129Z 31 AUG
FR. POLYNESIA	RIKITEA	23.1S	135.0W	1203Z 31 AUG
	HIVA OA	10.0S	139.0W	1210Z 31 AUG
	PAPEETE	17.5S	149.6W	1406Z 31 AUG
ANTARCTICA	THURSTON IS.	71.8S	100.0W	1352Z 31 AUG
	CAPE ADARE	71.0S	170.0E	1733Z 31 AUG
KIRIBATI	FLINT IS.	11.4S	151.8W	1359Z 31 AUG
	MALDEN IS.	3.9S	154.9W	1421Z 31 AUG
	CHRISTMAS IS.	2.0N	157.5W	1455Z 31 AUG
	KANTON IS.	2.8S	171.7W	1638Z 31 AUG
	TARAWA IS.	1.5N	173.0E	1847Z 31 AUG
HAWAII	HILO	19.7N	155.1W	1440Z 31 AUG
	HONOLULU	21.3N	157.9W	1513Z 31 AUG
	NAWILIWILI	22.0N	159.4W	1516Z 31 AUG

COOK ISLANDS	PENRYN IS.	8.9S 157.8W	1444Z 31 AUG
	RAROTONGA	21.2S 159.8W	1522Z 31 AUG
	PUKAPUKA IS.	10.8S 165.9W	1559Z 31 AUG
JARVIS IS.	JARVIS IS.	0.4S 160.1W	1509Z 31 AUG
PALMYRA IS.	PALMYRA IS.	6.3N 162.4W	1542Z 31 AUG
JOHNSTON IS.	JOHNSTON IS.	16.7N 169.5W	1628Z 31 AUG
NIUE	NIUE IS.	19.0S 170.0W	1633Z 31 AUG
AMERICAN SAMOA	PAGO PAGO	14.3S 170.7W	1635Z 31 AUG
SAMOA	APIA	13.8S 171.8W	1645Z 31 AUG
TOKELAU	NUKUNONU IS.	9.2S 171.8W	1646Z 31 AUG
HOWLAND-BAKER	HOWLAND IS.	0.6N 176.6W	1720Z 31 AUG
WALLIS-FUTUNA	WALLIS IS.	13.2S 176.2W	1722Z 31 AUG
TONGA	NUKUALOFA	21.0S 175.2W	1723Z 31 AUG
KERMADEC IS	RAOUL IS.	29.2S 177.9W	1728Z 31 AUG
MIDWAY IS.	MIDWAY IS.	28.2N 177.4W	1737Z 31 AUG
NEW ZEALAND	EAST CAPE	37.5S 178.5E	1748Z 31 AUG
	GISBORNE	38.7S 178.0E	1759Z 31 AUG
	NAPIER	39.5S 176.9E	1820Z 31 AUG
	WELLINGTON	41.5S 174.8E	1828Z 31 AUG
	NORTH CAPE	34.4S 173.3E	1840Z 31 AUG
	DUNEDIN	45.9S 170.5E	1856Z 31 AUG
	LYTTELTON	43.6S 172.7E	1934Z 31 AUG
	AUCKLAND(E)	36.7S 175.0E	1941Z 31 AUG
	BLUFF	46.6S 168.3E	2005Z 31 AUG
	AUCKLAND(W)	37.1S 174.2E	2009Z 31 AUG
	NELSON	41.3S 173.3E	2019Z 31 AUG
	MILFORD SOUND	44.5S 167.8E	2022Z 31 AUG
	NEW PLYMOUTH	39.1S 174.1E	2043Z 31 AUG
	WESTPORT	41.8S 171.2E	2122Z 31 AUG
TUVALU	FUNAFUTI IS.	7.9S 178.5E	1758Z 31 AUG
FIJI	SUVA	18.1S 178.4E	1841Z 31 AUG
MARSHALL IS.	MAJURO	7.1N 171.4E	1905Z 31 AUG
	KWAJALEIN	8.7N 167.7E	1933Z 31 AUG
	ENIWETOK	11.4N 162.3E	2009Z 31 AUG
RUSSIA	MEDNNY IS	54.7N 167.4E	1916Z 31 AUG
	UST KAMCHATSK	56.1N 162.6E	1938Z 31 AUG
	PETROPAVLOVSK K	53.0N 159.5E	1952Z 31 AUG
	URUP IS	46.1N 150.5E	2044Z 31 AUG
	SEVERO KURILSK	50.8N 156.1E	2049Z 31 AUG
NAURU	NAURU	0.5S 166.9E	1938Z 31 AUG
WAKE IS.	WAKE IS.	19.3N 166.6E	1941Z 31 AUG
VANUATU	ANATOM IS.	20.2S 169.9E	1950Z 31 AUG
	ESPERITU SANTO	15.1S 167.3E	2003Z 31 AUG
KOSRAE	KOSRAE IS.	5.5N 163.0E	2016Z 31 AUG
SOLOMON IS.	KIRAKIRA	10.4S 161.9E	2022Z 31 AUG
	AUKI	8.8S 160.6E	2043Z 31 AUG
	HONIARA	9.3S 160.0E	2054Z 31 AUG
	GHATERE	7.8S 159.2E	2055Z 31 AUG
	PANGGOE	6.9S 157.2E	2113Z 31 AUG
	MUNDA	8.4S 157.2E	2116Z 31 AUG
	FALAMAE	7.4S 155.6E	2134Z 31 AUG
NEW CALEDONIA	NOUMEA	22.3S 166.5E	2037Z 31 AUG
POHNPEI	POHNPEI IS.	7.0N 158.2E	2054Z 31 AUG
MARCUS IS.	MARCUS IS.	24.3N 154.0E	2058Z 31 AUG
AUSTRALIA	HOBART	43.3S 147.6E	2114Z 31 AUG

	SYDNEY	33.9S 151.4E	2207Z 31 AUG
	BRISBANE	27.2S 153.3E	2230Z 31 AUG
	CAIRNS	16.7S 145.8E	0003Z 01 SEP
	GLADSTONE	23.8S 151.4E	0006Z 01 SEP
	MACKAY	21.1S 149.3E	0136Z 01 SEP
JAPAN	KUSHIRO	42.8N 144.2E	2125Z 31 AUG
	HACHINOHE	40.5N 141.8E	2153Z 31 AUG
	KATSUURA	35.1N 140.3E	2212Z 31 AUG
	SHIMIZU	32.8N 132.8E	2337Z 31 AUG
	OKINAWA	26.2N 128.0E	0005Z 01 SEP
PAPUA NEW GUINE	KIETA	6.1S 155.6E	2131Z 31 AUG
	AMUN	6.0S 154.7E	2155Z 31 AUG
	RABAUL	4.2S 152.3E	2216Z 31 AUG
	KAVIENG	2.5S 150.7E	2234Z 31 AUG
	LAE	6.8S 147.0E	2249Z 31 AUG
	MANUS IS.	2.0S 147.5E	2307Z 31 AUG
	PORT MORESBY	9.5S 147.0E	2308Z 31 AUG
	MADANG	5.2S 146.0E	2312Z 31 AUG
	VANIMO	2.6S 141.3E	2350Z 31 AUG
	WEWAK	3.5S 143.6E	2356Z 31 AUG
CHUUK	CHUUK IS.	7.4N 151.8E	2143Z 31 AUG
N. MARIANAS	SAIPAN	15.3N 145.8E	2212Z 31 AUG
GUAM	GUAM	13.4N 144.7E	2221Z 31 AUG
YAP	YAP IS.	9.5N 138.1E	2309Z 31 AUG
BELAU	MALAKAL	7.3N 134.5E	2348Z 31 AUG
INDONESIA	JAYAPURA	2.4S 140.8E	2354Z 31 AUG
	WARSA	0.6S 135.8E	0026Z 01 SEP
	MANOKWARI	0.8S 134.2E	0043Z 01 SEP
	BEREBERE	2.5N 128.7E	0051Z 01 SEP
	GEME	4.8N 126.8E	0053Z 01 SEP
	SORONG	0.8S 131.1E	0059Z 01 SEP
	PATANI	0.4N 128.8E	0114Z 01 SEP
CHINESE TAIPEI	HUALIEN	24.0N 121.7E	0053Z 01 SEP
	TAITUNG	22.7N 121.2E	0056Z 01 SEP
	CHILUNG	25.2N 121.8E	0126Z 01 SEP
TAIWAN	HUALIEN	24.0N 121.8E	0053Z 01 SEP
PHILIPPINES	DAVAO	6.8N 125.7E	0058Z 01 SEP
	PALANAN	17.1N 122.6E	0104Z 01 SEP
	LEGASPI	13.2N 124.0E	0107Z 01 SEP

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT.
THE TSUNAMI WARNING WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.

4.11.10 Pacific-Wide Tsunami Warning - Supplement (WEPA40 PHEB)

```
TSUNAMI BULLETIN NUMBER 007
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0734Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.
... A WIDESPREAD TSUNAMI WARNING IS IN EFFECT ...

A TSUNAMI WARNING IS IN EFFECT FOR

 ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA / NICARAGUA /
 CHILE / GUATEMALA / EL SALVADOR / HONDURAS / MEXICO / PITCAIRN /
 FR. POLYNESIA / ANTARCTICA / KIRIBATI / HAWAII / COOK ISLANDS /
 JARVIS IS. / PALMYRA IS. / JOHNSTON IS. / NIUE /
 AMERICAN SAMOA / SAMOA / TOKELAU / HOWLAND-BAKER /
 WALLIS-FUTUNA / TONGA / KERMADEC IS / MIDWAY IS. / NEW ZEALAND /
 TUVALU / FIJI / MARSHALL IS. / RUSSIA / NAURU / WAKE IS. /
 VANUATU / KOSRAE / SOLOMON IS. / NEW CALEDONIA / POHNPEI /
 MARCUS IS. / AUSTRALIA / JAPAN / PAPUA NEW GUINEA / CHUUK /
 N. MARIANAS / GUAM / YAP / BELAU / INDONESIA / CHINESE TAIPEI /
 TAIWAN / PHILIPPINES

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES.  ONLY
NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE
DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND
ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

 ORIGIN TIME -  0301Z 31 AUG 2007
 COORDINATES -   1.8 SOUTH   81.4 WEST
 DEPTH       -   20 KM
 LOCATION    -  OFF COAST OF ECUADOR
 MAGNITUDE   -  8.7

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

 GAUGE LOCATION        LAT   LON    TIME       AMPL         PER
 ------------------- ----- ------ ----- -------------- -----
 LA LIBERTAD EC        2.2S  80.9W  0322Z   2.40M /  7.8FT  26MIN
 LOBOS DE AFUERA PE    6.9S  80.7W  0420Z   1.29M /  4.2FT  24MIN
 BALTRA GALAPAGOS EC   0.3S  90.3W  0508Z   1.23M /  4.0FT  28MIN
 SANTA CRUZ GALAP EC   0.8S  90.3W  0513Z   0.95M /  3.1FT  26MIN
 DART PANAMA 32411     4.9N  90.7W  0521Z   0.20M /  0.6FT  31MIN
 CALLAO LA-PUNTA PE   12.1S  77.1W  0517Z   0.84M /  2.7FT  25MIN
 ATICO PE             16.2S  73.7W  0545Z   0.70M /  2.3FT  27MIN
 DART CHILE 32401     19.5S  74.8W  0609Z   0.12M /  0.4FT  30MIN

 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.

EVALUATION

 SEA LEVEL READINGS CONFIRM THAT A TSUNAMI HAS BEEN GENERATED
 WHICH COULD CAUSE WIDESPREAD DAMAGE. AUTHORITIES SHOULD TAKE
 APPROPRIATE ACTION IN RESPONSE TO THIS THREAT. THIS CENTER WILL
 CONTINUE TO MONITOR SEA LEVEL DATA TO DETERMINE THE EXTENT AND
 SEVERITY OF THE THREAT.

 A TSUNAMI IS A SERIES OF WAVES AND THE FIRST WAVE MAY NOT BE THE
 LARGEST. TSUNAMI WAVE HEIGHTS CANNOT BE PREDICTED AND CAN VARY
 SIGNIFICANTLY ALONG A COAST DUE TO LOCAL EFFECTS. THE TIME FROM
 ONE TSUNAMI WAVE TO THE NEXT CAN BE FIVE MINUTES TO AN HOUR, AND
 THE THREAT CAN CONTINUE FOR MANY HOURS AS MULTIPLE WAVES ARRIVE.

 FOR ALL AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS
 AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT
 OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME
 THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN
 CONTINUE FOR SEVERAL HOURS DUE TO RAPID CURRENTS. AS LOCAL
 CONDITIONS CAN CAUSE A WIDE VARIATION IN TSUNAMI WAVE ACTION THE
 ALL CLEAR DETERMINATION MUST BE MADE BY LOCAL AUTHORITIES.

BULLETINS WILL BE ISSUED HOURLY OR SOONER IF CONDITIONS WARRANT.
THE TSUNAMI WARNING WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
```

4.11.11 Pacific-Wide Tsunami Warning - Cancellation (WEPA40 PHEB)

```
TSUNAMI BULLETIN NUMBER 022
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 2234Z 31 AUG 2007

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

... TSUNAMI WARNING CANCELLATION ...

THIS BULLETIN APPLIES TO AREAS WITHIN AND BORDERING THE PACIFIC
OCEAN AND ADJACENT SEAS...EXCEPT ALASKA...BRITISH COLUMBIA...
WASHINGTON...OREGON AND CALIFORNIA.

THE TSUNAMI WARNING AND/OR WATCH ISSUED BY THE PACIFIC TSUNAMI
WARNING CENTER IS NOW CANCELLED FOR

 ECUADOR / PERU / COLOMBIA / PANAMA / COSTA RICA / NICARAGUA /
 CHILE / GUATEMALA / EL SALVADOR / HONDURAS / MEXICO / PITCAIRN /
 FR. POLYNESIA / ANTARCTICA / KIRIBATI / HAWAII / COOK ISLANDS /
```

JARVIS IS. / PALMYRA IS. / JOHNSTON IS. / NIUE /
AMERICAN SAMOA / SAMOA / TOKELAU / HOWLAND-BAKER /
WALLIS-FUTUNA / TONGA / KERMADEC IS / MIDWAY IS. / NEW ZEALAND /
TUVALU / FIJI / MARSHALL IS. / RUSSIA / NAURU / WAKE IS. /
VANUATU / KOSRAE / SOLOMON IS. / NEW CALEDONIA / POHNPEI /
MARCUS IS. / AUSTRALIA / JAPAN / PAPUA NEW GUINEA / CHUUK /
N. MARIANAS / GUAM / YAP / BELAU / INDONESIA / CHINESE TAIPEI /
TAIWAN / PHILIPPINES

THIS BULLETIN IS ISSUED AS ADVICE TO GOVERNMENT AGENCIES. ONLY NATIONAL AND LOCAL GOVERNMENT AGENCIES HAVE THE AUTHORITY TO MAKE DECISIONS REGARDING THE OFFICIAL STATE OF ALERT IN THEIR AREA AND ANY ACTIONS TO BE TAKEN IN RESPONSE.

AN EARTHQUAKE HAS OCCURRED WITH THESE PRELIMINARY PARAMETERS

ORIGIN TIME - 0301Z 31 AUG 2007
COORDINATES - 1.8 SOUTH 81.4 WEST
DEPTH - 20 KM
LOCATION - OFF COAST OF ECUADOR
MAGNITUDE - 8.7

MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

GAUGE LOCATION	LAT	LON	TIME	AMPL	PER
LA LIBERTAD EC	2.2S	80.9W	0322Z	2.40M / 7.8FT	26MIN
LOBOS DE AFUERA PE	6.9S	80.7W	0420Z	1.29M / 4.2FT	24MIN
BALTRA GALAPAGOS EC	0.3S	90.3W	0508Z	1.23M / 4.0FT	28MIN
SANTA CRUZ GALAP EC	0.8S	90.3W	0513Z	0.95M / 3.1FT	26MIN
DART PANAMA 32411	4.9N	90.7W	0521Z	0.20M / 0.6FT	31MIN
CALLAO LA-PUNTA PE	12.1S	77.1W	0517Z	0.84M / 2.7FT	25MIN
ATICO PE	16.2S	73.7W	0545Z	0.70M / 2.3FT	27MIN
DART CHILE 32401	19.5S	74.8W	0609Z	0.12M / 0.4FT	30MIN
HILO HAWAII	19.7N	155.1W	1510Z	1.76M / 5.7FT	26MIN
OWENGA CHATHAM NZ	44.0S	176.7W	1740Z	0.82M / 2.7FT	21MIN
UST-KAMCHATSK RU	56.0N	163.0E	1950Z	0.77M / 2.5FT	28MIN
HANASAKI HOKKAIDO	43.3N	145.8E	2123Z	0.95M / 3.1FT	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.

EVALUATION

A WIDESPREAD DESTRUCTIVE TSUNAMI HAS OCCURRED, AND TSUNAMI WAVES HAVE NOW CROSSED THE ENTIRE PACIFIC. FOR ALL AREAS - WHEN NO MAJOR WAVES ARE OBSERVED FOR TWO HOURS AFTER THE ESTIMATED TIME OF ARRIVAL OR DAMAGING WAVES HAVE NOT OCCURRED FOR AT LEAST TWO HOURS THEN LOCAL AUTHORITIES CAN ASSUME THE THREAT IS PASSED. DANGER TO BOATS AND COASTAL STRUCTURES CAN CONTINUE FOR SEVERAL

```
 HOURS DUE TO RAPID CURRENTS. AS LOCAL CONDITIONS CAN CAUSE A WIDE
 VARIATION IN TSUNAMI WAVE ACTION THE ALL CLEAR DETERMINATION MUST
 BE MADE BY LOCAL AUTHORITIES. DUE TO LOCAL EFFECTS SOME AREAS MAY
 CONTINUE TO EXPERIENCE SMALL SEA LEVEL CHANGES FOR AN EXTENDED
 PERIOD LASTING HOURS OR EVEN DAYS.

 FOR ALL AREAS COVERED BY THIS CENTER...THE TSUNAMI WARNING IS
 CANCELLED.

THIS WILL BE THE FINAL BULLETIN ISSUED FOR THIS EVENT UNLESS
ADDITIONAL INFORMATION BECOMES AVAILABLE.

THE WEST COAST/ALASKA TSUNAMI WARNING CENTER WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
```

4.11.12 Communication Test (WEPA40 PHEB)

```
TEST... COMMUNICATIONS TEST ...TEST
PACIFIC TSUNAMI WARNING CENTER/NOAA/NWS
ISSUED AT 0153Z 11 JUL 2007

TEST... PTWC TSUNAMI PRODUCTS COMMUNICATION TEST ...TEST

FROM - NOAA/NWS PACIFIC TSUNAMI WARNING CENTER
       EWA BEACH HAWAII

TO - DESIGNATED 24-HOUR TSUNAMI WARNING FOCAL POINTS OF THE
     PACIFIC TSUNAMI WARNING SYSTEM FOR THE FOLLOWING COUNTRIES
     AND PLACES IN THE PACIFIC OCEAN AND ITS MARGINAL SEAS.

     AMERICAN SAMOA...AUSTRALIA...BELAU...BRUNEI...CAMBODIA...
     CHILE...CHINA...CHINESE TAIPEI...CHUUK...COLOMBIA...
     COOK ISLANDS...COSTA RICA...DPR OF KOREA...ECUADOR...
     EL SALVADOR...FIJI...FRENCH POLYNESIA...GUAM...GUATEMALA...
     HAWAII...HONDURAS...HONG KONG...HOWLAND BAKER...INDONESIA...
     JAPAN...JARVIS ISLAND...KERMADEC ISLANDS...KIRIBATI...
     KOSRAE...MALAYSIA...MARSHALL ISLANDS...MEXICO...
     MIDWAY ISLAND...NAURU...NEW CALEDONIA...NEW ZEALAND...
     NICARAGUA...NIUE...NORTHERN MARIANAS...PALMYRA ISLAND...
     PANAMA...PAPUA NEW GUINEA...PERU...PHILIPPINES...
     PITCAIRN ISLAND...POHNPEI...REPUBLIC OF KOREA...
     RUSSIAN FEDERATION...SAMOA...SINGAPORE...SOLOMON ISLANDS...
     THAILAND...TOKELAU...TONGA...TUVALU...VANUATU...VIETNAM...
     WALLIS AND FUTUNA...WAKE ISLAND...YAP

     ALL OTHERS PLEASE DISREGARD

SUBJECT - PTWC TSUNAMI PRODUCTS COMMUNICATION TEST

THIS IS A TEST TO VERIFY COMMUNICATION LINKS AND DETERMINE
TRANSMISSION TIMES INVOLVED IN THE DISSEMINATION OF OPERATIONAL
TSUNAMI ADVICE PRODUCTS FROM THE PACIFIC TSUNAMI WARNING CENTER
TO DESIGNATED 24-HOUR TSUNAMI WARNING FOCAL POINTS OF THE PACIFIC
```

```
TSUNAMI WARNING SYSTEM.

RECIPIENTS ARE REQUESTED TO PLEASE RESPOND BACK TO THE
PACIFIC TSUNAMI WARNING CENTER WITH THE FOLLOWING INFORMATION.

  1 - NAME OF OFFICE THAT RECEIVED THIS TEST MESSAGE

  2 - METHOD OR METHODS BY WHICH THE TEST MESSAGE WAS RECEIVED
      IF BY GTS...   PLEASE INDICATE BY GTS
      IF BY AFTN...  PLEASE INCLUDE AFTN ADDRESS
      IF BY EMWIN... PLEASE INDICATE BY EMWIN
      IF BY RANET... PLEASE INDICATE BY RANET
      IF BY FAX...   PLEASE INCLUDE FAX NUMBER
      IF BY EMAIL... PLEASE INCLUDE EMAIL ADDRESS

  3 - TIME OF RECEIPT OF THIS TEST MESSAGE BY EACH METHOD

PLEASE RESPOND VIA ONE OF THE FOLLOWING MEANS

  EMAIL   -  PTWC@PTWC.NOAA.GOV
  TELEFAX -  1-808-689-4543

THANK YOU FOR YOUR PARTICIPATION IN THIS COMMUNICATION TEST.
```

SECTION 5 - WEST COAST/ALASKA TSUNAMI WARNING CENTER (WC/ATWC)

5.1 INTRODUCTION

The West Coast/Alaska Tsunami Warning Center (WC/ATWC) located in Palmer, Alaska, is operated by the Alaska Region of the U.S. National Weather Service and is a part of the U.S. National Oceanographic and Atmospheric Administration (NOAA). The WC/ATWC provides international tsunami warning services to the PTWS as a result of its service to the Pacific coasts of Canada, as well as to the U.S. West Coast and Alaska. In addition, WC/ATWC serves as a backup to PTWC and would issue messages to the Pacific on PTWC's behalf should PTWC become disabled.

5.2 AREA OF RESPONSIBILITY

WC/ATWC's area-of-responsibility (AOR) within the PTWS is the Pacific coasts of the U.S. States of Alaska, Washington, Oregon, and California, as well as the Pacific coast of Canada. Outside the PTWS, the WC/ATWC AOR is all U.S. Atlantic and Gulf of Mexico coasts, the Atlantic coast of Canada, Puerto Rico and the U.S. Virgin Islands, and the British Virgin Islands. WC/ATWC collaborates with the Pacific Tsunami Warning Center PTWC to provide tsunami warning services, and mutual backup, to tsunami threatened areas throughout the United States and the PTWS.

5.3 OPERATIONAL PROCEDURES

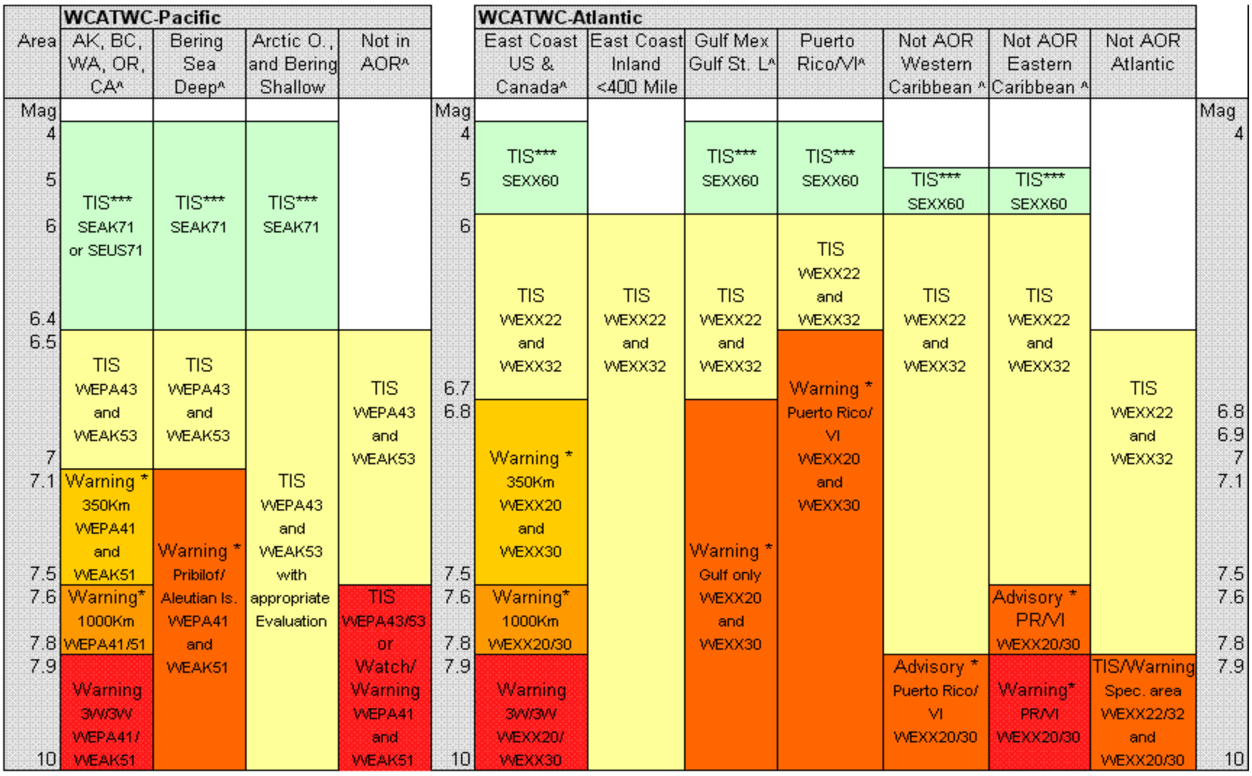
5.3.1 Response and Analysis

To accomplish its mission of providing accurate and timely tsunami bulletins to its AOR, WC/ATWC detects, locates, sizes, and analyzes earthquakes throughout the world. Earthquakes that activate the center's alarm system initiate an earthquake and tsunami investigation which includes the following four basic steps: automatic locating and sizing the earthquake; earthquake analysis and review; sea level data analysis to verify the existence of a tsunami and to calibrate models; and disseminating information to the appropriate emergency management officials.

The WC/ATWC staff level was increased in 2005 and 2006 so that the center could operate 24 hours every day with two watchstanders on duty. The center began 24x7x2 operations on April 23, 2006.

5.4 WARNING CRITERIA

WC/ATWC procedures and criteria are organized by the source's geographic region and magnitude. The basic procedures are summarized in the bar chart in Figure 5.1. The actions shown in Figure 5.1 indicate the first message (and in many cases the only message) to be issued. Follow up actions are based on observed wave amplitudes, tsunami models, historical data, and earthquake parameters. Supplemental warning or watch bulletins for events within the AOR are issued every 30 minutes, though they may be less often during later times of an event.



*** Based on magnitude and distance from the coast. ^ if deeper than 100km and <7.9, use TIS * No Watch
No TIS for Alaska if less than magnitude 5 and West of 155W
3W/3W => warning for area impacted within 3 hours and watch for area 3 to 6 hours away
TIS = Tsunami Information Statement
WMO product IDs listed under message type

Figure 5.1. WC/ATWC procedural chart

5.5 TYPES OF WC/ATWC MESSAGES

There are four basic types of messages issued by the WC/ATWC. These definitions have been recently updated within the U.S. Tsunami Warning System and will be in effect in early 2009.

5.5.1 Information Statement

An Information Statement is issued to inform emergency management officials and the public that an earthquake has occurred. In most cases, Information Statements are issued to indicate there is no threat of a destructive tsunami affecting the issuing Tsunami Warning Center's Area of Responsibility 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.

5.5.2 Tsunami Advisory

A Tsunami Advisory is issued by the Tsunami Warning Centers due to the threat of a potential tsunami which may produce strong currents or waves dangerous to those in or near the water. Coastal regions historically prone to damage due to strong currents induced by tsunamis are at the greatest risk. The threat may continue for several hours after the arrival of the initial wave, but significant widespread 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.

5.5.3 Tsunami Watch

A Tsunami Watch is issued by the Tsunami Warning Centers 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.

5.5.4 Tsunami Warning

A Tsunami Warning is issued by the Tsunami Warning Centers 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 arrival of the initial wave. Warnings also 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.

5.5.5 Communication Test

Communication tests are conducted monthly. Two tests are conducted: one for primary recipients in the Atlantic basin and one for primary recipients in the Pacific basin. Time that it takes to reach recipient is noted and those who do not receive the test are queried for a response. An example monthly summary sheet is attached.

5.6 WC/ATWC PRODUCT IDENTIFIERS AND DISSEMINATION

5.6.1 WMO and AWIPS Product IDs

WC/ATWC tsunami bulletins are National Weather Service products. All NWS products are described by both a World Meteorological Organization (WMO) Header and a National Weather Service AWIPS ID. The following table describes the products. For watch, warning, advisory, and information statements (with the WExxxx distribution), there are two products. The standard products (WEPA41, WEPA43, WEXX20, and WEXX22) are segmented within the bulletin with the watch, warning, and information only sections separated by Universal Generic Codes (for watch and warning messages). The new public products (WEAK51, WEAK53, WEXX30, and WEXX32) are in a format intended for the general public and contain action statements and information highlighting the dangers of tsunamis. Experimental web-based products are created and issued by the WC/ATWC to its web site and through RSS feeds. The web-based products are written in an html format with embedded links to related information and are similar in format to the public products.

WC/ATWC issues monthly communication test message using the WEPA41 and WEXX20 product headers.

WMO Header	NWS AWIPS ID	Explanation
WEPA41 PAAQ	TSUWCA	Tsunami Warnings, Watches, and Advisories AK, BC, and US West Coast
WEPA43 PAAQ	TIBWCA	Information Statements AK, BC, and US West Coast
WEAK51 PAAQ	TSUAK1	“Public” Tsunami Warnings, Watches, and Advisories AK, BC, and US West Coast
WEAK53 PAAQ	TIBAK1	“Public” Information Statements AK, BC, and US West Coast
SEAK71 PAAQ	EQIAKX	Information Statements Alaska (M<6.5)
SEUS71 PAAQ	EQIWOC	Information Statements BC and US West Coast (M<6.5)
WEXX20 PAAQ	TSUAT1	Tsunami Warnings, Watches, and Advisories PR/VI, US East, Gulf, and Canadian Maritime Provinces
WEXX22 PAAQ	TIBAT1	Information Statements PR/VI, US East, Gulf, and Canadian Maritime Provinces
WEXX30 PAAQ	TSUATE	“Public” Tsunami Warnings, Watches, and Advisories PR/VI, US East, Gulf, and Canadian Maritime Provinces
WEXX32 PAAQ	TIBATE	“Public” Information Statements PR/VI, US East, Gulf, and Canadian Maritime Provinces
SEXX60 PAAQ	EQIAT1	Information Statements (M<6) PR/VI, US East, Gulf, and Canadian Maritime Provinces

5.6.2 WC/ATWC Product Dissemination

Message dissemination routes used by the WC/ATWC are summarized in Figure 5.2. Primary routes are the National Warning System (NAWAS), the NOAA Weather Wire (NWWS), NWS private circuits to the NWS Telecommunications Gateway, and the Federal Aviation Administration’s (FAA) NADIN2 communication system. The NWS Telecommunications Gateway is the conduit to WMO’s Global Telecommunications System. Secondary routes are the web site, email, RSS feeds, cell phone text messaging, USGS dissemination systems, and telephone calls.

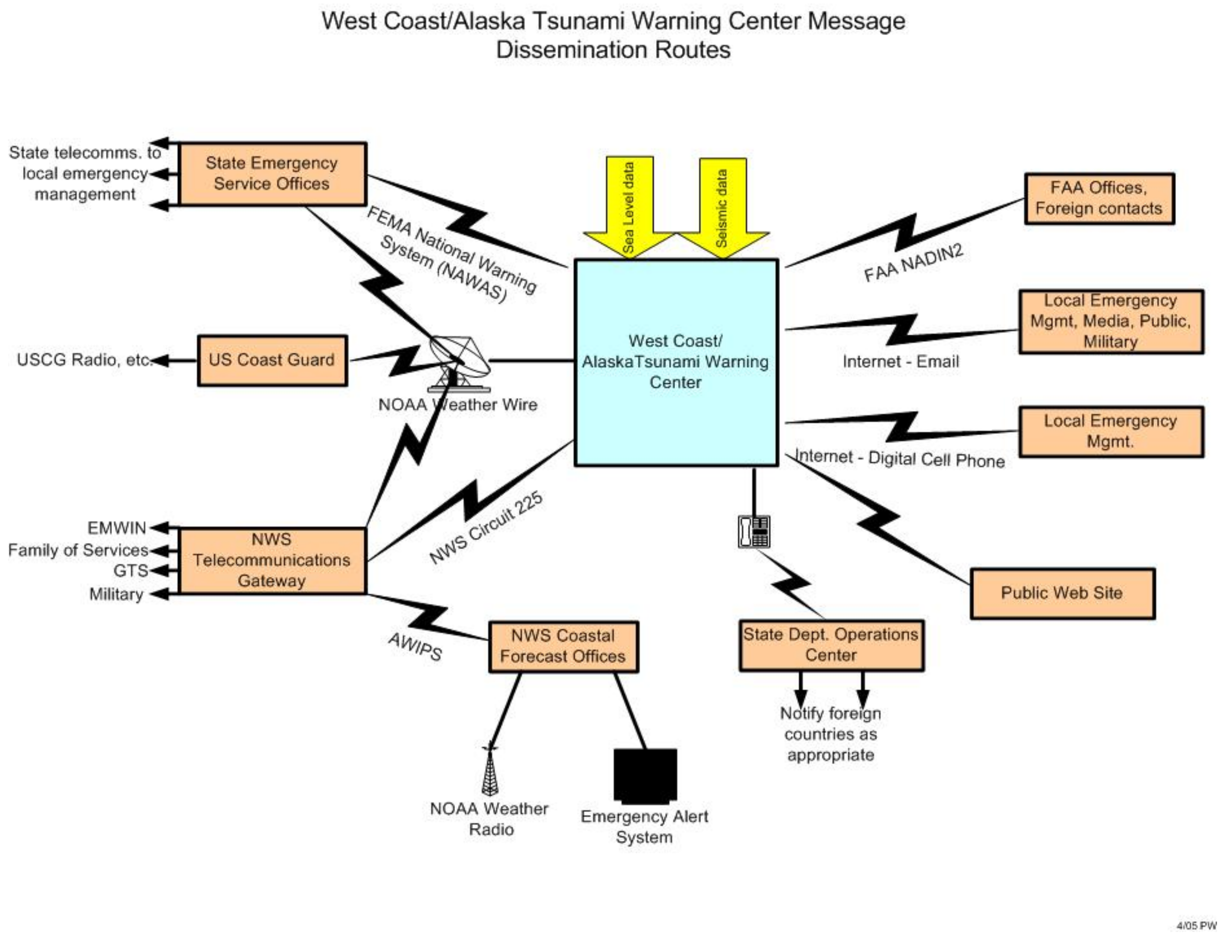


Figure 5.2. WC/ATWC message dissemination

5.7 EXAMPLE MESSAGES

Representative example products are shown below.

5.7.1 Pacific AOR Tsunami Warning/Watch/Advisory (WEPA41)

```
WEPA41 PAAQ 130850
TSUWCA

BULLETIN
TSUNAMI MESSAGE NUMBER 1
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
1150 PM AKST SAT JAN 12 2008

...THIS MESSAGE IS FOR TEST PURPOSES TO SHOW AN EXAMPLE
   WEPA41 MESSAGE...

...A TEST TSUNAMI WARNING IS IN EFFECT WHICH INCLUDES THE ALASKA
   COASTAL AREAS FROM KODIAK ALASKA TO ATTU ALASKA...

...A TEST TSUNAMI WATCH IS IN EFFECT FOR THE CALIFORNIA - OREGON
   - WASHINGTON - BRITISH COLUMBIA AND ALASKA COASTAL AREAS
```

FROM POINT REYES CALIFORNIA TO KODIAK ALASKA...
...THIS MESSAGE IS INFORMATION ONLY FOR U.S. AND CANADIAN
PACIFIC COASTAL REGIONS NOT INCLUDED IN THE AREAS LISTED
ABOVE...

TSUNAMI WARNINGS MEAN THAT A TSUNAMI WITH SIGNIFICANT WIDESPREAD
INUNDATION IS IMMINENT OR EXPECTED. WARNINGS INDICATE THAT
WIDESPREAD DANGEROUS COASTAL FLOODING ACCOMPANIED BY POWERFUL
CURRENTS IS POSSIBLE AND MAY CONTINUE FOR SEVERAL HOURS AFTER THE
INITIAL WAVE ARRIVAL.

TSUNAMI WATCHES ARE AN ADVANCE ALERT TO AREAS THAT COULD BE IMPACTED
BY A TSUNAMI AT A LATER TIME. WATCH AREAS MAY UPGRADED TO A
WARNING OR ADVISORY - OR CANCELED - BASED ON NEW INFORMATION
OR ANALYSIS. PERSONS IN A WATCH AREA SHOULD CLOSELY FOLLOW
SUBSEQUENT TSUNAMI MESSAGES.

RECOMMENDED ACTIONS
IT IS NOT KNOWN - REPEAT NOT KNOWN - IF A TSUNAMI EXISTS BUT A
TSUNAMI MAY HAVE BEEN GENERATED. PERSONS IN LOW-LYING COASTAL
AREAS SHOULD BE ALERT TO INSTRUCTIONS FROM THEIR LOCAL EMERGENCY
OFFICIALS. EVACUATIONS ARE ONLY ORDERED BY EMERGENCY RESPONSE
AGENCIES.
- PERSONS IN TSUNAMI WARNING COASTAL AREAS SHOULD MOVE INLAND TO
HIGHER GROUND.
- PERSONS IN TSUNAMI WATCH AREAS SHOULD STAY ALERT FOR
SUPPLEMENTAL INFORMATION.

THIS MESSAGE IS BASED MAINLY ON EARTHQUAKE DATA. AS MORE
INFORMATION BECOMES AVAILABLE THE ALERT AREAS WILL BE REFINED.

PRELIMINARY EARTHQUAKE PARAMETERS
MAGNITUDE - 7.9
TIME - 2345 AKST JAN 12 2008
0045 PST JAN 13 2008
0845 UTC JAN 13 2008
LOCATION - 52.4 NORTH 175.2 WEST
45 MILES/72 KM NW OF ATKA VILLAGE ALASKA
75 MILES/121 KM NE OF ADAK ALASKA
DEPTH - 17 MILES/27 KM

THE PACIFIC TSUNAMI WARNING CENTER IN EWA BEACH HAWAII WILL
ISSUE MESSAGES FOR HAWAII AND OTHER AREAS OF THE PACIFIC
OUTSIDE THE STATES AND PROVINCES LISTED ABOVE.

MESSAGES WILL BE ISSUED EVERY 30 MINUTES OR MORE FREQUENTLY IF
THE SITUATION WARRANTS. THE TSUNAMI ALERT WILL REMAIN IN EFFECT
UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.

PKZ136>138-132-150-155-170-171-172-175-176-AKZ171-181-185-
187-191-130950-
COASTAL AREAS BETWEEN AND INCLUDING KODIAK ALASKA TO ATTU

ALASKA
1150 PM AKST SAT JAN 12 2008

...A TEST TSUNAMI WARNING IS IN EFFECT WHICH INCLUDES THE ALASKA
COASTAL AREAS FROM KODIAK ALASKA TO ATTU ALASKA...

TSUNAMI WARNINGS MEAN THAT A TSUNAMI WITH SIGNIFICANT WIDESPREAD
INUNDATION IS IMMINENT OR EXPECTED. TSUNAMIS ARE A SERIES OF
WAVES POTENTIALLY DANGEROUS SEVERAL HOURS AFTER INITIAL ARRIVAL
TIME. ESTIMATED TIMES OF INITIAL WAVE ARRIVAL FOR SELECTED
SITES IN THE WARNING ARE PROVIDED BELOW.

ADAK-AK 0009 AKST JAN 13 SAND PT.-AK 0222 AKST JAN 13
SHEMYA-AK 0103 AKST JAN 13 COLD BAY-AK 0255 AKST JAN 13
DUTCH HARBOR-AK 0105 AKST JAN 13 KODIAK-AK 0316 AKST JAN 13
FOR ARRIVAL TIMES AT ADDITIONAL LOCATIONS SEE
WCATWC.ARH.NOAA.GOV

$$

PZZ455-540-450-356-353-350-255-250-210-110-156-153-150-130>135-
170-PKZ310-041-031>036-042-043-011>013-021-022-051-052-053-
125>129-121-120-130-140-141-CAZ505-002-001-ORZ022-002-021-
001-WAZ503-506>511-001-514>517-021-AKZ023-024-026>029-018>022-
025-017-135-131-125-121-145-130950-
COASTAL AREAS FROM POINT REYES CALIFORNIA TO KODIAK ALASKA
1150 PM AKST SAT JAN 12 2008

...A TEST TSUNAMI WATCH IS IN EFFECT FOR THE CALIFORNIA - OREGON
- WASHINGTON - BRITISH COLUMBIA AND ALASKA COASTAL AREAS
FROM POINT REYES CALIFORNIA TO KODIAK ALASKA...

TSUNAMI WATCHES ARE AN ADVANCE ALERT TO AREAS THAT COULD BE
IMPACTED BY A TSUNAMI AT A LATER TIME. TSUNAMIS ARE A SERIES OF
WAVES POTENTIALLY DANGEROUS SEVERAL HOURS AFTER INITIAL ARRIVAL
TIME. ESTIMATED TIMES OF INITIAL WAVE ARRIVAL FOR SELECTED
SITES IN THE WARNING ARE PROVIDED BELOW.

SEWARD-AK 0341 AKST JAN 13 JUNEAU-AK 0500 AKST JAN 13
YAKUTAT-AK 0350 AKST JAN 13 TOFINO-BC 0624 PST JAN 13
SITKA-AK 0351 AKST JAN 13 NEAH BAY-WA 0636 PST JAN 13
VALDEZ-AK 0400 AKST JAN 13 CHARLESTON-OR 0640 PST JAN 13
LANGARA-BC 0500 PST JAN 13 CRESCENT CITY-CA 0648 PST JAN 13
CORDOVA-AK 0410 AKST JAN 13 SEASIDE-OR 0649 PST JAN 13
HOMER-AK 0434 AKST JAN 13 WESTPORT-WA 0650 PST JAN 13
KETCHIKAN-AK 0458 AKST JAN 13
FOR ARRIVAL TIMES AT ADDITIONAL LOCATIONS SEE
WCATWC.ARH.NOAA.GOV

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

$$

5.7.2 Pacific AOR Tsunami Information Statement (WEPA43)

WEPA43 PAAQ 130942
TIBWCA

TSUNAMI INFORMATION STATEMENT NUMBER 1
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
142 AM PST SUN JAN 13 2008

...THIS MESSAGE IS FOR TEST PURPOSES TO SHOW AN EXAMPLE
WEPA43 MESSAGE...

...THIS TEST TSUNAMI INFORMATION STATEMENT IS FOR ALASKA/ BRITISH
COLUMBIA/ WASHINGTON/ OREGON AND CALIFORNIA ONLY...

NO - REPEAT NO - WARNING... WATCH OR ADVISORY IS IN EFFECT FOR
THE STATES AND PROVINCES LISTED ABOVE.

EVALUATION
BASED ON MAGNITUDE AND HISTORIC TSUNAMI RECORDS THE EARTHQUAKE
WAS NOT SUFFICIENT TO GENERATE A TSUNAMI DAMAGING TO CALIFORNIA/
OREGON/ WASHINGTON/ BRITISH COLUMBIA OR ALASKA. SOME OF THESE
AREAS MAY EXPERIENCE NON-DAMAGING SEA LEVEL CHANGES. IN COASTAL
AREAS OF INTENSE SHAKING LOCALLY GENERATED TSUNAMIS CAN BE
TRIGGERED BY UNDERWATER LANDSLIDES.

PRELIMINARY EARTHQUAKE PARAMETERS
MAGNITUDE - 6.7
TIME - 0035 AKST JAN 13 2008
0135 PST JAN 13 2008
0935 UTC JAN 13 2008
LOCATION - 42.2 NORTH 124.7 WEST
100 MILES/161 KM NW OF EUREKA CALIFORNIA
255 MILES/410 KM SW OF PORTLAND OREGON
DEPTH - 6 MILES/10 KM

THE PACIFIC TSUNAMI WARNING CENTER IN EWA BEACH HAWAII WILL ISSUE
MESSAGES FOR HAWAII AND OTHER AREAS OF THE PACIFIC.

THIS WILL BE THE ONLY STATEMENT ISSUED FOR THIS EVENT BY THE
WEST COAST/ALASKA TSUNAMI WARNING CENTER UNLESS ADDITIONAL
INFORMATION BECOMES AVAILABLE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.

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

$$

5.7.3 Alaska Information Statement (SEAK71)

```
SEAK71 PAAQ 281844
EQIAKX

TSUNAMI SEISMIC INFORMATION STATEMENT
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
944 AM AKST TUE NOV 28 2006

...THIS MESSAGE IS FOR TEST PURPOSES TO SHOW AN EXAMPLE
   SEAK71 MESSAGE...

...THIS IS AN INFORMATION STATEMENT...

EVALUATION
 AN EARTHQUAKE HAS OCCURRED WITH A LOCATION AND MAGNITUDE SUCH
 THAT A TSUNAMI WILL NOT BE GENERATED. THIS WILL BE THE ONLY
 WCATWC MESSAGE ISSUED FOR THIS EVENT.

PRELIMINARY EARTHQUAKE PARAMETERS
 MAGNITUDE - 5.2
 TIME      - 0930 AKST NOV 28 2006
             1030  PST NOV 28 2006
             1830  UTC NOV 28 2006
 LOCATION  - 61.1 NORTH 143.3 WEST
              25 MILES SW OF MCCARTHY ALASKA
             220 MILES E OF ANCHORAGE ALASKA
 DEPTH     - 25 MILES

THE LOCATION AND MAGNITUDE ARE BASED ON PRELIMINARY INFORMATION.
FURTHER INFORMATION WILL BE ISSUED BY THE UNITED STATES
GEOLOGICAL SURVEY - EARTHQUAKE.USGS.GOV.

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

$$
```

5.7.4 U.S. West Coast Information Statement (SEUS71)

```
SEUS71 PAAQ 130948
EQIWOC

TSUNAMI SEISMIC INFORMATION STATEMENT
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
148 AM PST SUN JAN 13 2008

...THIS MESSAGE IS FOR TEST PURPOSES TO SHOW AN EXAMPLE
   SEUS71 MESSAGE...

...THIS IS A TEST INFORMATION STATEMENT...
```

```
EVALUATION
 AN EARTHQUAKE HAS OCCURRED WITH A MAGNITUDE SUCH THAT A TSUNAMI
 WILL NOT BE GENERATED. THIS WILL BE THE ONLY WCATWC MESSAGE
 ISSUED FOR THIS EVENT.

PRELIMINARY EARTHQUAKE PARAMETERS
 MAGNITUDE - 5.2
 TIME      - 0045 AKST JAN 13 2008
             0145  PST JAN 13 2008
             0945  UTC JAN 13 2008
 LOCATION  - 52.2 NORTH 129.3 WEST
             130 MILES/209 KM SE OF SANDSPIT BRITISH COLUMBIA
             445 MILES/716 KM NW OF SEATTLE WASHINGTON
 DEPTH     - 6 MILES/10 KM

THE LOCATION AND MAGNITUDE ARE BASED ON PRELIMINARY INFORMATION.
FURTHER INFORMATION WILL BE ISSUED BY THE UNITED STATES
GEOLOGICAL SURVEY - EARTHQUAKE.USGS.GOV - OR THE APPROPRIATE
REGIONAL SEISMIC NETWORK.

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

$$
```

5.7.5 Communications Test (WEPA41)

```
WEPA41 PAAQ 051740
TSUWCA

TEST...TSUNAMI MESSAGE NUMBER 1...TEST
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
1040 AM PDT SUN OCT 5 2008

...THIS IS A TEST TO DETERMINE TRANSMISSION TIMES INVOLVED IN THE
   DISSEMINATION OF TSUNAMI INFORMATION...

RESPONSES ARE REQUIRED FROM

1. ALL NATIONAL WEATHER SERVICE FORECAST OFFICES IN ALASKA
   AND ALL COASTAL FORECAST OFFICES IN WASHINGTON - OREGON
   AND CALIFORNIA.

2. ALASKA WEATHER SERVICE OFFICES AT KING SALMON - COLD BAY -
   KODIAK - VALDEZ - YAKUTAT - ANNETTE AND ST. PAUL AND USAF
   11TH RESCUE COORDINATION CENTER AT FORT RICHARDSON.

3. STATE WARNING POINTS OR EOC AT FORT RICHARDSON AK -
   CAMP MURRAY WA - SALEM OR - SACRAMENTO CA AND THE PROVINCIAL
   EMERGENCY PROGRAM BC.
```

4. FNMOC MONTEREY, U.S. COAST GUARD 11TH - 13TH - 17TH DISTRICT OFFICES
KODIAK COMMSTA AND CAMSPAC POINT REYES CA.

5. FAA REGIONAL OPERATIONS CENTERS AT ANCHORAGE - LOS ANGELES
AND SEATTLE.

6. ALL TSUNAMIREADY COMMUNITY WARNING POINTS.

RESPONSES SHOULD INCLUDE
A. TIME-OF-RECEIPT
B. AGENCY NAME
C. EMAIL ADDRESS
D. PHONE NUMBER

WEATHER SERVICE OFFICES SHOULD RESPOND IN ACCORDANCE WITH LOCAL DIRECTIVES. ALL OTHERS SHOULD REPLY BY ONE OF THE AVAILABLE METHODS BELOW

EMAIL ADDRESS - WCATWC-AT SIGN-NOAA.GOV
AFTN ADDRESS - PAAQYQYX
FAX - 907-745-6071

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-AKZ191-187-185-181-171-145-111-101-121-125-131-135-
017>029-WAZ001-503-506>511-514>517-021-ORZ001-002-021-022-
CAZ001-002-505-506-006-508-509-514-515-009-034-035-039>046-
087-051840-
ALASKA/ BRITISH COLUMBIA/ WASHINGTON/ OREGON/ AND CALIFORNIA
COASTAL AREAS
1040 AM PDT SUN OCT 5 2008

...THIS IS A TEST TO DETERMINE TRANSMISSION TIMES INVOLVED IN THE
DISSEMINATION OF TSUNAMI INFORMATION...

$$

SECTION 6 - NORTHWEST PACIFIC TSUNAMI ADVISORY CENTER (NWPTAC)

6.1 INTRODUCTION

Since 1978, in-depth discussions have been made by the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU, now renamed the ICG/PTWS) on the establishment of regional tsunami warning centers to issue tsunami advisories tailored for respective regions in the Pacific. With regard to the Northwest Pacific region, the Republic of Korea proposed at the 14th session of ICG/ITSU (Tokyo, 1993) that a center could be assumed by the Japan Meteorological Agency (JMA). This triggered a feasibility study in ICG/ITSU to set up the regional center for the Northwest Pacific.

At the 17th ICG/ITSU session (Seoul, 1999), JMA, based on the survey of the regional requirement as well as state-of-the-art technology of predicting tsunami wave amplitude, submitted a proposal to the session to establish a regional tsunami warning center for the Northwest Pacific at JMA and the session accepted the proposal. After concentrated efforts of research and development to fully meet the requirements of the center, JMA submitted a report at the 19th ICG/ITSU session (Wellington, 2003) to demonstrate its readiness for the operation of the center. In 2004, Executive Council of the Intergovernmental Oceanographic Commission (IOC), at its 37th session (Paris, 2004), adopted a resolution to start the services of the regional center at JMA by March 2005.

On such an international consensus, JMA initiated the operation of the regional center in the Tsunami Forecast Center in the Headquarters of the Agency to provide tsunami advisories to the countries in the Northwest Pacific in March 2005. At the 20th ICG/ITSU session (Vina del Mar, October 2005), JMA reported the inauguration of the Northwest Pacific Tsunami Advisory Center (NWPTAC) and the ICG/ITSU expressed its appreciation to Japan for undertaking the responsibilities of the NWPTAC. At the same session, the Group requested JMA to provide the interim tsunami advisory service for the South China Sea region. JMA upgraded its system and started the service in April 2006.

6.2 GEOGRAPHICAL COVERAGE, TIMING AND CRITERIA FOR ISSUANCE

(1) The Northwest Pacific Tsunami Advisory (NWPTA) is issued when the NWPTAC detects occurrence of an earthquake of magnitude 6.5 or greater in its coverage area (see Figure 6), which includes the northwestern and a portion of the southwestern Pacific and, on an interim basis, the South China Sea regions.

(2) When the NWPTAC receives reports of tsunami observations, the tsunami observational data is presented in the subsequent NWPTA messages as necessary.

(3) When the location and magnitude of the earthquake are re-estimated using seismic data subsequently obtained and/or an unexpectedly significant tsunami is observed, further NWPTA is issued to revise the previous advisory.

6.3 CONTENTS OF THE ADVISORY

The NWPTA contains: (1) Earthquake information; (2) Tsunamigenic potential; (3) Estimated amplitude and arrival time of tsunami; and (4) Observations of tsunami. Dates and time used in the NWPTA are given in Universal Time Coordinated (UTC). The earthquake parameters on the NWPTA are coordinated and consistent with those of the PTWC bulletin. The template and sample messages of the NWPTA are presented in 6.7.

6.3.1 Earthquake information

a. Origin time

b. Coordinates (latitude and longitude) of the epicenter

c. Location (name of geographical area)

d. Depth (only for the earthquake at a depth of 100 km or deeper)

e. Magnitude (Moment magnitude. In case it is JMA Magnitude (Mjma), "(MJMA)" is attached. See the JMA part of the annexes.)

6.3.2 Tsunamigenic potential

Tsunamigenic potential is evaluated according to the magnitude of the earthquake as following.

$M>7.8$	Possibility of a destructive ocean-wide tsunami
$7.8 \geq M>7.5$	Possibility of a destructive regional tsunami within 1,000 km of the epicenter
$7.5 \geq M>7.0$	Possibility of a destructive local tsunami within 100 km of the epicenter
$7.0 \geq M \geq 6.5$	Very small possibility of a destructive local tsunami

No tsunamigenic potential is applied for earthquakes occurring in inland areas or at a depth of 100 km or deeper.

6.3.3 Estimated amplitude and arrival time of tsunami

Tsunami amplitude and arrival time are estimated for each forecast point on coasts (see Figure 6 and Table 6). The estimated amplitude and arrival time are listed in the NWPTA messages with the names of forecast points and their latitude and longitude (in 0.1 degree), in groups of coastal blocks.

Definition of 'amplitude' is the largest difference between the crests of tsunami wave and the undisturbed sea level. Estimated tsunami amplitude is indicated only for the forecast points where the tsunami of 0.5 m or greater is expected to reach. Tsunami amplitude is classified in categories of "0.5m"; "1m"; "2m"; "3m"; "4m"; "6m"; "8m"; and "OVER 10m". When tsunami amplitude of less than 0.5 m is estimated for all forecast points, "ESTIMATION AT THE FORECAST POINTS - NO TSUNAMIS WITH AMPLITUDE OF 0.5 METER OR OVER ARE EXPECTED AT ANY OF THEM" is described in the NWPTA message.

6.3.4 Observations of tsunami

When tsunami waves are actually recorded at tidal stations which are telemetrically linked to the NWPTAC, those observational data are provided as necessary, including the amplitude of the largest wave in 0.1 m unit (in this case, the 'amplitude' is the half of the vertical length from the trough to the crest of the wave).

6.4 MEANS OF DISSEMINATION

The NWPTA is provided via the GTS with the heading of WEPA40 RJTD, e-mail and facsimile. Recipients are strongly encouraged to receive the Advisories by multi communication means in order to ensure the receipt.

6.5 COMMUNICATIONS TEST

The NWPTAC conducts communications tests approximately on a quarterly basis to verify that communications links to the recipient organizations are functioning properly. An announcement will be made by the NWPTAC in advance of the communications tests. In the test, a dummy message will be sent to the recipient organizations (see Sample Message 6). The recipients are kindly requested to acknowledge the test message with the form below to:

Facsimile: +81-3-3215-2963 and/or **E-mail**: hokusei@eqvol.kishou.go.jp

Acknowledge Form for Reception of the NWPTA Test Message

Name of country

Recipient organization

Responsible office

Officer in charge
Name:

Reception status of the NWPTA test message

GTS

Received	( )	time of receipt (UTC):	h	m
Failed to receive	( )			
Not registered	( )			

E-mail

Received	( )	time of receipt (UTC):	h	m
Failed to receive	( )			
Not registered	( )			

Facsimile

Received	( )	time of receipt (UTC):	h	m
Failed to receive	( )			
Not registered	( )			

6.6 STATUS OF THE ADVISORY

The provision of the NWPTAs aims at allowing recipient countries to take timely and appropriate actions against tsunami threats, in conjunction with tsunami bulletins from the Pacific Tsunami Warning Center (PTWC). It should be noted, however, that the NWPTA is nothing more than an advisory to be considered by recipients in alerting the people and announcing evacuation notices at their own responsibility. The accuracy of the estimation of amplitude and arrival time of tsunamis in the NWPTA as well as the time required for the forecast operation depend on the availability of seismic data and the technologies of hypocenter determination and quantitative tsunami forecasting. It is highly advisable, therefore, that the recipient countries should make the best use of the NWPTA with thorough understanding of the technological background of the Advisory as described below and in the annexes of the Users Guide.

The NWPTAC makes its utmost effort to disseminate NWPTAs as quickly as possible. However, people need to be alerted in advance of the receipt of the NWPTA in case of occurrence of a strong earthquake in the vicinity of their coasts, considering that tsunamis might be generated and reach the coasts in the shortest time.

The NWPTA does not refer to the cancellation of any warnings in its subsequent issues because the NWPTAC itself does not issue warnings. The NWPTAC is of the view that warnings should be officially issued and cancelled by the authorities of the countries concerned at their own responsibility, on the ground that tsunamis varies depending on the coastal terrains.

In case of significant difference in the evaluation of severity of tsunami between the PTWC's bulletin and NWPTA, severer one should be adopted.

The operational system for the NWPTA service in JMA is duplicated in case of partial malfunction of the system. However, possibility of a serious failure in the system cannot be totally excluded. In case a NWPTA is not issued due to such an unforeseen emergency, the recipient countries/organizations of NWPTAs should take appropriate actions according to the bulletins from the PTWC.

6.7 TEMPLATE OF THE NWPTA

```
WEPA40 RJTD DDhhmm                                          <--- (1)

TSUNAMI BULLETIN NUMBER NNN                                 <--- (2)
 ISSUED BY NWPTAC(JMA)
 ISSUED AT hhmmZ DD MMM YYYY
 PART nn OF NN PARTS

HYPOCENTRAL PARAMETERS                                      <--- (3)
  ORIGIN TIME:hhmmZ DD MMM YYYY
  PRELIMINARY EPICENTER:LAT LL.L[NORTH][SOUTH] LON
LLL.LEAST
Geographical Area (Regional Scale)
  Geographical Area (Wider Scale)
  MAG:M.M[MJMA]
                                                            <--- (4)
EVALUATION
 Tsunamigenic Potential
                                                            <--- (5)
THIS BULLETIN IS FOR
Coastal Block 1
Coastal Block 2
Coastal Block 3
...
                                                            <--- (6)
ESTIMATED TSUNAMI ARRIVAL TIME AND ESTIMATED TSUNAMI
WAVE AMPLITUDE
Coastal Block 1
 LOCATION    COORDINATES          ARRIVAL TIME   AMPL
 FP1-1       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
Coastal Block 2
 LOCATION    COORDINATES          ARRIVAL TIME   AMPL
 FP2-1       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
 FP2-2       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
 FP2-3       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
Coastal Block 3
 LOCATION    COORDINATES          ARRIVAL TIME   AMPL
 FP3-1       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
 FP3-2       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
 FP3-3       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
 FP3-4       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
 FP3-5       LL.L[N][S] LLL.LE    hhmmZ DD MMM   AMPLM
...
 ...
 ...

AMPL – AMPLITUDE IN METERS FROM MIDDLE TO CREST
                                                            <--- (7)
Remarks
```

6.7.1 Heading

Heading of the message on the GTS circuit. **DDhhmm** represents the day, hour and minute of the issuance time in UTC.

6.7.2 Bulletin Number

NNN is the number of the bulletin. The number will be increased in the subsequent issue. **hhmm**, **DD**, **MMM** and **YYYY** represent the hour, minute, day, month and year of the issuance time in UTC. If the NWPTA message is too long, it may be divided into several parts. **nn** represents the turn of the part and **NN** is the total number of separated parts of the advisory. In case the massage is not divided, both **nn** and **NN** will be 01.

6.7.3 Hypocentral Parameters

Hypocentral parameters. **hhmm**, **DD**, **MMM** and **YYYY** represent the hour, minute, day, month and year of the origin time of the earthquake in UTC. **LL.L** and **LLL.L** represent the latitude and longitude of the epicenter, respectively. As for the latitude, either "**NORTH**" or "**SOUTH**" is added while the longitude is always "EAST". **Geographical Area** is the region of the epicenter according to the Flinn-Engdahl regionalization*. **M.M** is the magnitude of the earthquake. If the magnitude is Mjma, "**(MJMA)**" will be added. Focal depth will be added only when the depth is 100 km or deeper. When the parameters are revised in the subsequent message, "(REVISION)" will be added in the first line of this part (see Sample Message 5).

*) See http://earthquake.usgs.gov/learning/topics/flinn_engdahl.php.

6.7.4 Tsunamigenic Potential

Tsunamigenic Potential. See 6.3.2

6.7.5 Coastal Blocks

If 0.5 m or greater tsunami is expected for any forecast points (FPs), the **Coastal Block**s of those FPs will be shown in this part. When the estimated tsunami amplitudes for all the FPs are less than 0.5 m, “ESTIMATION AT THE FORECAST POINTS - NO TSUNAMI WITH AMPLITUDE OF 0.5 METER OR OVER ARE EXPECTED AT ANY OF THEM” is described. "(ADDITION)", "(REVISION)", or "(CANCELLATION)" will be attached according to the revision of (6) below in the subsequent issues due to the update of the earthquake parameters or an observation of unexpectedly significant tsunami (see Sample Message 5).

6.7.6 Forecast Amplitude and Arrival Time

The estimated tsunami amplitude (**AMPL** in meter) and arrival time (**hhmm** **DD** **MMM** in UTC) is listed for each FP in groups of the **Coastal Block**. When the expected tsunami is less than 0.5 m for all the FPs, this part will not appear in the message. If it is found that new FPs should be added or the expected arrival time / amplitude of tsunami should be changed in the revised issue due to the update of the earthquake parameters or observations of unexpectedly significant tsunami, "(ADDITION)" or "(REVISION)" will be attached in the line for the FPs concerned. As for the FPs which appeared in the previous NWPTA message but should be removed due to the revision, "(CANCELLATION)" will be attached in the revised issue (see Sample Message 5).

6.7.7 Remarks

Remarks. Some remarks are attached.

6.8 SAMPLE MESSAGES OF THE NWPTA

6.8.1 Sample Message 1. Tsunami of 0.5 m or greater is expected.

```
WEPA40 RJTD 240904

TSUNAMI BULLETIN NUMBER 001
 ISSUED BY NWPTAC(JMA)
 ISSUED AT 0859Z 24 MAR 2005
PART 01 OF 01 PARTS

HYPOCENTRAL PARAMETERS
  ORIGIN TIME:0858Z 24 MAR 2005
  PRELIMINARY EPICENTER:LAT 3.0SOUTH LON 148.0EAST
    EASTERN CAROLINE ISLANDS, MICRONESIA
  PACIFIC BASIN
  MAG:8.2

EVALUATION
 THERE IS A POSSIBILITY OF A DESTRUCTIVE OCEAN-WIDE TSUNAMI

THIS BULLETIN IS FOR
  EAST COASTS OF PHILIPPINES
  NORTH COASTS OF IRIAN JAYA
  NORTH COASTS OF PAPUA NEW GUINEA
  CELEBES SEA

ESTIMATED TSUNAMI ARRIVAL TIME AND ESTIMATED TSUNAMI WAVE
AMPLITUDE
EAST COASTS OF PHILIPPINES
 LOCATION    COORDINATES        ARRIVAL TIME        AMPL
 LEGASPI     13.2N 123.8E  1257Z 24 MAR        0.5M
NORTH COASTS OF IRIAN JAYA
 LOCATION    COORDINATES        ARRIVAL TIME        AMPL
 MANOKWARI          00.8S 134.2E  1116Z 24 MAR        1M
 WARSA              00.6S 135.8E  1046Z 24 MAR        1M
 JAYAPURA    02.4S 140.8E  1002Z 24 MAR        3M
NORTH COASTS OF PAPUA NEW GUINEA
 LOCATION    COORDINATES        ARRIVAL TIME        AMPL
 VANIMO             02.6S 141.3E  0953Z 24 MAR        2M
 WEWAK              03.5S 143.7E  0931Z 24 MAR        4M
 MADANG             05.2S 145.8E  0935Z 24 MAR        8M
 MANUS_IS.   02.0S 147.5E  0858Z 24 MAR        4M
 RABAUL             04.2S 152.3E  1000Z 24 MAR        2M
CELEBES SEA
  LOCATION   COORDINATES        ARRIVAL TIME        AMPL
 MANADO             01.6N 124.9E  1304Z 24 MAR        0.5M

AMPL – AMPLITUDE IN METERS FROM MIDDLE TO CREST
```

HOWEVER AT SOME COASTS, PARTICULARLY THOSE NEAR THE EPICENTER, HIGHER TSUNAMIS MAY ARRIVE EARLIER THAN OUR ESTIMATION AT THE NEARBY FORECAST POINTS. AUTHORITIES SHOULD BE AWARE OF THIS POSSIBILITY.

FURTHERMORE THE EVALUATION OF TSUNAMIGENIC POTENTIAL AND ESTIMATED ARRIVAL TIME OF TSUNAMIS MAY BE DIFFERENT FROM THOSE OF PTWC DUE TO DIFFERENCES IN THE ESTIMATED EARTHQUAKE PARAMETERS. AUTHORITIES SHOULD USE THE EARLIEST ARRIVAL TIMES FOR GREATEST SAFETY.

THIS WILL BE THE FINAL BULLETIN UNLESS THERE ARE CHANGES ABOUT THE POTENTIAL OF TSUNAMI GENERATION BY RE-EVALUATION OF THE EARTHQUAKE OR THERE ARE REPORTS ON TSUNAMI OBSERVATIONS.

6.8.2 Sample Message 2. Less than 0.5 m tsunami expected for all forecast points.

WEPA40 RJTD 100743

TSUNAMI BULLETIN NUMBER 001
ISSUED BY NWPTAC(JMA)
ISSUED AT 0739Z 10 JAN 2005
PART 01 OF 01 PARTS

HYPOCENTRAL PARAMETERS
ORIGIN TIME: 0724Z 10 JAN 2005
PRELIMINARY EPICENTER: LAT7.0NORTH LON138.0EAST
WESTERN CAROLINE ISLANDS, MICRONESIA
CAROLINE ISLANDS TO GUAM
MAG:6.6

EVALUATION
THERE IS A VERY SMALL POSSIBILITY OF A DESTRUCTIVE LOCAL TSUNAMI

ESTIMATION AT THE FORECAST POINTS - NO TSUNAMIS WITH AMPLITUDE OF 0.5 METER OR OVER ARE EXPECTED AT ANY OF THEM

HOWEVER AT SOME COASTS, PARTICULARLY THOSE NEAR THE EPICENTER, HIGHER TSUNAMIS MAY ARRIVE THAN OUR ESTIMATION. AUTHORITIES SHOULD BE AWARE OF THIS POSSIBILITY.

THIS WILL BE THE FINAL BULLETIN UNLESS THERE ARE CHANGES ABOUT THE POTENTIAL OF TSUNAMI GENERATION BY RE-EVALUATION OF THE EARTHQUAKE OR THERE ARE REPORTS ON TSUNAMI OBSERVATIONS.

6.8.3 Sample Message 3. Earthquake occurs in an inland area.

```
WEPA40 RJTD 100743

TSUNAMI BULLETIN NUMBER 001
 ISSUED BY NWPTAC(JMA)
 ISSUED AT 0739Z 10 JAN 2005
PART 01 OF 01 PARTS

HYPOCENTRAL PARAMETERS
ORIGIN TIME: 0724Z 10 JAN 2005
PRELIMINARY EPICENTER: LAT17.5NORTH LON121.0EAST
 LUZON, PHILIPPINE ISLANDS
 THE PHILIPPINES
MAG:6.5

EVALUATION
 THERE IS NO POSSIBILITY OF A TSUNAMI

THIS WILL BE THE FINAL BULLETIN UNLESS THERE ARE CHANGES ABOUT THE
POTENTIAL OF TSUNAMI GENERATION BY RE-EVALUATION OF THE
EARTHQUAKE OR THERE ARE REPORTS ON TSUNAMI OBSERVATIONS.
```

6.8.4 Sample Message - 4. Earthquake occurs at a depth of 100 km or more.

```
WEPA40 RJTD 100743

TSUNAMI BULLETIN NUMBER 001
 ISSUED BY NWPTAC(JMA)
 ISSUED AT 0739Z 10 JAN 2005
PART 01 OF 01 PARTS

HYPOCENTRAL PARAMETERS
ORIGIN TIME: 0724Z 10 JAN 2005
PRELIMINARY EPICENTER: LAT7.0NORTH LON138.0EAST
 WESTERN CAROLINE ISLANDS, MICRONESIA
 CAROLINE ISLANDS TO GUAM
FOCAL DEPTH:120KM MAG:6.6

EVALUATION
 THERE IS NO POSSIBILITY OF A TSUNAMI

 THIS WILL BE THE FINAL BULLETIN UNLESS THERE ARE CHANGES ABOUT
THE POTENTIAL OF TSUNAMI GENERATION BY RE-EVALUATION OF THE
EARTHQUAKE OR THERE ARE REPORTS ON TSUNAMI OBSERVATIONS.
```

6.8.5 Sample Message - 5. Revision of the Advisory.

```
WEPA40 RJTD 240934

TSUNAMI BULLETIN NUMBER 002
```

ISSUED BY NWPTAC(JMA)
ISSUED AT 0929Z 24 MAR 2005
PART 01 OF 01 PARTS
HYPOCENTRAL PARAMETERS(REVISION)
ORIGIN TIME:0858Z 24 MAR 2005
PRELIMINARY EPICENTER:LAT 3.5SOUTH LON148.2EAST
EASTERN CAROLINE ISLANDS, MICRONESIA
PACIFIC BASIN
MAG:8.3

EVALUATION
THERE IS A POSSIBILITY OF A DESTRUCTIVE OCEAN-WIDE TSUNAMI

THIS BULLETIN IS FOR
EAST COASTS OF PHILIPPINES(REVISION)
NORTH COASTS OF IRIAN JAYA(REVISION)
NORTH COASTS OF PAPUA NEW GUINEA(REVISION)
CELEBES SEA

ESTIMATED TSUNAMI ARRIVAL TIME AND ESTIMATED TSUNAMI WAVE AMPL

EAST COASTS OF PHILIPPINES

LOCATION	COORDINATES	ARRIVAL TIME	AMPL
LEGASPI	13.2N 123.8E	(ALREADY ARRIVED)	
DAVAO	06.9N 125.7E	1237Z 24 MAR	1M(ADDITION)

NORTH COASTS OF IRIAN JAYA

LOCATION	COORDINATES	ARRIVAL TIME	AMPL
MANOKWARI	00.8S 134.2E	1116Z 24 MAR	0.5M(REVISION)
WARSA	00.6S 135.8E	1046Z 24 MAR	1M
JAYAPURA	02.4S 140.8E	1002Z 24 MAR	3M

NORTH COASTS OF PAPUA NEW GUINEA

LOCATION	COORDINATES	ARRIVAL TIME	AMPL
VANIMO	02.6S 141.3E	0953Z 24 MAR	2M
WEWAK	03.5S 143.7E	0931Z 24 MAR	4M
MADANG	05.2S 145.8E	0935Z 24 MAR	8M
MANUS_IS.	02.0S 147.5E	0858Z 24 MAR	4M
RABAUL	04.2S 152.3E	(CANCELLATION)	

CELEBES SEA

LOCATION	COORDINATES	ARRIVAL TIME	AMPL
MANADO	01.6N 124.9E	1304Z 24 MAR	0.5M

AMPL - AMPLITUDE IN METERS FROM MIDDLE TO CREST

HOWEVER AT SOME COASTS, PARTICULARLY THOSE NEAR THE EPICENTER, HIGHER TSUNAMIS MAY ARRIVE EARLIER THAN OUR ESTIMATION AT THE NEARBY FORECAST POINTS. AUTHORITIES SHOULD BE AWARE OF THIS POSSIBILITY.

FURTHERMORE THE EVALUATION OF TSUNAMIGENIC POTENTIAL AND ESTIMATED ARRIVAL TIME OF TSUNAMIS MAY BE DIFFERENT FROM THOSE OF PTWC DUE TO DIFFERENCES IN THE ESTIMATED EARTHQUAKE PARAMETERS. AUTHORITIES SHOULD USE THE EARLIEST ARRIVAL TIMES FOR GREATEST SAFETY.

MEASUREMENTS OR REPORTS ON TSUNAMI
LOCATION COORDINATES ARRIVAL TIME AMPL
LEGASPI 13.2N 123.8E
MAXIMAM TSUNAMI WAVE 0810Z 10 JAN 0.5M

MAXIMUN TSUNAMI WAVE -- HALF OF AMPLITUDE FROM THE TROUGH TO THE CREST

THIS WILL BE THE FINAL BULLETIN UNLESS THERE ARE CHANGES ABOUT THE POTENTIAL OF TSUNAMI GENERATION BY RE-EVALUATION OF THE EARTHQUAKE OR THERE ARE REPORTS ON TSUNAMI OBSERVATIONS.

6.8.6 Sample Message - 6. Dummy Message for Communication Test

WEPA40 RJTD 240934

COMMUNICATION TEST
ISSUED BY NWPTAC(JMA)
ISSUED AT 0929Z 24 MAR 2005

THIS IS A TEST BULLETIN

TEST MESSAGE IS FORWARDED TO EACH RECIPIENT ORGANIZATION
IN ORDER TO EXAMINE THE COMMUNICATION

6.9 FORECAST POINTS AND COASTAL BLOCKS

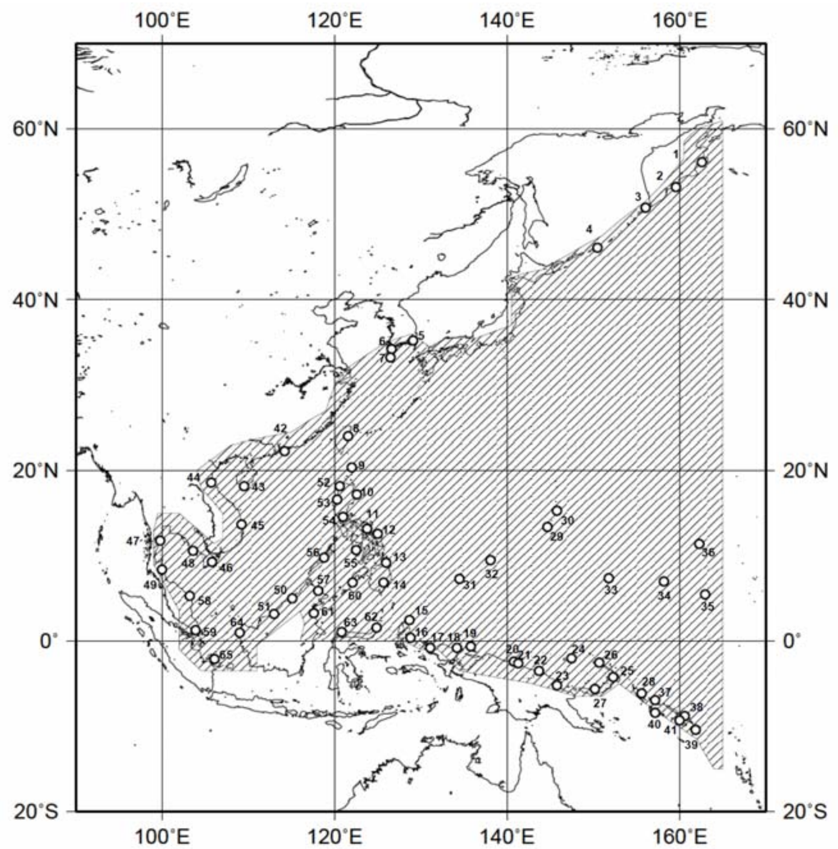


Figure 6. The geographical coverage (hatched area) and the forecast points (open circle) of the NWPTA. The numbers at each point correspond with those in the right column of Table 6.

Table 6. Forecast points and coastal blocks of NWPTAC.

Coastal Block	Forecast Point	Latitude	Longitude	Number in Fig. 6
EAST COASTS OF KAMCHTKA PENINSULA	UST_KAMCHATSK	56.1N	162.6E	1
	PETROPAVLOVSK_K	53.2N	159.6E	2
KURIL ISLANDS	SEVERO_KURILSK	50.8N	156.1E	3
	URUP_IS.	46.1N	150.5E	4
SOUTH COASTS OF KOREAN PENINSULA	BUSAN	35.2N	129.1E	5
	NOHWA	34.2N	126.6E	6
	SEOGWIPO	33.2N	126.5E	7
EAST COASTS OF TAIWAN	HUALIEN	24.0N	121.6E	8
EAST COASTS OF PHILIPPINES	BASCO	20.4N	122.0E	9
	PALANAN	17.2N	122.6E	10
	LEGASPI	13.2N	123.8E	11
	LAOANG	12.6N	125.0E	12
	MADRID	09.2N	126.0E	13
	DAVAO	06.9N	125.7E	14
NORTH COASTS OF IRIAN JAYA	BEREBERE	02.5N	128.7E	15
	PATANI	00.4N	128.8E	16
	SORONG	00.8S	131.1E	17
	MANOKWARI	00.8S	134.2E	18
	WARSA	00.6S	135.8E	19
	JAYAPURA	02.4S	140.8E	20
NORTH COASTS OF PAPUA NEW GUINEA	VANIMO	02.6S	141.3E	21
	WEWAK	03.5S	143.7E	22
	MADANG	05.2S	145.8E	23
	MANUS_IS.	02.0S	147.5E	24
	RABAUL	04.2S	152.3E	25
	KAVIENG	02.5S	150.7E	26
	KIMBE	05.6S	150.2E	27
	KIETA	06.1S	155.6E	28
MARIANA ISLANDS	GUAM	13.4N	144.7E	29
	SAIPAN	15.3N	145.8E	30
PALAU	MALAKAL	07.3N	134.5E	31
MICRONESIA	YAP_IS.	09.5N	138.1E	32
	CHUUK_IS.	07.4N	151.8E	33
	POHNPEI_IS.	07.0N	158.2E	34
	KOSRAE_IS.	05.5N	163.0E	35
MARSHALL ISLANDS	ENIWETOK	11.4N	162.3E	36
NORTH COASTS OF SOLOMON ISLANDS	PANGGOE	06.9S	157.2E	37
	AUKI	08.8S	160.6E	38
	KIRAKIRA	10.4S	161.9E	39
SOLOMON SEA	MUNDA	08.4S	157.2E	40
	HONIARA	09.3S	160.0E	41

Table 6. --- continued

Coastal Block	Forecast Point	Latitude	Longitude	Number in Fig. 6
COASTS OF SOUTH CHINA SEA	HONG_KONG	22.3N	114.2E	42
	SANYA	18.2N	109.5E	43
COASTS OF GULF OF TONKIN	VINH	18.6N	105.7E	44
EAST COASTS OF INDO CHINA PENINSULA	QUI_NHON	13.7N	109.2E	45
	BAC_LIEU	09.3N	105.8E	46
GULF OF THAILAND	PRACHUAP_KHIRI KHAN	11.8N	099.8E	47
	SIHANOUKVILLE	10.6N	103.6E	48
	NAKHON_SI_THAMMARAT	08.4N	100.0E	49
NORTHWEST COASTS OF KALIMANTAN	MUARA	05.0N	115.1E	50
	BINTULU	03.2N	113.0E	51
WEST COASTS OF PHILIPPINES	LAOAG	18.2N	120.6E	52
	SAN_FERNANDO	16.6N	120.3E	53
	MANILA	14.6N	121.0E	54
SULU SEA	ILOILO	10.7N	122.5E	55
	PUERTO_PRINCESA	09.8N	118.8E	56
	SANDAKAN	05.9N	118.1E	57
EAST COASTS OF MALAY PENINSULA	KUARA_TERENGGANU	05.3N	103.2E	58
	SINGAPORE	01.3N	103.9E	59
CELEBES SEA	ZAMBOANGA	06.9N	122.1E	60
	TARAKAN	03.3N	117.6E	61
	MANADO	01.6N	124.9E	62
	TOLITOLI	01.1N	120.8E	63
NATUNA SEA	SINGKAWANG	01.0N	109.0E	64
	PANGKALPINANG	02.1S	106.1E	65

6.10 EXCERPTS FROM SUMMARY REPORTS OF RELEVANT SESSIONS OF THE ICG/PTWS (with paragraph numbering)

Summary Report of the ICG/ITSU-XIV Session (1993)

90 The Representative of Korea proposed the establishment of the Far East Tsunami Warning Center. One of the possible locations for the Center could be at the Japan Meteorological Agency. The Representative of Japan informed the Group that much discussion and consensus among the Member States concerned would be necessary to establish the Center and obtain additional tide and seismic data from and improve communications with the concerned countries in the are of Japan, Yellow and East China Seas for the tsunami warning service.

91 After a discussion in which many Member States participated, **the Group agreed** that it would be desirable for the Member States bordering on these Seas to discuss the possibility of establishing a Far East Tsunami Warning Center. Japan was requested to advise the Secretary of the results of any discussions, so that if appropriate, the issue can be included as Agenda Item at ITSU-XV.

Summary Report of the ICG/ITSU-XV Session (1995)

96 **The Group received** the comments of the Delegate of Japan relative to the proposal made by the Delegate of the Republic of Korea at ITSU-XIV, regarding the establishment of a Far East Tsunami Warning Centre and its possible location at the Japan Meteorological Agency. There were a number of concerns open for discussion: the area of responsibility of the Centre, communications for warnings and the need for additional seismic and tidal data which would be required to support the operations of the Centre.

Summary Report of the ICG/ITSU-XVI Session (1997)

77 The Delegate of Japan reported on the progress made in relation to the establishment of the Far East Tsunami Centre in JMA. In the case of a regional centre he expressed concern on communication problems, especially on transmission of seismic signals to determine the hypocenters. Trying to solve this problem, JMA is considering to arrange a questionnaire survey within the countries of the region in order to identify problems, needs and requirements for a regional centre. The Delegate of USA expressed appreciation for the Japanese initiative due to the fact that PTWC cannot be operationally effective for this region.

78 The Delegate of the Republic of Korea thanked Japan for the initiative underway, and expressed his willingness to participate and co-operate in it.

79 **The Group recognized** the effort made by Japan, expressed its appreciation for it and encouraged it to continue the progress of this activity.

Summary Report of the ICG/ITSU-XVII Session (1999)

110 The Delegate of Japan recalled the discussions held at ITSU-XVI regarding the establishment of the Far East Centre. In response to ITSU-XVI recommendations, Japan Meteorological Agency conducted a survey of 6 Member States of the Western Pacific on the interest and possibility to provide seismic and tidal observational data to JMA for facilitating early tsunami warning.

111 The survey showed the interest of the Member States and their readiness to collaborate with Japan on this important initiative. The Member States requested Japan to include in tsunami forecasts information on the location and the magnitude of the earthquake, the estimated times of the first tsunami arrival and the forecast of estimated tsunami heights.

112 JMA began to operate its new tsunami forecasting system in April 1999. This system has the capability to make forecasts of tsunamis caused by the earthquakes for surrounding coastal areas. In 2000, it will be able to issue a tsunami forecast and after minor modifications of the system transmit it automatically to the Member States concerned.

113 **The Group expressed deep appreciation** to Japan for its efforts in providing for the surrounding coastal areas, the estimated tsunami height and times of the first wave arrival caused by the earthquake in the sea between the Asian continent, Korean peninsula and Japan. The tsunami forecast would be transmitted through Global Telecommunications System (GTS) to the Member States concerned, in accordance with the ITSU Communication Plan. **The Group advised** that the possibility of using the Internet should also be considered.

114 **The Group recommended** that information on tsunamis provided by Japan should be transmitted to responsible national authorities directly.

115 **The Group endorsed** Japan's proposal and **adopted,** in principle, the procedure to issue the tsunami forecast as given in Annex IX. **The Group urged** the Member States concerned to ensure that a transmitted tsunami forecast be relayed to Member States securely and rapidly, in accordance with the ITSU Communication Plan. **The Group requested** the IOC Executive Secretary to inform the Governments of China and the Democratic People's Republic of Korea of the developments and invite them to join the system.

116 **The Group further urged** Japan to continue considering the possibility of expanding the centre's functions to the coastal areas in and around the Yellow Sea, the East China Sea and the Western North Pacific. **The Group supported** the need for a regional workshop with the participation of all countries concerned to discuss actions to be taken for the smooth running of the system.

Summary Report of the ICG/ITSU-XVIII Session (2001)

120 The Delegate of Japan reported that on 15 January 2001, the Japan Meteorological Agency (JMA) partially began operations of the Regional Tsunami Warning Centre (Doc. IOC/ITSU-XVIII/7 Japan) to provide the tsunami forecasts in the sea between the Asian continent, Korean Peninsula and Japan to overseas authorities concerned. The JMA prepared and distributed a '*Handbook for Tsunami Forecast in the Japan Sea*' with the explanation of the procedure for the effective utilization of forecasts.

121 The next stage will be the expansion of the target area to the Northwestern Pacific. Its boundaries will be determined later. The Delegate of Japan explained that real-time seismic waveform data in the target area are indispensable for determining the hypocenters accurately and quickly (Doc. IOC/ITSU-XVIII/21). The JMA is proceeding with a study on optimal distribution of seismographic stations, considering the tsunami travel time to each coast.

122 The Delegate of Japan explained that JMA was planning to include tsunami heights and arrival times in the content of the forecast like those for the sea between the Asian continent, Korean Peninsula and Japan. By executing numerical simulation for various cases, the characteristics of tsunamis on each coast will be obtained and used to set up the forecast areas. For that purpose, the JMA is going to carry out many simulations and analyse the results.

123 **The Group expressed** deep appreciation to Japan and **invited** the country to continue its efforts. Member States were encouraged to co-operate with Japan in the acquisition of real-time seismic waveform data in the target areas.

124 The Delegate of Japan explained that at this stage there is no need for a regional workshop to discuss actions to be taken for the smooth running of the system. The Group decided to come back to this issue when the target area of the Far East TWC is expanded and experience gained.

Summary Report of the ICG/ITSU-XIX Session (2003)

185 This Agenda Item was introduced by Mr. Noritake Nishide (Japan). He recalled the Earthquake that occurred on 25 September 2003 in Hokkaido, Japan. He then proceeded to provide information on the tsunami warning centre based at JMA and its activities. In Document IOC/ITSU-XIX/13, Japan explained the present status of technical improvement of determining earthquake location using LISS (Live Internet Seismic Server) data. Japan also presented the quick determination method for Mw using P wave according to the same document.

186 Mr. Nishide explained Japan's quantitative tsunami forecast method for local and distant tsunami as described in the National Report of Japan, and provided information on

Japan's tide gauge network for tsunami observation in detail as information for Sea Level Enhancement discussed under Agenda item 3.6.

187 Responding to a question from Australia, Japan explained about the reliability of LISS for the operational tsunami warning system as follows: there are almost no problems because data of about 20 stations can usually be used for hypocenter determination of large earthquakes even if some stations may drop, but, it is not appropriate for the operational tsunami warning system to rely only on LISS because LISS uses the Internet.

Summary Report of the IOC/EC-XXXVII Session (2004)

Resolution EC-XXXVII.4

THE INTERNATIONAL CO-ORDINATION GROUP
FOR THE TSUNAMI WARNING SYSTEM IN THE PACIFIC

The Executive Council,

Recalling that the IOC Tsunami Programme is a high priority programme of the Commission,

Appreciating:

(i) the support of Chile, France, New Zealand, Republic of Korea and USA to the IOC Tsunami Programme in 2002–2003 through Trust Fund and in-kind contributions,
(ii) the support of the USA in hosting and co-funding the operation of the International Tsunami Information Centre (ITIC) in Hawaii, and of Chile for the post of ITIC Associate Director,
(iii) the establishment of the North-western Pacific Tsunami Information Centre by Japan in 2004*,

Considering the Summary Report, Resolution and Recommendations of the 19th Session of the International Co-ordination Group for the Tsunami Warning System in the Pacific (ITSU-XIX), held in Wellington, New Zealand, from 29 September to 2 October 2003, and the progress achieved by the ICG in the implementation of the ITSU Programme at the national and international levels,

Welcoming the studies in support of the development of sub-regional tsunami warning systems for the Central American Pacific Coast and for the South-west Pacific and Indian Ocean, and the possible development of a comprehensive tsunami hazard-reduction programme,

Endorses the Summary Report and Resolution **and adopts** the Recommendations of ITSU-XIX;

*) *Japanese fiscal year (April 2004 ~ March 2005)*

Summary Report of the ICG/ITSU-XX Session (2005)

254 The Delegate of Japan introduced this Agenda item. Japan established the North West Pacific Tsunami Advisory Centre (NWPTAC) in March 2005. --- *rest part omitted* ---

255 Several Member States requested Japan to expand coverage of the NWPTAC to the South China Sea and the Sea of Okhotsk. Japan explained that the coverage area of the NWPTAC will be expanded on a step-by-step basis. The expansion to the South China Sea is in preparation and will be able to be included in the coverage area of the NWPTAC by March 2006. However, it was pointed out that there are currently insufficient sea-level gauges in that area to provide quality tsunami advisory information.

256 **The Group expressed** its high appreciation to Japan for the establishment of the North West Pacific Tsunami Advisory Centre as an important contribution to the Pacific Tsunami Warning System.

259 **The Group requested** both the PTWC and the JMA to provide an interim tsunami advisory service for the South China Sea. **The Group further requested** the PTWC and the JMA to develop a communication plan for the South China Sea that describes messages, criteria, etc. for distribution to the concerned countries.

Summary Report of the ICG/PTWS-XXII Session (2006)

81 He* informed the Group of the increase in the JMA permanent tsunami staffing starting in 2006 in response to the 2004 Sumatra tsunami. He reported the official inauguration of the Northwest Pacific Tsunami Advisory Center as of 1 February 2006 after about 1 year as a developing Centre, and the start of interim tsunami advisory services for the South China Sea Region as of 1 April 2006.

85 **The Group thanked** the government of Japan and its JMA for its initiative to start a subregional warning service for the Northwest Pacific and for extending the service to the South China Sea on an interim basis.

*) *Mr. Osamu Kamigaichi, a representative from Japan*

ANNEX I: TSUNAMIS

TERMINOLOGY

"Tsunami" is the Japanese term meaning harbor wave. As such it is most descriptive of the observed phenomenon sometimes referred to as tidal wave or seismic sea wave. In South America, the term "maremoto", or moving sea, is frequently used. However the word "tsunami" is most commonly accepted by scientists and by most of the lay public in Pacific basin countries.

For the PTWS, tsunamis can be categorized as local, regional, or Pacific-wide, with those terms being used to describe the extent of potential destruction relative to the tsunami source area. Local tsunamis are those with destruction generally limited to within 100 km of their source. They can be generated by earthquakes but are often associated with submarine or subaerial landslides or volcanic explosions. An extreme example of a local tsunami is the one that occurred on July 9, 1958, at Lituya Bay, Alaska. Wave run-up exceeded 485 meters but the destruction was confined to a very limited area. Destructive local tsunamis with runups of no more than a few tens of meters are more common.

Regional tsunamis are those with destruction generally limited to within 1000 km of their source. Destruction may be limited in areal extent either because the energy released was not sufficient to generate a destructive Pacific-wide tsunami, or because the source was within a confined sea.

Pacific-wide destructive tsunamis are much less frequent, but still occur a few times each century. Such tsunamis can have disastrous consequences because their source area is large, initial wave heights are great, and even distant coastal areas are subject to impact. The Pacific-wide tsunami of May 22, 1960, spread death and destruction across the Pacific from Chile to Hawaii, Japan, and the Philippines.

TSUNAMI GENERATION

A tsunami is a series of very long ocean waves usually formed as a result of a large-scale vertical displacement of the sea surface over a short duration in time. Gravity returns the sea to equilibrium through a series of oscillations or waves that propagate outward from the source region. Most tsunamis are caused by vertical displacements of the seafloor associated with the occurrence of great earthquakes. However, tsunamis can also be generated by submarine volcanic eruptions, by the movement of submarine sediments, by coastal landslides, and even by meteor impacts.

Every major earthquake generates seismic waves or vibrations that can be detected and measured by seismic stations throughout the world. However, not all major coastal or near-coastal earthquakes produce tsunamis. At present, there is no operational method to determine from the seismic data alone if a tsunami has been generated. The seismic data only indicates a level of tsunamigenic potential and it is necessary to detect the arrival and measure the amplitude and other characteristics of the tsunami waves with a network of coastal or deep ocean sea level stations.

EARTHQUAKE SEISMOLOGY

When a major earthquake occurs, the resultant seismic energy released into the earth will propagate with a wide range of frequencies and velocities. Although earth movements discernible to a person may be confined to a region near the earthquake epicenter, the various seismic waves propagating throughout the earth create small, but measurable, ground motions which can be detected by a seismometer. Such signals can be recorded in digital form for analysis on a computer.

For tsunami warning purposes, probably the most important earthquake signal is the P-wave. It is a compressional or pressure wave that travels through the earth's interior at a velocity that varies from approximately 8.0 km/second near the crust-mantle boundary to about 13.5 km/second at the mantle-core boundary. It is the first seismic phase to be recorded at each seismic station and it provides the earliest indication that a distant earthquake has occurred. P-wave travel times in the earth as a function of distance from and depth of the earthquake hypocenter are known. Thus, the location and depth of the earthquake can be determined by finding the hypocenter that best fits the pattern of P-wave arrival times from many stations. The earthquake moment magnitude, Mw, can also be quickly estimated from the long-period component of the P-waves recorded by broad-band seismometers. This type of measurement of Mw is called Mwp.

Another kind of seismic energy is trapped within the upper layers of the earth – primarily the mantle. These surface waves are the basis for measuring an earthquake's mantle magnitude, Mm, using vibrations with periods (the time of one wave cycle) between 50 and 400 seconds. There is a simple direct relation between the mantle magnitude and the moment magnitude. For earthquakes with magnitudes greater than 8.0 as well as for slow-rupturing earthquakes, the moment magnitude computed using the mantle magnitude is more accurate than Mwp. However, because the surface waves travel more slowly than the P-waves, Mw based on Mm is typically not available for tens of minutes after the initial earthquake evaluation based on Mwp.

TSUNAMI PROPAGATION

Tsunami waves travel outward in all directions from the generating area, with the direction of the main energy propagation generally being 90° to the line of the earthquake rupture. A key characteristic that makes tsunami waves differ from other ocean waves such as wind waves or tides is their period -- the time of one wave cycle. Tsunami wave periods range from 5 minutes to as much as 60 minutes. Wind waves have periods of just a few seconds for and tides have periods of many hours. The speed of propagation of tsunami waves depends on the depth of the ocean water. Consequently, the speed and direction of the tsunami waves change as they pass through the ocean because of its varying depth. In the deep ocean, tsunamis typically travel at speeds of 500 to 1,000 kilometers per hour (300 to 600 miles per hour), and the distance between successive wave crests can be as much as 500 to 650 kilometers (300 to 400 miles). However, in the deep ocean, the height of potentially destructive tsunami waves may be no more than a few centimeters (1 to 3 inches), and is usually no more than a meter. Variations in the strength of propagating tsunami waves are due to the shape and size of the source region, absorptions and reflections at coasts, and to focusing or defocusing by the bathymetric features of the seafloor. The tsunami wave motions extend through the entire water column from sea surface to the ocean bottom, even in mid ocean. It is this characteristic that accounts for the great amount of energy transmitted by a tsunami.

Waves of a tsunami in the deep sea have such great length and so little height they are not visually recognizable from a surface vessel or from an airplane. The passing of each wave produces only a gentle rise and fall of the sea surface over a long time – usually tens of minutes. During the April 1946 tsunami in Hawaii, ships standing off the coast observed tremendous waves striking the shore but did not undergo any perceptible change in sea level at their offshore locations.

TSUNAMI IMPACT

Upon reaching shallow water, the speed of an advancing tsunami wave diminishes to the speed of more ordinary wind-driven swell, its wave length decreases, and its height may increase greatly, owing to a compression of its energy and a piling up of the water. The configuration of the coastline, shape of the ocean floor, and character of the advancing waves play an important role in the destruction wrought by tsunamis along any coast, whether near the generating area or thousands of kilometers away. Consequently, there can be a great variation in the level of destruction along a single coast, with one area being hard-hit while an adjacent area is not affected.

Detection of tsunamis is usually made by sea level stations at the shore where the shoaling effect can be observed. The first visible indication of an approaching tsunami can be a recession of water caused by the trough preceding an advancing wave. Any withdrawal of the sea, therefore, should be considered a natural warning of an approaching tsunami wave. However, a rise in water level also may be the first event.

A network of sea bottom pressure sensors has been deployed to detect tsunamis in the deep ocean. This is essential since a vast amount of the Pacific does not have islands or other land masses where coastal sea level gauges can be deployed, and importantly, these data provide a reading of the tsunami that has not been affected by near-shore bathymetry and morphology. Furthermore, these data are showing great potential for providing good wave forecasts that the PTWC, WC/ATWC and other warning centers can use to give threat evaluations before tsunamis hit vulnerable coasts.

The force and destructive effects of tsunamis should not be underestimated. At some places, an advancing turbulent front is the most destructive part of the wave. Where the sea level rise is slow and relatively benign, the outflow of water to the sea between crests may be rapid and destructive, sweeping all before it and undermining roads, buildings, and other works of man with its swift currents. Debris picked up and carried by the strong and persistent currents can cause great damage. Most people killed by tsunamis are crushed, not drowned. Ships, unless moved away from the shore to deep water, can be thrown against breakwaters, wharves, and other craft, or washed ashore and left grounded during withdrawals of the sea.

In the shallow water of bays and harbors, a tsunami frequently will initiate seiching – an almost frictionless slow oscillation of the body of water back and forth. If the tsunami period is related closely to that of the bay, the seiche is amplified by synchronous forcing from succeeding tsunami waves. Under these circumstances, maximum wave activity can be observed much later than the arrival of the first wave.

A tsunami is not one wave, but a series of waves. The time that elapses between passage of successive wave crests at a given point can range from 5 to 60 minutes. Oscillations of destructive proportions may continue for several hours, and even several days may pass before the sea returns to its normal state.

During the 101-year period from 1900 to 2001, 796 tsunamis were observed or recorded in the Pacific Ocean according to the Tsunami Laboratory in Novosibirsk. 117 caused casualties and damage near the source only while at least nine caused widespread destruction in the Pacific. The greatest number of tsunamis during any one year was 19 in 1938, but all were minor and caused no damage. There was no single year of the period that was free of tsunamis.

Seventeen percent of the tsunamis in that period were generated in or near Japan. The distribution of tsunami generation in other areas is as follows: South America, 15 percent: New

Guinea and the Solomon Islands, 13 percent; Indonesia, 11 percent: the Kuril Islands and Kamchatka, 10 percent; Mexico and Central America, 10 percent; the Philippines, 9 percent; New Zealand and Tonga, 7 percent; Alaska and the West Coast of Canada and the United States, 7 percent; and Hawaii, 3 percent.

REFERENCES

Bolt, B. A.; Horn, W. L.; Macdonald, G. A.; and Scott, R., Geological Hazards, Springer-Verlag, 1975.

Murty, T.S., Seismic Sea Waves, Tsunamis, Department of Fisheries and the Environment, Ottawa, Canada, Bulletin 198, 1977.

Neumann, F., Principles Underlying the Interpretation of Seismograms, Department of Commerce Special Publication No. 254, U. S. Government printing Office, 1966.

UNESCO-IOC International Tsunami Information Centre. Tsunami: The Great Waves. IOC Brochure 2006-2. Paris, UNESCO, 2005. *Earlier versions in Spanish and French; 2005 version being translated into Spanish, French. 2005 version available in Chinese.*

UNESCO-IOC International Tsunami Information Centre. Tsunami Glossary. IOC Information document No. 1221. Paris, UNESCO, 2006. *Earlier versions in Spanish and French; 2006 version currently in translation.*

PACIFIC EVENT CATALOGUES

Berninghausen, W.H., Tsunamis reported from the west coast of South America, 1562-1960. Bull. Seismol. Soc. Amer., 52, 915-921, 1962.

Cox, Doak C., and Pararas-Carayannis, George, Catalog of Tsunamis in Alaska, Revised 1976, World Data Center A for Solid Earth Geophysics, NOAA/ Environmental Data Service, National Geophysical Data Center, 1976.

Dunbar, P.K., P. A. Lockridge, and L. S. Whiteside, Catalogue of Significant Earthquakes 2150BC-1991AD. US Department of Commerce, NOAA, National Geophysical Data Center, Boulder, USA, World Data Center A for Solid Earth Geophysics Reports SE-49, 320 pp, 1992.

Everingham, I.B., Preliminary Catalogue of Tsunamis for the New Guinea I Solomon Island Region 1768-1972, Bureau of Mineral Resources, Canberra, Australia, Report 180, 78 pp, 1977.

Iida, K., D. Cox, and G. Pararas-Carayannis, Preliminary catalog of tsunamis occurring in the Pacific Ocean. Data Report No. 5, Hawaii Institute of Geophysics, HIG-67-10. Honolulu: University of Hawaii, re-issued 1972. URL:http://www.soest.hawaii.edu/Library/Tsunami%20Reports/Iida_et_al.pdf

Lander, J.F, P.A. Lockridge, and M.J. Kozuch, Tsunamis affecting the West Coast of the United States 1806-1992. US Department of Commerce, NOAA, National Geophysical Data Center, Boulder, USA, NGDC Key to Geophysical Records Documentation KGRD-29. 242 pp, 1993.

Lander, J., and P. Lockridge, United States Tsunamis (including United States Possessions) 1690-1988. Publication 41-2, Boulder: National Geophysical Data Center, 1989.

Lockridge, P.A. and R. H. Smith, Map of Tsunamis in the Pacific Basin, 1900-1983. Scale 1:17,000,000. US NOAA National Geophysical Data Center World Data Centre A For Solid

Earth Geophysics and Circum-Pacific Council for Energy and Minteralo Resources Map Project, 1984.

Molina, E.e (Seccion de Sismologia, INSIVUMEH, Guatemala), Tsunami catalogue for Central America 1539-1996 [Report], Reduction of natural disasters in Central America, Universitas Bergensis Technical Report no. II 1-04, Bergen, Norway, Institute of Solid Earth Physics, University of Berger, 1997.

Pararas-Carayannis, George, Catalog of Tsunamis in Hawaii, Revised 1977, World Data Center A for Solid Earth Geophysics, NOAA/Environmental Data Service. National Geophysical Data Center, 1977.

Soloviev, S.L., and C. N. Go, A catalogue of tsunamis on the western shore of the Pacific Ocean. Academy of Sciences of the USSR, Nauka Publishing House, Moscow, 310 pp. *Canadian Translation of Fisheries and Aquatic Sciences No. 5077, 1984, translation available from Canada Institute for Scientific and Technical Information, National Research Council, Ottawa, Ontario, Canada K1A OS2, 447 pp, 1974.*

ANNEX II: EARTHQUAKE SOURCE CHARACTERIZATION

ANNEX II.a HYPOCENTRAL DETERMINATION

(1) Pacific Tsunami Warning Center (PTWC)

This section will be added in a later version of this document.

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

WC/ATWC has both an automatic and interactive process for locating earthquakes. For the automatic process, program loc_wcatwc locates earthquakes given Earthworm TYPE_PICKTWC format P wave arrival times. The first task of loc_wcatwc is to sort Ps into buffers which contain just picks from the same earthquake. This can be a very difficult task for some station geometries. Stations are placed into a buffer if one of the nearest 15 stations to that station has a P-time in that buffer (a maximum of 100 buffers are used). If there are no buffers with near stations, the P is placed into a buffer with no other picks. If there is a buffer with a near station, P-times are compared with all stations in the buffer so that the maximum possible time between the stations is not exceeded. If it is exceeded, the P-pick will be moved to a different buffer.

After a buffer has filled with 5 P-picks, the solution is computed. If a good solution is made, P's from other buffers are compared to this solution and are added back into the buffer if they fit (unless they are in a buffer which has produced a good location). Also, P's which were eliminated in the location by a Bad P discriminator (described below) are placed in a different P buffer. This scavenging and removal of Ps after locations are made is effectively a second stage sorting of Ps throughout the different buffers. As new P-data enters a buffer which has more than 5 picks, the hypocenter is updated for that buffer.

Both automatic and interactive earthquake locations are computed using Geiger's method given an initial location. The initial location estimate is first assigned to the location of the first P-time in the buffer. If a solution cannot be computed from this initial location, a routine is called to compute the initial location from azimuth and distance determined from a quadrapartite of stations. If a location can still not be determined, a bad P-pick discriminator is called. This simply throws out stations one-at-a-time (up to three stations at once) and re-computes the location. Good solutions are verified by comparing the observed P-time minus computed P-time residual, azimuth control, and distance of nearest arrival.

The IASPEI91 travel times are used as the basis for earthquake locations in this program. A time/distance/depth table has been created from software provided by the National Earthquake Information Center. Locations with this set of P times have been compared to those made with the Jefferey's-Bullen set of times and were found to be superior in regards to depth discrimination and epicentral location with poor azimuthal control. The P-table is arranged on 10km depth increments and 0.5 degree distance increments.
A routine was added in 2006 which provides better depth control for solutions. The earthquake depth is fixed to the average depth for the region (based on USGS historical data on a one degree by one degree grid). When enough P control is attained the depth will float, but will be limited by the maximum depth of the region plus 50km.
After a good location has been computed, magnitude is output based on the amplitude/periods/integrations reported by the P-picker. Mb, Ml, MS, Mw, and Mwp magnitudes are computed depending on epicentral distance.

(3) Japan Meteorological Agency (JMA)

For forecasting of tsunamis, information on the hypocenters such as location and magnitude of earthquakes are essentially required. To determine hypocenters, JMA collects seismic waveform data from global seismological networks such as IRIS/USGS* and IRIS/IDA** through the Internet. The least square method is applied for determining hypocenters with observed arrival time of P and S waves and theoretical arrival time calculated from the IASPEI91 which is used as the travel timetable. Since a depth of an earthquake is one of the determining factors in tsunami generation, JMA utilizes arrival time of various reflected phases such as depth phases (pP, sS, PcP etc) for more reliable hypocenter determination.

Although the Internet is a useful mean for international communications, availability of data is not always secured because of various communication troubles including uncontrollable ones. To avoid the serious consequences of unavailability of data via the Internet, JMA also obtains earthquake parameters from the seismic array system of Matsushiro Seismological Observatory (Nagano, Japan) and from the large aperture array comprised of Japanese seismological observation networks. However, lack of seismic waveform data via the Internet could lead to delayed issuance and affect the accuracy of tsunami forecast.

* IRIS: Incorporated Research Institutions for Seismology, http://www.iris.edu/
  USGS: United States Geological Survey, http://earthquake.usgs.gov/
** IDA: International Deployment of Accelorometers, http://ida.ucsd.edu/

ANNEX II.b MAGNITUDES CALCULATED BY TSUNAMI WARNING CENTERS AND THE WORLD DATA CENTER FOR SEISMOLOGY

August 2007

This document summarizes the magnitude calculation methods used by presently existing tsunami warning centers in the Pacific to estimate earthquake magnitude in near real-time. Included in this compilation are the techniques of the Pacific Tsunami Warning Center PTWC (Hawaii, USA) and West Coast/Alaska Tsunami Warning Center WC/ATWC (Alaska, USA), Japan Meteorological Agency JMA (Tokyo), and the Centre Polynésien de Prévention des Tsunamis CPPT (Papeete, Tahiti, France).

Although not all earthquakes cause tsunamis, most tsunamis are generated by earthquakes. Thus, the monitoring of earthquake seismicity and subsequent near real-time magnitude estimation provides the fastest evaluation of tsunamigenic potential, and enables warning centers to provide the earliest advisories to emergency officials responsible for public safety. Earthquake magnitude is currently the best proven early indicator of tsunamigenic potential.

In general, the fastest magnitude estimates are obtained using techniques to estimate Mwp. It is generally thought that magnitudes are reliable through Mwp ~8.0 and perhaps up to 8.3. The minimum epicentral distance required is related to the S minus P time and to the P-wave integration window length used to determine magnitude. It is essential that the P-wave integration window is not contaminated by S-waves. Accuracy is sensitive to the response characteristics of the seismometer, and the seismogram time window used for the Mwp calculation. The larger the earthquake, the more likely it is that significant energy will be contained at long wave periods requiring further distances for Mwp measurement (as the integration window length will be longer), and the more likely that the earthquake rupture will be complex - both of these situations, and a combination, would result in significant Mwp underestimates of the true earthquake magnitude. Practically, a M7.5 will require about 60 s of data (or minimum epicentral distance (Δ) of about 5 degrees). Integration window lengths of 300 seconds or more are required to characterize larger earthquakes. For great earthquakes (M8+), Mm is the best indicator of earthquake size available at the TWCs as this is calculated using long period surface waves; these arrive much later than the P-waves and so Mm is available much after the Mwp estimate.

For 'local' earthquakes, a number of magnitude methods are possible, but each will be sensitive to the local and regional crustal structure. For this, magnitude sensitivity studies are essential in order to obtain accurate correction factors to local magnitude formulations. For Mwp 5.5 to 7, stations closer than 5 degrees can be used as long as the P wave is not contaminated by S waves.

References

JMA (2004), Revision of the JMA Magnitude, Quarterly Journal of Seismology, 67(1-4), in Japanese.

Kamigaichi, O. (2004), JMA Earthquake Early Warning, Journal of Japan Association for Earthquake Engineering, 4(3-Special Issue).

Kanjo K., T. Furudate, and S. Tsuboi (2006), Application of Mwp to the Great December 26, 2004 Sumatra Earthquake, Earth, Planets and Space, 58, 1-5.

Nishimae, Y., K. Nakasoko, and M. Okada (2002), Empirical formulas for quick estimation of the moment magnitude of tele-seismic earthquakes with STS-2 seismometer, Technical Reports of the Matsushiro Seismological Observatory, 19, 57-79, in Japanese.

Ogahara, T., T. Furudata, and M. Okada (2004), Preliminary empirical formula to estimate moment magnitude, Technical Reports of the Matsushiro Seismological Observatory, 21, 75-81, in Japanese.

Okal, E.A. and Talandier, J. (1987), Theory of a Variable-period Mantle Magnitude, Geophys Res Lett, 14, 836-839.

Okal, E.A. and Talandier, J. (1989), A Variable Period Mantle Magnitude, Geophys Res, 94, 4169-4193.

Tsuboi, S., K. Abe, K. Takano, and Y. Yamanaka (1995), Rapid Determination of Mw from Broadband P waveforms, Bull Seismo Soc Amer, 85, 606-613.

Tsuboi, S., P. M. Whitmore, and T. J. Sokolowski (1999), Application of Mwp to Deep and Teleseismic Earthquakes, Bull Seismo Soc Amer, 89, 5, 1345-1351

U.S. Geological Survey,
http://neic.usgs.gov/neis/phase_data/mag_formulas.html
http://earthquake.usgs.gov/learning/topics/measure.php
http://earthquake.usgs.gov/learning/topics.php?topicID=24&topic=Magnitudes

Utsu, T., Seismology, 2nd edition, Kyoritsu, in Japanese.

Whitmore, M. P., S. Tsuboi, B. Hirshorn, and T.J. Sokolowski (2002), Magnitude-dependent correction for Mwp, Science of Tsunami Hazards, 20(4), 187.

Pacific Tsunami Warning Center (PTWC)

PTWC computes M_b, M_l, M_{wp}, M_S, and M_m (M_S and M_m are not used for the bulletins directly).

PTWC uses M_w for the bulletins by estimating from M_{wp} or $M_{m.}$

The first tsunami message is based on initial magnitudes.

M_b : This is the standard Richter M_b and expressed as M_b=log(A/T)+Q(h, Δ) where A : maximum amplitude, T : period, h : depth, Δ : epicentral distance

Theoretically, M_b allows the use of 0.3 ~ 3.0s period wave for earthquakes of magnitude < 6.0. However, PTWC uses 0.7 ~ 2.0s period wave for earthquakes of $12° \leq \Delta$ with magnitude < 5.5.

M_l : This is the local magnitude and expressed as M_l=logA+f(Δ) .

Theoretically, M_l allows the use of 0.3 ~ 3.0s period wave for earthquakes of magnitude < 6.5. However, PTWC uses 0.3 ~ 1.5s period wave for earthquakes of $\Delta \leq 9°$ with magnitude < 5.5.

M_{wp}: This is originally developed by Tsuboi (1995,1999) and expressed as

Mo = Max (|p1|, |p1-p2|) * $(4\pi\rho\alpha^3 r)$/Fp

where

p1, p2: 1st, 2nd peak values in the integrated displacement seismogram, respectively
ρ : density
α : P wave velocity
r: epicentral distance
Fp: radiation pattern

M_w is estimated from Mo by the relation:

M_w=(log Mo-9.1)/1.5.

where Mo is in Nm.

PTWC computes M_{wp} for far field earthquakes of magnitude > 5.5 in any depth, by using P wave in the broadband seismic data.

M_m : This is developed by Emile Okal and J. Talandier (1988) and less sensitive to earthquake slowness or saturation than M_S, particularly at the longest periods.

When M_b, M_l, or M_{wp} > 5.0, PTWC computes M_m over a suite of periods ranging from 51s to 273s using a window of 660s, but M_m should be applied for $\Delta \geq 15°$ with magnitude > 6.0. M_m is not the moment magnitude but is related to it with the simple expression $M_w=M_m/1.5+2.6$ PTWC does not use M_m directly for the bulletins, but can used this to estimate M_w.

M_S : This is developed by Richter and expressed as M_S= αlogΔ+logA+γ.

PTWC computes M_S using 20s surface wave in a window of 14 minutes. PTWC uses band-pass filter between 14s and 23s for the data. M_S is applied for $\Delta \geq 5°$ but not used as the basis for bulletins. However, this is useful and helpful in diagnosing deep earthquakes.

M_w : This is a moment magnitude and used for the bulletins.
PTWC doesn't compute M_w directly; it estimates M_w from M_{wp}, or sometimes from M_m.

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

WC/ATWC computes Mb, Ml, MS, Mw, and Mwp depending on epicentral distance.

Mb, Ml, Mwp are calculated as the initial magnitude estimation depending on the size and location of the earthquake. The first tsunami message is based on these initial magnitudes.

When Mb, Ml, or Mwp are greater than 5.0, MS and Mw are also computed.

M_b : This is the standard Richter M_b, with formula:

$$M_b = \log(A/T)+Q(h, \Delta)$$

Where
A : maximum amplitude
T : period
h : depth
Δ : epicentral distance)

Theoretically, M_b can be applied for 0.3 ~ 3.0s period wave for earthquakes of magnitude < 6.0. Practically, M_b is used with 0.7 ~ 2.0s period wave for earthquakes $12° \leq \Delta$ and magnitude < 5.5.

M_l : This is the local magnitude, with formula:

$$M_l = \log A+f(\Delta)$$

Theoretically, M_l can be applied for 0.3 ~ 3.0s period wave for earthquakes of magnitude < 6.5. Practically, M_l is used with 0.3 ~ 1.5s period wave for earthquakes $\Delta \leq 9°$ and magnitude < 5.5.

The WC/ATWC Ml magnitude is based on the maximum amplitude (A) recorded on stations within 9 degrees of the epicenter (Sindorf, 1972).

For stations less than Δ =1.65 degrees epicentral distance,
ML = log (A/T) + 0.8*log(Δ **2) – 0.066.

For stations 1.65 degree to 9 degree epicentral distance,
ML = log (A/T) + 1.5*log(Δ **2) – 0.364,

where A = ground amplitude (peak-to-trough height) in nM,
T = wave period,
Δ = epicentral distance in degrees

M_{wp} : This is originally developed by Tsuboi (1995,1999), with formula:

$$Mo = Max (|p1|, |p1-p2|) * (4\pi \rho \alpha^3 r)/Fp$$

where

p1, p2 : 1st, 2nd peak values in the integrated displacement seismogram, respectively

ρ : density

α : P wave velocity

r : epicentral distance

Fp: radiation pattern

M_w is estimated from Mo by the relation:

$$M_w = (\log Mo - 9.1)/1.5$$

where Mo is in Nm.

WC/ATWC computes M_{wp} for far field earthquakes (no limitation on Δ and depth) of magnitude > 5.5, using P waves from broadband seismograms

M_S : This is developed by Richter, with formula:

$$M_S = \alpha \log\Delta + \log A + \gamma.$$

ATWC computes M_S using long period Rayleigh waves from broadband seismograms.
M_S can be applied for earthquakes $\geq 4°$.
This is not used for bulletins but useful to help in characterizing earthquake.

M_w : This is computed by using M_m technique

Theoretically, M_m can be applied for earthquakes $\Delta \geq 15°$ with magnitude > 5.0
Practically, Mm is used for earthquakes of magnitude > 6.0.
M_w is also computed by using a moment tensor inversion technique for earthquakes of magnitude $6.0 \leq M \leq 7.5$. This is based on waveform inversion using several stations $\Delta \geq 20°$, with the first 200 seconds of waveform after P wave arrival (discrete periods are not used). The inversion takes at least 12 minutes, so ATWC rarely uses this for bulletins.

Japan Meteorological Agency (also as NWPTAC)

Generation of tsunamis heavily depends on the magnitude of the earthquakes. Hence, it is essential for tsunami forecast to estimate the magnitude as quickly as possible with highest accuracy. The JMA NWPTAC computes Mjma, Mwp (Tsuboi), and Mwp (Nishimae). Mjma is used for local earthquakes (generally < 600 km from Japanese main islands while Mwp is used for regional and teleseismic earthquakes). The first tsunami message is based on these initial magnitudes.

(1) Local Earthquakes : **Mjma**

JMA operates about 180 seismic stations in Japan to determine the location and the magnitude of earthquakes in and around the country. In that sense, we can also say that "local earthquakes" are the events for which JMA can calculate the hypocenter and magnitude precisely by using the domestic networks only. Local earthquakes are usually located within 600 km of the Japanese coasts. Magnitude determined using the JMA seismic network is described as Mjma [Katsumata (2004), Funasaki et al. (2004)] and when a local earthquake occurs, JMA determines Mjma and it appears on domestic and international tsunami messages including the NWPTA.

Mjma is computed using body waves of period < 30s with the formula:

$$Mjma = \log(A_D)+\beta_D(\Delta,H)+C_D,$$

where

A_D :	maximum displacement amplitude derived by the integration of acceleration record (in 10^{-6}m)
Δ :	epicentral distance (km)
H :	source depth (km)
β_D :	decay correction
C_D :	constant.

Theoretically, Mjma can be applied for earthquakes of $\Delta \leq 2000$ km.

When earthquakes meet the specific conditions, JMA uses the Earthquake Early Warning (EEW) magnitude as Mjma, with the formula:

$$Mjma = \log(A_D)+\log \Delta+a_1 \Delta +a_2,$$

where a_1, a_2 are constant.

The conditions JMA uses the EEW magnitude as Mjma are:

- Magnitude > 6.5 and depth $\leq$ 100 km
- Earthquake occurs near coasts (approximately within 150 ~ 200 km)
- Hypocenter and magnitude are determined in certain level of accuracy.

Reference:

Katsumata, A., Revision of the JMA displacement magnitude, 2004, *Quarterly Journal of Seismology*, **67**, 1-10 (Japanese)

Funasaki, J. and Earthquake Prediction Information Division, Revision of the JMA velocity magnitude, 2004, *Quarterly Journal of Seismology*, **67**, 11-20 (Japanese)

(2) Teleseismic Earthquakes : **Mwp** (Tsuboi and Nishimae)

The moment magnitude (Mw), which is derived from the long-period components of the seismic signal, is useful for tsunami forecast because it is more accurate for large earthquakes than the traditional Richter magnitude. In order to obtain Mw more rapidly, JMA calculates Mwp, which is equivalent with Mw, from the signals of the first arriving seismic P-waves using two techniques proposed by Nishimae (2002), and Tsuboi (1995) with the correction of Whitmore (2002).

Mwp (Nishimae) is calculated using band-pass filtered STS-1 (~ 360s), STS-2 (~ 120s), CMG (~ 100s) data (Fig.1), with the formula:

$$Mwp\ (Nishimae) = a*\log(A)+b*\sin(\Delta/2)+c,$$

where

a, b, c : empirically estimated coefficients for relating the amplitude and the epicentral distance with the magnitude. They are determined by the least square method to meet the Harvard moment magnitude.

A : Root mean square (RMS) of vertical component of P wave potion. As the window length for RMS, one of time length of 2, 3, 4, or 5 min. is chosen

Δ : epicentral distance(deg)

Theoretically, Mwp (Nishimae) can be applied for the earthquakes of magnitude > 5.5 and $20° \leq \Delta \leq 80°$.

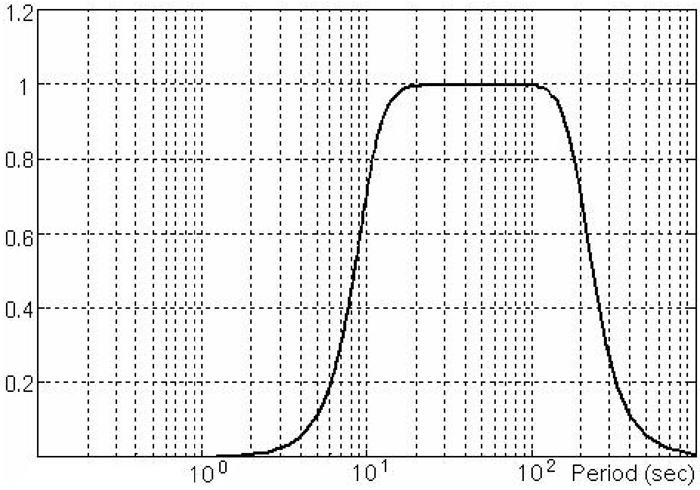


Fig.. 1 Band-pass filter for calculation of Mwp (Nishimnae)

As for Tsuboi Mwp, see reference below.

References:

Nishimae, Y., K. Nakasoko, and M. Okada, Empirical formulas for quick estimation of the moment magnitude of teleseismic earthquakes with STS2 seismometer, 2002, *Technical Reports of the Matsushiro Seismological Observatory*, **19**, 57-79 (Japanese)

Tsuboi, S., K. Abe, K. Takano, and Y. Yamanaka, Rapid Determination of Mw from Broadband P waveforms, 1995, *Bull. Seism. Soc. Am.*, **85**, 606-613

Whitmore, P., S. Tsuboi, B. Hirshorn, T. Sokolowski, Magnitude-Dependent Correction for Mwp, 2002, *Science of Tsunami Hazards*, **20**, No. 4, 187-192

(3) Some Additional Notes

(i) Tsunami Earthquake

"Tsunami earthquakes" are defined as earthquakes which generate tsunamis greatly larger than that estimated from their normal magnitudes. Generally, the ground motion is small compared to that which is expected from the actually observed tsunami record. Usual method often underestimates the magnitude for those earthquakes and unexpected large tsunamis strike the coast. When a long-period wave is found predominant in the seismic record, JMA takes the possibility of a tsunami earthquake into consideration and takes actions according to the situation if necessary.

(ii) Earthquake Early Warning (EEW):

The EEW technique is developed to announce estimated seismic intensity and arrival time before the strong motion reaches each area. When an earthquake occurs, seismographic data near the hypocenter are analyzed to estimate the location and magnitude immediately. The arrival time of the main movement and the seismic intensity in various places are estimated, and information is announced as quickly as possible. Even after the issuance of the first EEW message, JMA continues to update the hypocenter and magnitude determination as more data becomes available. Accordingly, EEWs are disseminated repeatedly with improved accuracy and reliance with time.

Centre Polynésien de Prévention des Tsunamis (CPPT)

CPPT computes mantle magnitude $\mathbf{M_m}$.

M_m is computed within its TREMORS (Tsunami Risk Evaluation through seismic Moment from a Real-time System) system that uses a single 3-component broadband seismic station to automatically estimate Mm and Mo for both close and far events. The system provides a relatively simple means by which to implement a reliable, autonomous and cost effective tsunami warning system, and is particular attractive to countries with no or poor seismic detection facilities. The system detects all events magnitude > 4.8 within 2000 km of the station. Epicentral accuracy is better than 3 deg in distance and 5 deg in azimuth for far field earthquakes (20 < delta < 100 deg), and about 150 km in the near field. For earthquakes greater than Mo 10 17 N.m, there is good agreement between the single station Mm and final published magnitudes. Mo is computed 13 minutes after the estimate Rayleigh wave arrival time. For close events (down to 50 km), warning triggers are based on the duration and amplitude of the signal. The system has been in operation since the 1988.

$\mathbf{M_m}$ is obtained from the amplitude spectrum in displacement of the surface waves over a broadband range of period (50 ~ 300s).

Mw is obtained directly from Mm: $M_w = M_m/1.5 + 2.6$

Attenuation and source effects are included in the process.
More information on M_m is provided in the explanation of magnitudes used in PTWC and ATWC sections.

US Geological Survey – National Earthquake Information Center World Data Center – Seismology Magnitude Definitions

References:

http://neic.usgs.gov/neis/phase_data/mag_formulas.html

http://earthquake.usgs.gov/learning/topics/measure.php

http://earthquake.usgs.gov/learning/topics.php?topicID=24&topic=Magnitudes

Type	Name	Formula
Mw	Moment Magnitude	Hanks and Kanamori formula (1979) **Mw = (2/3) log Mo - 10.7** where **Mo** is the scalar moment of the best double couple in dyne-cm.

Type	Name	Formula
Me	Energy Magnitude	These energy magnitudes are computed from the radiated energy using the Choy and Boatwright (1995) formula **Me = (2/3) log Es - 2.9** where **Es** is the radiated seismic energy in Newton-meters. **Me**, computed from high frequency seismic data, is a measure of the seismic potential for damage.
Ms	Surface Wave Magnitude	IASPEI formula **Ms = log (A/T) + 1.66 log D + 3.3** where **A** is the maximum ground amplitude in micrometers (microns) of the vertical component of the surface wave within the period range 18 <= T <= 22. **T** is the period in seconds. **D** is the distance in geocentric degrees (station to epicenter) and 20° <= D <= 160°. • No depth corrections are applied, and Ms magnitudes are not generally computed for depths greater than 50 kilometers. The Ms value published is the average of the individual station magnitudes from reported T and A data. • If the uncertainty of the computed depth is considered great enough that the depth could be less than 50 kilometers, an Ms value may still be published, computed by the IASPEI formula and NOT corrected for depth. • In general, the Ms magnitude is more reliable than the mb magnitude as a means of yielding the relative "size" of a shallow-focus earthquake.
mb	Compressional Body Wave (P-wave) Magnitude	**mb = log (A/T) +Q(D,h)** defined by Gutenberg and Richter (1956) except that **T**, the period in seconds, is restricted to 0.1 <= T <= 3.0 and **A**, the ground amplitude in micrometers, is not necessarily the maximum in the P group. **Q** is a function of distance (**D**) and depth (**h**) where D >= 5°.
mbLg	Body Wave Magnitude using the Lg wave	**mbLg = 3.75 + 0.90 log D + log (A/T)** for 0.5° <= D <= 4° or **mbLg = 3.30 + 1.66 log D + log (A/T)** for 4° <= D <= 30° as proposed by Nuttli (1973) where **A** is the ground amplitude in micrometers and **T** is the period in seconds calculated from the vertical component 1-second Lg waves. **D** is the distance in geocentric degrees.
ML	Local ("Richter") Magnitude	**ML = log A - log Ao** defined by Richter (1935) where **A** is the maximum trace amplitude in millimeters recorded on a standard short-period seismometer and **log Ao** is a standard value as a function of distance where distance <= 600 kilometers.

Notes and further explanations (excerpts):

Magnitude

Richter magnitude – further references:

http://earthquake.usgs.gov/learning/topics/richter.php

http://pubs.usgs.gov/gip/earthq4/severitygip.html

http://siovizcenter.ucsd.edu/library/TLTC/TLTCmag.htm

Richter's original magnitude scale (M_L) was extended to observations of earthquakes of any distance and of focal depths ranging between 0 and 700 km. Because earthquakes excite both body waves, which travel into and through the Earth, and surface waves, which are constrained to follow the natural wave guide of the Earth's uppermost layers, two magnitude scales evolved - the m_b and M_S scales.

The standard body-wave magnitude formula is

$$m_b = \log_{10}(A/T) + Q(D,h) ,$$

where *A* is the amplitude of ground motion (in microns); *T* is the corresponding period (in seconds); and Q(*D*,*h*) is a correction factor that is a function of distance, *D* (degrees), between epicenter and station and focal depth, *h* (in kilometers), of the earthquake. The standard surface-wave formula is

$$M_S = \log_{10} (A/T) + 1.66 \log_{10} (D) + 3.30 .$$

There are many variations of these formulas that take into account effects of specific geographic regions, so that the final computed magnitude is reasonably consistent with Richter's original definition of M_L. Negative magnitude values are permissible.

The original m_b scale utilized compressional body P-wave amplitudes with periods of 4-5 s, but recent observations are generally of 1 s-period P waves. The M_S scale has consistently used Rayleigh surface waves in the period range from 18 to 22 s.

When initially developed, these magnitude scales were considered to be equivalent; in other words, earthquakes of all sizes were thought to radiate fixed proportions of energy at different periods. But it turns out that larger earthquakes, which have larger rupture surfaces, systematically radiate more long-period energy. Thus, for very large earthquakes, body-wave magnitudes badly underestimate true earthquake size; the maximum body-wave magnitudes are about 6.5 - 6.8. In fact, the surface-wave magnitudes underestimate the size of very large earthquakes; the maximum observed values are about 8.3 - 8.7. Some investigators have suggested that the 100 s mantle Love waves (a type of surface wave) should be used to estimate magnitude of great earthquakes. However, even this approach ignores the fact that damage to structure is often caused by energy at shorter periods. Thus, modern seismologists are increasingly turning to two separate parameters to describe the physical effects of an earthquake: seismic moment and radiated energy.

Fault Geometry and Seismic Moment, M_O

The orientation of the fault, direction of fault movement, and size of an earthquake can be described by the fault geometry and seismic moment. These parameters are determined from waveform analysis of the seismograms produced by an earthquake. The differing shapes and directions of motion of the waveforms recorded at different distances and azimuths from the earthquake are used to determine the fault geometry, and the wave amplitudes are used to compute moment. The seismic moment is related to fundamental parameters of the faulting process.

$$M_O = \mu S\langle d\rangle ,$$

where μ is the shear strength of the faulted rock, S is the area of the fault, and <d> is the average displacement on the fault. Because fault geometry and observer azimuth are a part of the computation, moment is a more consistent measure of earthquake size than is magnitude, and more importantly, moment does not have an intrinsic upper bound. These factors have led to the definition of a new magnitude scale M_W, based on seismic moment, where

$$M_W = 2/3 \log_{10}(M_O) - 10.7 .$$

The two largest reported moments are 2.5×10^{30} dyn·cm (dyne·centimeters) for the 1960 Chile earthquake (M_S 8.5; M_W 9.6) and 7.5×10^{29} dyn·cm for the 1964 Alaska earthquake (M_S 8.3; M_W 9.2). M_S approaches it maximum value at a moment between 10^{28} and 10^{29} dyn·cm.

Energy, *E*

The amount of energy radiated by an earthquake is a measure of the potential for damage to man-made structures. Theoretically, its computation requires summing the energy flux over a broad suite of frequencies generated by an earthquake as it ruptures a fault. Because of instrumental limitations, most estimates of energy have historically relied on the empirical relationship developed by Beno Gutenberg and Charles Richter:

$$\log_{10}E = 11.8 + 1.5M_S$$

where energy, *E*, is expressed in ergs. The drawback of this method is that M_S is computed from a bandwidth between approximately 18 to 22 s. It is now known that the energy radiated by an earthquake is concentrated over a different bandwidth and at higher frequencies. With the worldwide deployment of modern digitally recording seismograph with broad bandwidth response, computerized methods are now able to make accurate and explicit estimates of energy on a routine basis for all major earthquakes. A magnitude based on energy radiated by an earthquake, M_e, can now be defined,

$$M_e = 2/3 \log_{10}E - 2.9.$$

For every increase in magnitude by 1 unit, the associated seismic energy increases by about 32 times.

Although M_w and M_e are both magnitudes, they describe different physical properties of the earthquake. M_w, computed from low-frequency seismic data, is a measure of the area ruptured by an earthquake. M_e, computed from high frequency seismic data, is a measure of seismic potential for damage. Consequently, M_w and M_e often do not have the same numerical value.

ANNEX III: INTERPRETATION OF PTWC MESSAGES AND EMERGENCY RESPONSE GUIDANCE

It is the responsibility of the Tsunami Warning Focal Point for each country where PTWC messages are received to establish procedures for acting on them in a way to save lives and reduce property damage. Each country is responsible for issuing appropriate guidance within their respective territories.

Tsunami Emergency Response Plans and Standard Operating Procedures should be prepared and practiced by stakeholders in order to familiarize the response prior to a real event. The procedures are advised to take into account and include:

1) Rapid enactment of emergency response procedures
2) Delegated decision-making regarding the ordering of evacuations and other protective measures, notification of authorities and recall of disaster response personnel
3) If warranted, rapid and comprehensive notification of the public at risk
4) Emergency procedures for evacuations including establishment of evacuation zones, routes, and public shelters
5) Emergency procedures in case of a tsunami disaster impact

Procedures can include pre-determined decisions, such as automatically notifying the public and media for nearby local tsunami events when time is very limited.

The following is a review of the various types of PTWC Messages and recommended actions to enact.

Types of PTWC Messages within the Pacific Basin based on Initial Earthquake Moment Magnitude (Mw) Criteria

Mw less than 6.5 (Mw: Moment Magnitude)	**Earthquake Message Only**
Mw 6.5 to 7.5	**Tsunami Information Bulletin**
Mw 7.6 to 7.8	**Regional Tsunami Warning**
Mw > 7.8	**Expanding Warning / Watch**
Confirmed Teletsunami	**Pacific-Wide Warning**

Note: These earthquake criteria are based on a shallow hypocenter depth (less than 100 km) capable of rupturing the ocean floor or coastal areas, possibly generating a tsunami. If an earthquake is large, but deep inside the earth, clearly inland, and thus not likely to cause a tsunami; or located outside the Pacific Basin area of operations, a Tsunami Information Bulletin will be issued.

PTWC Message Definitions and Actions:

- **Tsunami Warning**

Definition

The highest level of tsunami alert. Warnings are issued to particular areas 1) when there is an imminent threat (usually within the next three hours) of a tsunami from a large undersea earthquake; or 2) following confirmation that a potentially destructive tsunami is crossing the Pacific that may destructively impact coasts along part or all of the named areas. They may initially be based only on seismic information as a means of providing the earliest possible alert. Warnings advise that appropriate actions be taken in response to the tsunami threat. Warnings are updated at least hourly or as conditions warrant to continue, expand, restrict, or end the warning.

A. **Pacific-Wide Tsunami Warning** is issued when there is confirmation that a tsunami has been generated capable of causing destruction in part or all of the Pacific Basin.

B. **Regional Expanding Tsunami Warning and Watch.** A Tsunami Warning status will initially encompass regions having less than 3 hours until the estimated time of tsunami arrival. Those areas having 3 to 6 hours will be placed in a Watch status. Additional messages will be issued hourly or sooner. If there is no cancellation, the warning and watch regions will continue to expand outward from the earthquake epicenter in an hourly rate.

C. **Regional Fixed Tsunami Warning.** The area placed in a fixed regional tsunami warning encompasses coastal regions within 1000-km of the earthquake epicenter. The fixed regional warning will not expand, unless conditions warrant an upgraded status.

Action

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.

A TSUNAMI WARNING MEANS EMERGENCY RESPONSE AGENCIES WITHIN THE DESIGNATED WARNING REGIONS SHOULD IMMEDIATELY ENACT PRE-DETERMINED EVACUATION PROCEDURES, SUCH AS AUTOMATICALLY NOTIFYING THE PUBLIC AND MEDIA, AND RECALL THEIR STAFFS FOR POTENTIAL 24 X 7 DUTY.

ALL RESIDENTS WITHIN THE WARNED AREA SHOULD BE ALERT FOR INSTRUCTIONS BROADCAST FROM THEIR LOCAL CIVIL AUTHORITIES. DO NOT RETURN TO EVACUATED AREAS UNTIL AN ALL CLEAR IS GIVEN BY LOCAL CIVIL AUTHORITIES. AN INITIAL TSUNAMI WARNING NEAR AN EARTHQUAKE EPICENTER IS BASED SOLELY ON EARTHQUAKE INFORMATION – THE TSUNAMI HAS NOT YET BEEN CONFIRMED.

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. 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.

Note to Mariners:
Mariners in water deeper than 400 meters should not be affected by a tsunami. Do not return to port if you are at sea and a tsunami warning or watch has been issued for your coastal area. For a distant tsunami, listen for official tsunami wave arrival times. If time allows, remove or deploy vessels to deep water. However, for a locally-generated tsunami, there will be no time to deploy a vessel because waves can come ashore within minutes. Leave your boat at the pier and physically move to higher ground.

- **Tsunami Watch**

Definition

The second highest level of tsunami alert. Watches are issued by the TWCs based on seismic information without confirmation that a destructive tsunami is underway. It is issued as a means of providing an advance alert to areas that could be impacted by destructive tsunami waves. Watches are updated at least hourly to continue them, expand their coverage, upgrade them to a Warning, or end the alert. A Watch for a particular area may be included in the text of the message that disseminates a Warning for another area.

Action

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

A TSUNAMI WATCH MEANS EMERGENCY RESPONSE AGENCIES WITHIN THE DESIGNATED WATCH REGION SHOULD NOTIFY AND RECALL THEIR STAFFS FOR THE POSSIBILITY OF THE WATCH BEING UPGRADED TO A WARNING IN THE NEAR FUTURE.

Note to Mariners:
Mariners in water deeper than 400 meters should not be affected by a tsunami. Do not return to port if you are at sea and a tsunami warning or watch has been issued for your coastal area. For a distant tsunami, listen for official tsunami wave arrival times. Consider how much time you have to possibly remove or deploy vessels to deep water if a tsunami warning is declared for your region. However, for a locally-generated tsunami, there will be no time to deploy a vessel because waves can come ashore within minutes. Leave your boat at the pier and physically move to higher ground.

- **Tsunami Advisory**

Definition

The third highest level of tsunami alert. Advisories are issued to coastal populations within areas not currently in either warning or watch status when a tsunami warning has been issued for another region of the same ocean. An Advisory indicates that an area is either outside the current warning and watch regions or that the tsunami poses no danger to that area. PTWC will continue to monitor the event, issuing updates at least hourly. As conditions warrant, the Advisory will either be continued, upgraded to a watch or warning, or ended.

Action

A TSUNAMI ADVISORY MEANS EMERGENCY RESPONSE AGENCIES WITHIN THE DESIGNATED ADVISORY REGION SHOULD NOTIFY AND RECALL THEIR STAFFS FOR THE POSSIBILITY OF THE ADVISORY BEING UPGRADED TO A WATCH OR WARNING IN THE NEAR FUTURE.

- **Tsunami Information**

Definition

A message issued to advise PTWS participants of the occurrence of a major earthquake in or near the Pacific, with an evaluation that there is either: a) no widespread tsunami threat but the small possibility of a local tsunami or b) there is no tsunami threat at all because the earthquake is located inland or deep inside the earth. A supplement or higher level of alert will be issued if tsunami waves are observed on nearby gauges.

A message is issued to inform that an earthquake has occurred and to advise regarding its potential to generate a tsunami. In most cases, a Tsunami Information Bulletin indicates there is no threat of a destructive tsunami, and are used to prevent unnecessary evacuations as the earthquake may have been felt in coastal areas. A Tsunami Information Bulletin may, in appropriate situations, caution about the possibility of a destructive local tsunami for coasts located near an earthquake epicenter (usually within 100 km). Because it takes 10-20 minutes for PTWC initial bulletins to be issued, they may not be very effective for a local tsunami that can be onshore in just minutes. In such situations, however, local authorities can at least investigate if a tsunami has occurred and if so quickly initiate recovery procedures. A supplemental Tsunami Information Bulletin may be issued if important additional information is received such as a sea level reading showing a tsunami signal. A Tsunami Information Bulletin may also be upgraded to a watch or warning if appropriate.

Action

A TSUNAMI INFORMATION BULLETIN MEANS EMERGENCY RESPONSE AGENCIES NEAR THE EPICENTER SHOULD ENSURE THAT THE PUBLIC IS NOTIFIED THAT AN EARTHQUAKE HAS OCCURRED, BUT BASED ON THE EARTHQUAKE MAGNITUDE AND HISTORIC TSUNAMI INFORMATION A DAMAGING TSUNAMI IS NOT EXPECTED ALONG THE COASTS. HOWEVER, AT COASTAL LOCATIONS WHICH HAVE EXPERIENCED STRONG GROUND SHAKING LOCAL TSUNAMIS ARE POSSIBLE DUE TO UNDERWATER LANDSLIDES.

References

Users Guide for the TsunamiWarning System in the West Coast/Alaska Tsunami Warning Center Area-of-Responsibility, August 2007

PTWC Operations, Systems and Procedures Manual, September 2006

Communications Plan for the Tsunami Warning System in the Pacific, April 2006

Users Guide for the Indian Ocean Tsunami Warning and Mitigation System Interim Tsunami Advisory Information Service, IOC Technical Series No. 72, 2007.

ANNEX IV: SEA LEVEL MEASUREMENT

Tsunami bulletins are issued by the PTWS TWCs (PTWC, WC/ATWC, and NWPTAC) based on the earthquake information in the first stage. After the issuance of the first bulletin, they start to monitor the real-time observation data transmitted from sea level stations. When the centers detect tsunamis, they include the observational data in the subsequent announcements accordingly. The tsunami observation data is expected to further activate the national tsunami warning and mitigation authorities in tsunami risk for their counter-tsunami actions because the data tells "tsunami is actually coming." The PTWS centers may revise their tsunami forecast using tsunami observation data if necessary and adequate.

However, each PTWS center reads tsunami parameters in a different way and criteria from tsunami waveform records and puts the parameters on their bulletins. Fig. A4-1, A4-2 and A4-3 are samples of the tsunami sea level measurement part of the PTWC, WC/ATWC and NWPTAC products. National tsunami warning centers (NTWCs) and national disaster management organizations (NDMOs) are requested to be fully aware of those differences and to interpret the observation data properly in order to take response actions in their country appropriately.

In general, sea level always changes up and down very slowly due to the tides. The oscillation period of tide force is about half a day. We should eliminate the astronomical tide level from the observed record to obtain the tsunami signal (Fig. A4-4). Then the following parameters are measured (also see Fig. A4-5).

Tsunami Arrival Time (in NWPTAC bulletins):
Time when the tsunami appears on the record.

Time of the Measurement (in PTWC and WC/ATWC bulletins):
Time when the center measured tsunami amplitude showed on its bulletin.

Period (in PTWC bulletins):
Period of time in minutes from one crest to the next.

Amplitude (AMPL):
For the PTWC and WC/ATWC, tsunami amplitude is measured relative to normal sea level. On the other hand, the NWPTAC reports "AMPL" in 0.1 meter unit by measuring half of trough-to-crest height.

Tsunami Height (for domestic messages in Japan only):
Amplitude from predicted tide level to the crest of the maximum wave.

Double Amplitude (not in use on international bulletins):
Wave amplitude from a trough to crest or a crest to trough.

```
MEASUREMENTS OR REPORTS OF TSUNAMI WAVE ACTIVITY

 GAUGE LOCATION LAT    LON    TIME   AMPL          PER
 --------------  -----  -----  -----  -------------- -----
 CALDERA CL             27.1S  70.8W 2205Z 0.44M /  1.5FT  54MIN
 ANTOFAGASTA CL 23.6S  70.4W 2251Z 0.25M /  0.8FT  24MIN
 IQUIQUE CL         20.2S  70.2W 2245Z 0.23M /  0.7FT  34MIN

     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.
```

Fig. A4-1 Tsunami Observation Section of a PTWC Bulletin

```
A TSUNAMI HAS BEEN OBSERVED AT THE FOLLOWING SITES

 LOCATION                    LAT    LON      TIME     AMPL
 ------------------------  -----  ------  -------  -----------
 HONIARA SOLOMON ISLAND          9.4S   159.9E   2148UTC   0.15M/0.5FT

TIME - TIME OF MEASUREMENT
AMPL - TSUNAMI AMPLITUDES ARE MEASURED RELATIVE TO NORMAL SEA
     LEVEL. THESE ARE NOT CREST-TO-TROUGH HEIGHTS.
```

Fig. A4-2 Tsunami Observation Section of a WC/ATWC Bulletin

```
MEASUREMENTS OR REPORTS ON TSUNAMI
 LOCATION                  COORDINATES ARRIVAL TIME      AMPL
 MIDWAY IS.                28.2N 177.4W
               MAXIMUM TSUNAMI WAVE 0911Z 13 JAN 0.2M
 WAKE IS.                  16.3N 166.6E
               MAXIMUM TSUNAMI WAVE 0848Z 13 JAN 0.1M
 CHICHIJIMA                27.1N 142.2E
               MAXIMUM TSUNAMI WAVE 0738Z 13 JAN 0.4M
 MIYAKO                    39.6N 142.0E
               MAXIMUM TSUNAMI WAVE 0633Z 13 JAN 0.1M
MAXIMUM TSUNAMI WAVE -- HALF OF AMPLITUDE FROM THE TROUGH
TO THE CREST
```

Fig. A4-3 Tsunami Observation Section of a NWPTA Bulletin

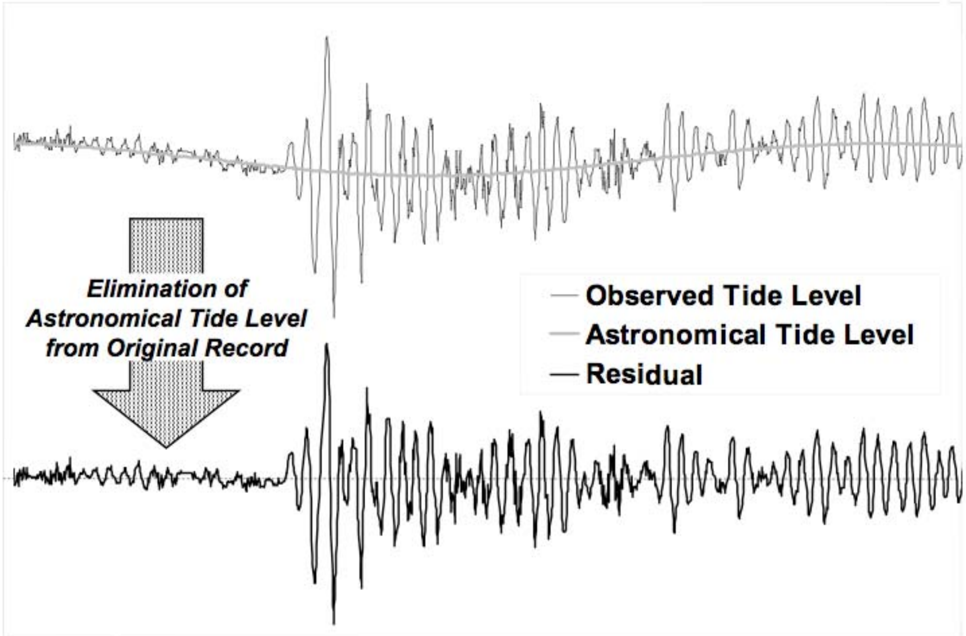


Fig. A4-4 Elimination of Astronomical Tide Level from Observed Sea Level Record

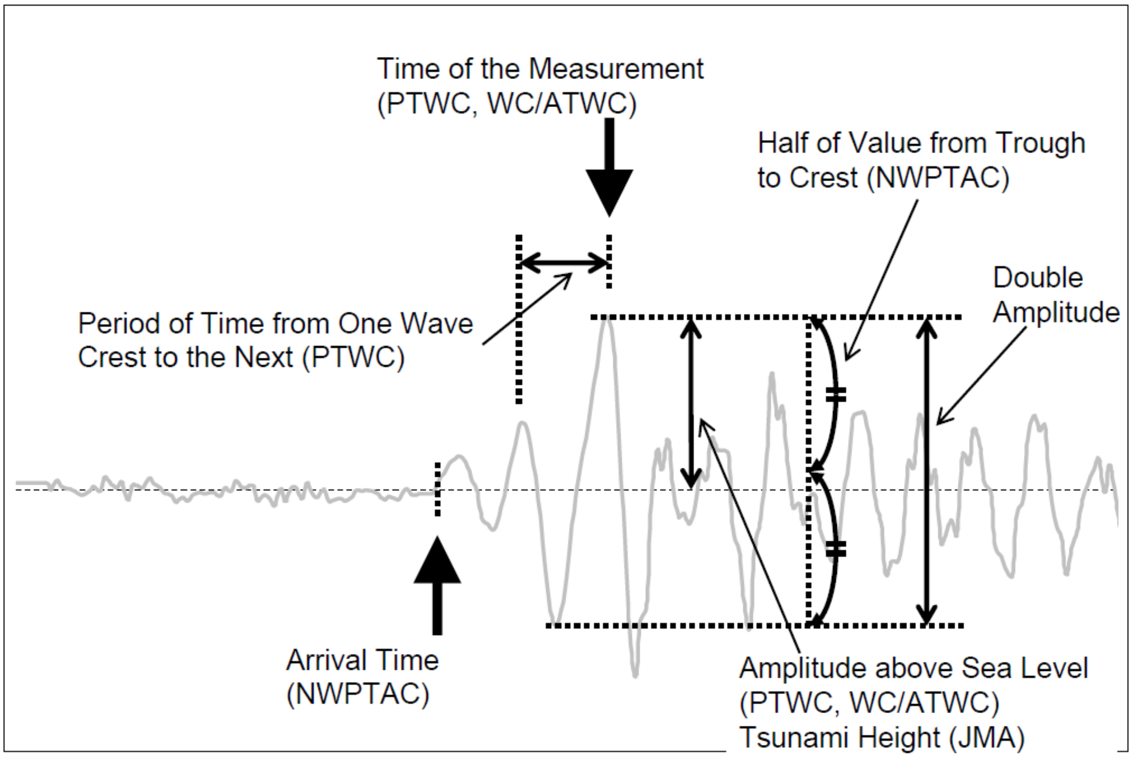


Fig. A4-5 Tsunami Observation Parameter on PTWS Centers' Bulletin

TSUNAMI OBSERVATIONS: VARIATIONS IN TSUNAMI ARRIVALS AT COASTAL SEA LEVEL (TIDE) STATIONS

The following background information on tsunami observations on coastal sea level stations was provided by the ITIC to participants during training courses in 2006 and 2007. It provides a practical illustration of the tsunami science principles.

1. WAVE HEIGHT AND PERIOD:

Relevant Points:

a. Tsunami are a series of waves that continue for many hours.

b. The 1st wave height may not be the largest.

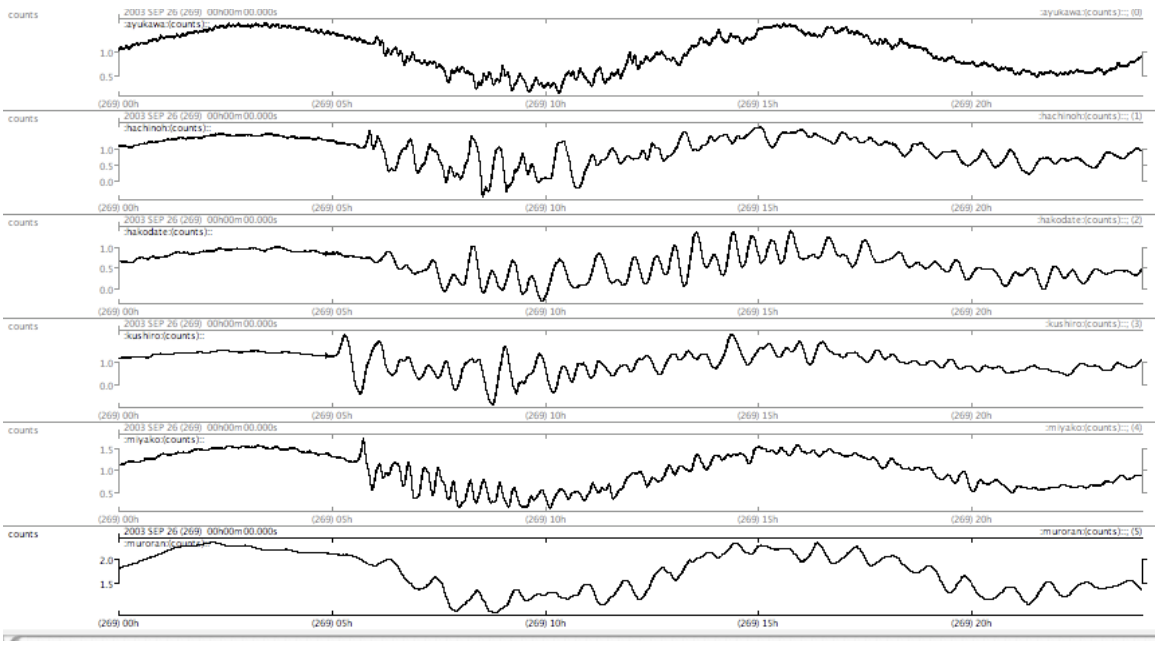
c. The largest wave may not occur at the station closest to the earthquake's epicenter.

d. Tsunami signals arriving at coastal stations are affected by local conditions, such as the roughness of seafloor, configuration of the coast (bays, headlands), rate of shoaling or shallowing of the seafloor. Consequently, the size of the tsunami can vary greatly over short distances along a coast.

e. Tsunami wave periods can vary from minutes (5-10) to one hour.

26 September 2003 M8.0 Tokachi-oki earthquake and tsunami.

---------------------- C --------------------
A B
| |



|--

|--------

--|
0
hr
5 hr
10 hr

Notes:

1. Record length is about 25 hrs, with tick marks every 5 hours. Amplitude scale of each record varies and normalized. Shown are high-frequency, low-amplitude wind-generated waves (A), tsunami (B), and diurnal tide (C, 1 ~12-hr cycle).
2. Showing of the tides is useful because you can determine if the tsunami will arrive at high tides (which would make it more dangerous), or low tide (less dangerous). Removal of tides is useful for showing the tsunami and measuring its arrival time, amplitude and period
3. Tsunami warnings are cancelled when signals become small on many stations. In this example, it would be cancelled after about 12 hrs.

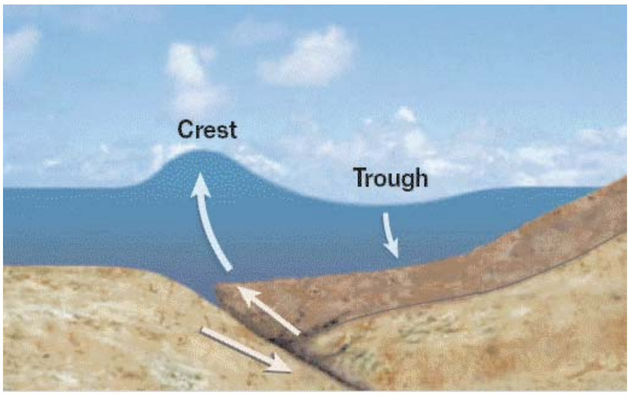
2. CHARACTER OF LEADING WAVES – WHEN IS THE 1st WAVE A RECEDING WAVE? PREDICTIONS BASED ON THEORY VS ACTUAL

Relevant Points:

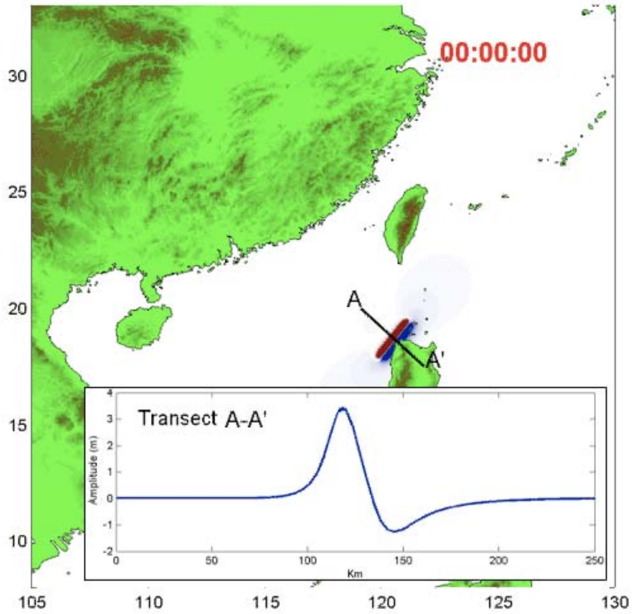
a. The earthquake rupture determines the initial character of the tsunami wave.

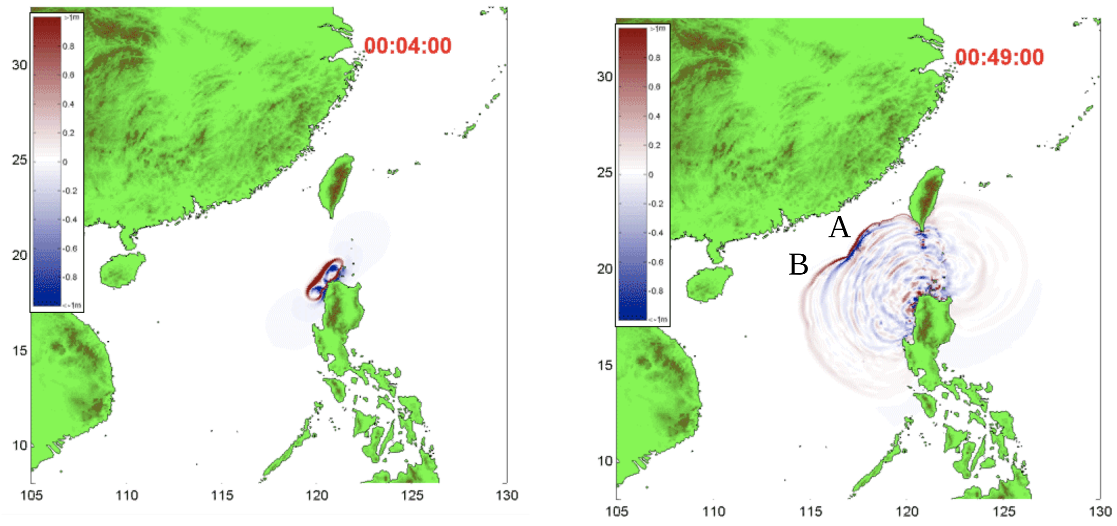
b. In theory, for a subduction zone thrust earthquake, the thrusting plate moves the ocean column upward creating a wave crest above and a trough behind. An advancing wave is created in the direction of the thrust, and a receding wave in the direction of plate subduction.

c. In reality, seafloor topography between the tsunami source and affected coast will modify and may complicate the character of the leading wave (so that the prediction from theory may be wrong).



Instantaneous push of ocean column upwards during thrust earthquake. Initial water displacement is advancing crest (red) and trough (blue).





Left: The 1st tsunami wave arrival will be an advancing wave (wall of water) toward China, and a receding wave at Luzon, Philippines.
Right: With time, the wave character is changed by seafloor topography. The trailing trough catches up to crest in the north (A), but not in the south (B).

Tsunami Source Propagation model: Dr. Philip Liu, Cornell University

ANNEX V: METHODS FOR TSUNAMI TRAVEL TIME CALCULATION
(Used by PTWC, WC/ATWC, and JMA)

Introduction

Tsunamis are categorized as long waves, therefore, tsunami travel times can be computed using water depth as the only variable (Murty, 1977). Long waves are those in which the distance between crests of the wave is much greater than the water depth through which the wave is traveling. Wave speed is computed from the square root of the quantity water depth times the acceleration of gravity. Thus, tsunami travel times can be computed without any knowledge of the tsunami's height, wavelength, etc.

There are, however, several situations in which the predicted estimated times of arrival may not match observed arrival times of the tsunami waves. These include, but are not limited to the following:

1. The bathymetry is not accurate in the vicinity of the epicenter.
2. The epicenter is not well located, or its origin time is uncertain.
3. The epicenter is on land and a pseudo-epicenter off the coast must be selected.
4. The bathymetry is not accurate in the vicinity of the reporting station.
5. Nonlinear propagation effects may be important in shallow water.
6. The observed travel times do not represent the first wave but instead are later arrivals.

As part of their standard operating procedures for responding to potentially tsunamigenic events, tsunami warning centers (TWC) calculate expected tsunami arrival times to various, pre-determined forecast points or regions. These arrival times help each TWC determine the urgency for alert notifications, and are included in their respective products for the Pacific, Indian Ocean, and Caribbean regions to assist national authorities in preparing for potentially destructive tsunami waves.

However, due to the dependency of propagation speed on the bottom topography and morphology, especially near-shore where the accuracy of the calculation is most heavily dependent on the accuracy of the bathymetry, actual arrival times of the first-arriving significant wave may vary substantially from the predicted times. *Thus, the primary value of quickly calculating an estimated tsunami arrival time is to provide immediate guidance to the TWC and to other emergency response stakeholders responsible for issuing and acting upon tsunami alerts to ensure public safety. Again, users and recipients of calculated travel times should be aware that these times are approximate.*

Description of PTWC and WC/ATWC Methods

The PTWC and WC/ATWC pre-computed travel times are from all points of interest to all possible source zones within each ocean basin and these results are stored in a database for quick table lookup. Software then accesses the travel times in order to calculate tsunami arrival times at forecast points for inclusion in messages. The WC/ATWC computes travel times using a 4' grid in the ocean and 30" grid near shore to approximately 500 points throughout the world (mostly within the center’s area of responsibility). The PTWC computes travel times using 2’ grid for the ocean and near shore for all designated forecast points within its area of responsibility (Pacific, Indian and Caribbean). The PTWC uses Tsunami Travel Time software developed by Geoware (TTT), and the WC/ATWC uses software written in-house.

Travel times are also computed immediately after an event so that travel time maps can be displayed on the center's web site. These times are computed on coarser grids than the pre-computed data base so that results are obtained more quickly. Arrival times reported in bulletins are taken from the data base.

The technique used by the software to compute travel times over an entire grid is an application of Huygen's principle. The principle states that all points on a wavefront are point sources for secondary spherical waves. Minimum travel times are computed over the grid starting at the point of interest (e.g. earthquake epicenter). From the starting point, times are computed to all surrounding points. The grid point with minimum time is then taken as the next starting point and times are computed from there to all surrounding points. The starting point is continually moved to the point with minimum total travel time until all grid points have been evaluated. This technique is explained in Shokin et al. (1987).

The TTT software facilitates predictions of tsunami travel times on a geographic (lat–lon) grid derived from a supplied bathymetric data grid. By assuming a long-wave approximation the propagation speed, *v*, of the tsunami front (i.e., the first arriving wave) is given by

$$v(x,y) = \sqrt{g(y) \cdot d(x,y)} \tag{1}$$

where *g* is the normal gravitational acceleration (considered a function of the latitude, *y*) and *d* is the water depth (positive down). TTT uses Huygens circle constructions to integrate the travel times from the epicenter to all nodes on the grid, i.e., we must add up increments of the form

$$\Delta t(r) = \int_0^r \frac{dx}{v(x)} = \int_0^r s(x)dx \tag{2}$$

where *r* is the distance from the current node to another node that lies on a circle of radius *r* and *s(x) = v-1(x)* is the slowness along the path. The slowness along this radial line is represented as a piecewise, linear function derived from the grid of velocities. The circles are necessarily approximated by polygons with up to 64 nodes to minimize any directional bias; thus a completely flat bottom bathymetry results in travel time contours that are close to concentric circles, and the travel times are everywhere within of 0.25% of the theoretical values.

Description of JMA Methods in Comparison to PTWC Methods

The Japan Meteorological Agency (JMA) uses different methods than the Pacific Tsunami Warning Center (PTWC) to calculate estimated tsunami arrival times in the Pacific and Indian Oceans.

For the Pacific Ocean, JMA has conducted numerical tsunami simulations for different scenarios and has stored the resulting estimated arrival times as well as maximum tsunami amplitudes in a database. JMA adopts "the time when estimated tsunami amplitude first exceeds 5 cm" as the "arrival time". This calculation method is different from the method of the Pacific Tsunami Warning Center. Furthermore, the following factors can also contribute to differences between the PTWC and JMA arrival time estimates:

1) For JMA, the nearest hypothetical fault model to the calculated epicenter is picked from the database. So, the difference between the center of the hypothetical fault (=assumed epicenter) and calculated epicenter location is one cause of discrepancy. By using this formulation, JMA is able to take into

account the "the finiteness of the seismic fault." In contrast, the PTWC uses the calculated epicenter as the tsunami source.

2) For JMA, the mesh interval of the bathymetry data is 5 arc minutes. A tsunami waveform is calculated by a simulation at the grid point (calculation point) which is the closest to the assigned "forecast point" (listed in the bulletin and in the Users Guide). The "arrival time" corresponds to that time estimated at that grid point. With this formulation, the tsunami arrival time in shallow coastal areas may be earlier (travel time is less) since the shallow bathymetry may not be well-depicted by 'coarsely-spaced' bathymetry.

For the Indian Ocean, JMA uses a method similar to the TTT algorithm used by PTWC. Huygen's principle that any wave will follow a path that takes it from one point to another in the shortest possible time is applied. However, the following are differences of the JMA method from PTWC's method.

1) The finiteness of the fault is taken into account by JMA. An elliptic tsunami source area centered at the calculated epicenter is assumed with its major axis length (L) given in terms of the empirical scaling law "log(L) = 0.5M – 1.9", and the aspect ratio 2:1, with the strike parallel to the nearest trench axis or coast line. The PTWC assumes a point source for the tsunami corresponding to the earthquake epicenter.

2) The mesh size is 5 arc minutes for JMA as compared to 1 arc minute for PTWC.

3) In JMA Tsunami Watch Information products, the estimated travel times for assigned coastal blocks (cf. Users Guide for IOTWS Interim Tsunami Advisory Information Service) are categorized into 6 categories -- "1 hour or less", "1 to 3 hours", "3 to 6 hours", "6 to 9 hours", "9 to 12 hours" and "more than 12 hours". PTWC products report specific estimated arrival times at specific forecast points.

Summary

Tsunami Warning Focal Points, National Tsunami Warning Centres, and other stakeholders should be aware of potential differences in the calculation and reporting of estimated arrival times by the TWCs, as well as uncertainties in the times no matter what method is used. These times should only be used as general guidance about when a tsunami impact might commence.

References

Generic Mapping Tools (GMT), P. Wessel and W. Smith, http://gmt.soest.hawaii.edu/.

Geoware, P. Wessel, http://www.geoware-online.com

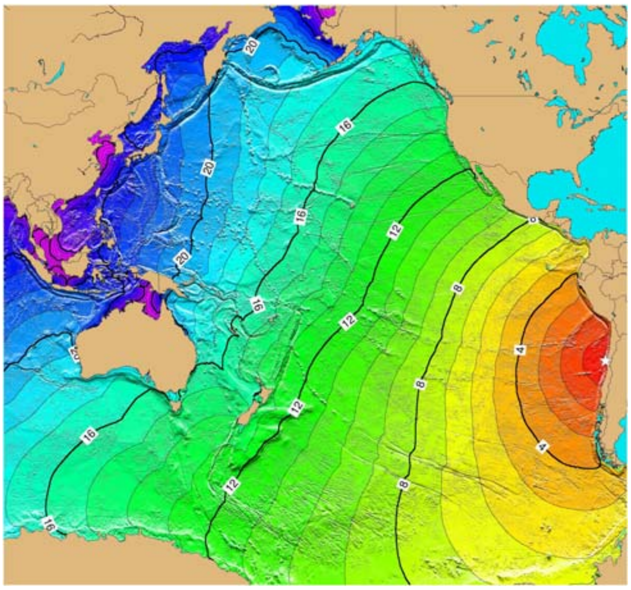
Murty, T.S., Seismic Sea Waves Tsunamis, Bulletin 198, Department of Fisheries and the Environment, Fisheries, and Marine Service, Ottawa, 336 p., 1977.

Shokin, Y.I., L.B. Chuborav, V.A. Novikov, and A.N. Sudakov, "Calculations of tsunami travel time charts in the Pacific Ocean - models algorithms, techniques, results, Science of Tsunami Hazards, Vol. 5, p. 85-113 1987.

Tsunami Travel Time (TTT) Software Package CD
Version 1.1, September 2007

US NOAA's National Geophysical Data Center, as the World Data Center (WDC) for Solid Earth Geophysics - Tsunamis, and the IOC's International Tsunami Information Centre (ITIC), are collaborating to provide, free of charge, tsunami travel time calculation and display software to government organizations involved in providing tsunami warning and mitigation services. Other interested organizations and individuals are requested to obtain the software directly from the developer.

The Tsunami Travel Time (TTT) software was developed by Dr. Paul Wessel (Geoware, http://www.geoware-online.com), and is used by the NOAA Pacific Tsunami Warning Center for its operations calculations. Map graphics are made using the open-source Generic Mapping Tools (GMT) developed by Drs. Paul Wessel and Walter Smith (http://gmt.soest.hawaii.edu/). The ITIC has purchased the TTT license to permit widespread free distribution. In this PC-environment distribution, the NGDC has provided display tools and sample scripts for running the software and producing maps such as that shown to the right.



The software included in the distribution CD is for systems using a Microsoft Windows operating system run from the Windows command line. It has been tested using Microsoft Windows XP, but should work on 98/NT/2000/Vista systems as well. The software code itself is not platform-specific, so it would be possible for NGDC/ITIC to provide other distribution versions, such as for Linux.

Components included on this CD

1. TTT (Tsunami Travel Time) software, version 3.0. Copyright Paul Wessel, Geoware, 2005. http://www.geoware-online.com. Licensed to NOAA/ITIC for redistribution**.** TTT library modified by NOAA/NGDC to provide GeoTIFF output.
2. Bathymetry grids derived from NGDC's ETOPO2 for the Pacific, Indian, and Atlantic Oceans at varying resolutions (60, 30, 20, 15, 10, 5, and 2 arc-minute).
3. Example input data, hands-on exercise to calculate and plot Indian Ocean and South China Sea region tsunami travel times
4. Example TTT maps
5. GMT (Generic Mapping Tools), version 4.1.4. Released under the GNU General Public License (GPL). http://gmt.soest.hawaii.edu/
6. NetCDF library, version 3.6.1. Copyright 1993-2006 University Corporation for Atmospheric Research/Unidata, released under a free license. http://www.unidata.ucar.edu/software/netcdf/
7. Ghostscript, version 8.54. Released under the Aladdin Free Public License (AFPL). http://www.cs.wisc.edu/~ghost/

For technical questions, please email Jesse Varner (Jesse.Varner@noaa.gov) or Paula Dunbar (Paula.Dunbar@noaa.gov) at NOAA NGDC. For general questions or further copies, please email Laura Kong (l.kong@unesco.org) at IOC ITIC.

Funding to support was provided by the NOAA Pacific Region Integrated Data Enterprise (PRIDE) Program to the ITIC under the FY05 Project entitled "Analysis of Extreme Events and Trends in Pacific Ocean Water Level Data and its Application to Risk and Vulnerability Assessment (M. Merrifield, L. Kong, and J. Marra)," and to the NGDC under the FY06 Project entitled "Integrated Pacific Region Tsunami-related Data and Information Products (P. Dunbar)."

ANNEX VI: TSUNAMI WAVE FORECASTING

(JMA Method for Estimation of Tsunami Arrival Time and Amplitude)

JMA has introduced the tsunami forecast system with a numerical simulation technique to issue quantitative tsunami warnings. Tsunami propagations originating from various types and locations of faults were simulated in advance and the calculated tsunami arrival time and amplitude are stored on the database along with magnitudes and hypocenter locations (presumed epicenters are shown in Figure A6). Once an earthquake occurs and its hypocenter and magnitude are determined, the best approximation of tsunami propagation is retrieved from the database according to the earthquake data.

Tsunami propagation is calculated using the long wave theory including effects of Coriolis force and sea floor friction [e.g. Satake (2002)]. The long wave theory is applied under the assumptions that “the wavelength of tsunami is much longer than the sea depth and the wave amplitude of tsunami is much smaller than the sea depth”. However, those assumptions are not realistic near the coasts where the sea depth is shallow. Hence, application of the numerical simulation on the long wave theory is limited in the sea area from epicenter up to points (“calculation points”) of several to several ten kilometers offshore depending on the coastal topography.

Tsunami amplitude at the calculation points is converted into that at a designated point on the coast (“forecast point”) based on the Green’s law [e.g. Satake (2002)]. Meanwhile, tsunami arrival time at the calculation points, which is obtained by the numerical simulation, is directly applied as that at the forecast points without any conversion. The arrival time is the time when estimated amplitude first exceeds 5 cm.

It should be noted that actual tsunami arrival time and amplitude may change depending on the coastal topography and the sea bed topography especially near the coasts where fine-mesh bathymetric data are not used in the numerical simulation of tsunamis. Further, the nearest simulation point, which is not always close to the actual epicenter, is chosen to estimate tsunami arrival time and amplitude. Therefore, even though the arrival time of a tsunami at each forecast point is given on a minute time scale, the time does not mean that they are estimated with the accuracy of such a time scale. Tsunamis may arrive at coasts earlier or later than the estimated arrival time in NWPTA messages.

Reference:

Satake, K., Tsunamis, 2002, International Handbook of Earthquake & Engineering Seismology, pp. 437-451, Academic Press

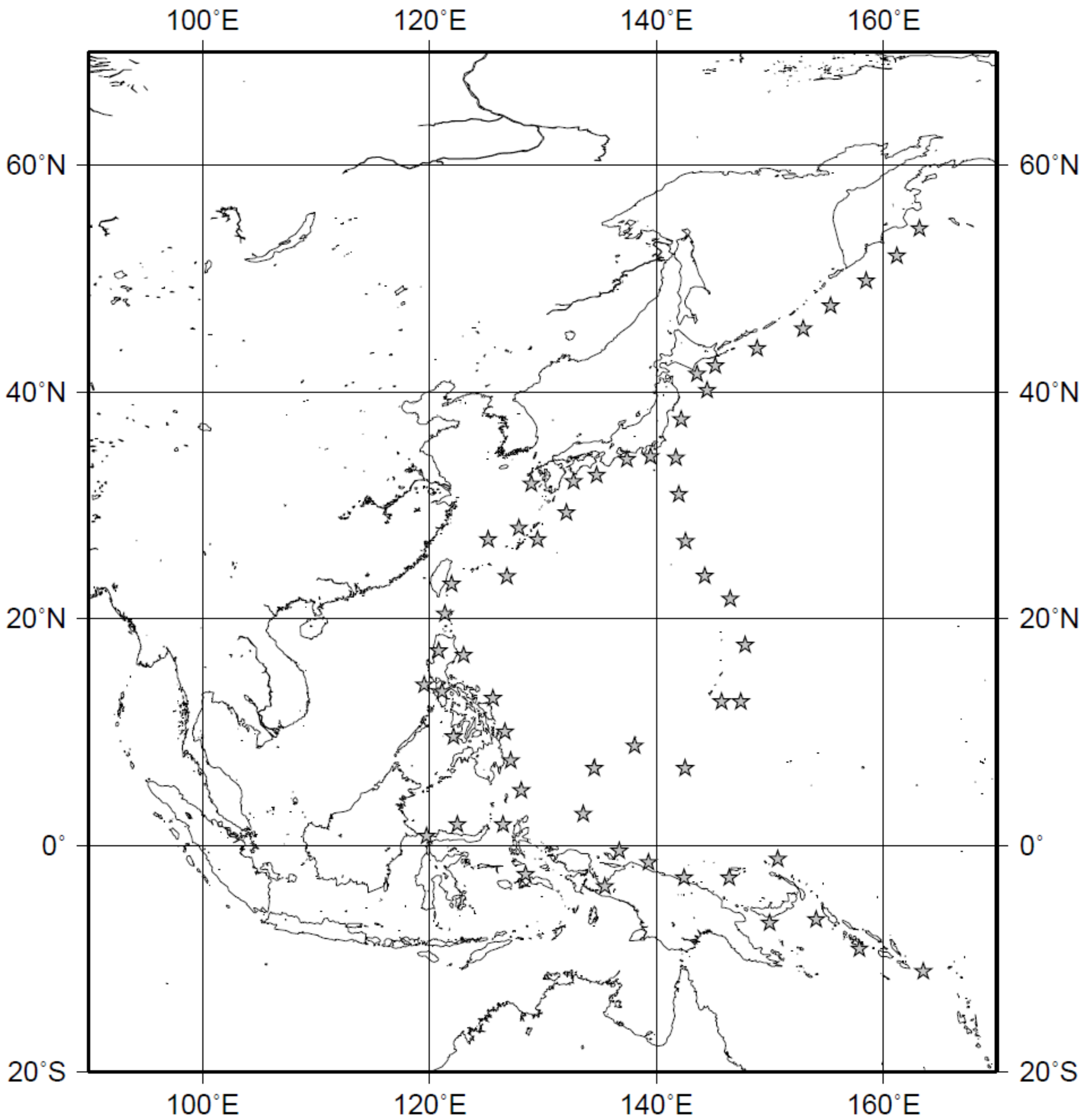


Figure A6. Simulation points (star) stored on the NWPTA database.

ANNEX VII: GLOSSARY OF TSUNAMI TERMS

To be included during final distribution

IOC Technical Series

No.	Title	Languages
1	Manual on International Oceanographic Data Exchange. 1965	(out of stock)
2	Intergovernmental Oceanographic Commission (Five years of work). 1966	(out of stock)
3	Radio Communication Requirements of Oceanography. 1967	(out of stock)
4	Manual on International Oceanographic Data Exchange - Second revised edition. 1967	(out of stock)
5	Legal Problems Associated with Ocean Data Acquisition Systems (ODAS). 1969	(out of stock)
6	Perspectives in Oceanography, 1968	(out of stock)
7	Comprehensive Outline of the Scope of the Long-term and Expanded Programme of Oceanic Exploration and Research. 1970	(out of stock)
8	IGOSS (Integrated Global Ocean Station System) - General Plan Implementation Programme for Phase I. 1971	(out of stock)
9	Manual on International Oceanographic Data Exchange - Third Revised Edition. 1973	(out of stock)
10	Bruun Memorial Lectures, 1971	E, F, S, R
11	Bruun Memorial Lectures, 1973	(out of stock)
12	Oceanographic Products and Methods of Analysis and Prediction. 1977	E only
13	International Decade of Ocean Exploration (IDOE), 1971-1980. 1974	(out of stock)
14	A Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment and Baseline Study Guidelines. 1976	E, F, S, R
15	Bruun Memorial Lectures, 1975 - Co-operative Study of the Kuroshio and Adjacent Regions. 1976	(out of stock)
16	Integrated Ocean Global Station System (IGOSS) General Plan and Implementation Programme 1977-1982. 1977	E, F, S, R
17	Oceanographic Components of the Global Atmospheric Research Programme (GARP) . 1977	(out of stock)
18	Global Ocean Pollution: An Overview. 1977	(out of stock)
19	Bruun Memorial Lectures - The Importance and Application of Satellite and Remotely Sensed Data to Oceanography. 1977	(out of stock)
20	A Focus for Ocean Research: The Intergovernmental Oceanographic Commission - History, Functions, Achievements. 1979	(out of stock)
21	Bruun Memorial Lectures, 1979: Marine Environment and Ocean Resources. 1986	E, F, S, R
22	Scientific Report of the Interealibration Exercise of the IOC-WMO-UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open Ocean Waters. 1982	(out of stock)
23	Operational Sea-Level Stations. 1983	E, F, S, R
24	Time-Series of Ocean Measurements. Vol.1. 1983	E, F, S, R
25	A Framework for the Implementation of the Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment. 1984	(out of stock)
26	The Determination of Polychlorinated Biphenyls in Open-ocean Waters. 1984	E only
27	Ocean Observing System Development Programme. 1984	E, F, S, R
28	Bruun Memorial Lectures, 1982: Ocean Science for the Year 2000. 1984	E, F, S, R
29	Catalogue of Tide Gauges in the Pacific. 1985	E only
30	Time-Series of Ocean Measurements. Vol. 2. 1984	E only
31	Time-Series of Ocean Measurements. Vol. 3. 1986	E only
32	Summary of Radiometric Ages from the Pacific. 1987	E only
33	Time-Series of Ocean Measurements. Vol. 4. 1988	E only
34	Bruun Memorial Lectures, 1987: Recent Advances in Selected Areas of Ocean Sciences in the Regions of the Caribbean, Indian Ocean and the Western Pacific. 1988	Composite E, F, S

(continued)

No.	Title	Languages
35	Global Sea-Level Observing System (GLOSS) Implementation Plan. 1990	E only
36	Bruun Memorial Lectures 1989: Impact of New Technology on Marine Scientific Research. 1991	Composite E, F, S
37	Tsunami Glossary - A Glossary of Terms and Acronyms Used in the Tsunami Literature. 1991	E only
38	The Oceans and Climate: A Guide to Present Needs. 1991	E only
39	Bruun Memorial Lectures, 1991: Modelling and Prediction in Marine Science. 1992	E only
40	Oceanic Interdecadal Climate Variability. 1992	E only
41	Marine Debris: Solid Waste Management Action for the Wider Caribbean. 1994	E only
42	Calculation of New Depth Equations for Expendable Bathymerographs Using a Temperature-Error-Free Method (Application to Sippican/TSK T-7, T-6 and T-4 XBTS. 1994	E only
43	IGOSS Plan and Implementation Programme 1996-2003. 1996	E, F, S, R
44	Design and Implementation of some Harmful Algal Monitoring Systems. 1996	E only
45	Use of Standards and Reference Materials in the Measurement of Chlorinated Hydrocarbon Residues. 1996	E only
46	Equatorial Segment of the Mid-Atlantic Ridge. 1996	E only
47	Peace in the Oceans: Ocean Governance and the Agenda for Peace; the Proceedings of *Pacem in Maribus* XXIII, Costa Rica, 1995. 1997	E only
48	Neotectonics and fluid flow through seafloor sediments in the Eastern Mediterranean and Black Seas - Parts I and II. 1997	E only
49	Global Temperature Salinity Profile Programme: Overview and Future. 1998	E only
50	Global Sea-Level Observing System (GLOSS) Implementation Plan-1997. 1997	E only
51	L'état actuel de 1'exploitation des pêcheries maritimes au Cameroun et leur gestion intégrée dans la sous-région du Golfe de Guinée *(cancelled)*	F only
52	Cold water carbonate mounds and sediment transport on the Northeast Atlantic Margin. 1998	E only
53	The Baltic Floating University: Training Through Research in the Baltic, Barents and White Seas - 1997. 1998	E only
54	Geological Processes on the Northeast Atlantic Margin (8^{th} training-through-research cruise, June-August 1998). 1999	E only
55	Bruun Memorial Lectures, 1999: Ocean Predictability. 2000	E only
56	Multidisciplinary Study of Geological Processes on the North East Atlantic and Western Mediterranean Margins (9^{th} training-through-research cruise, June-July 1999). 2000	E only
57	Ad hoc Benthic Indicator Group - Results of Initial Planning Meeting, Paris, France, 6-9 December 1999. 2000	E only
58	Bruun Memorial Lectures, 2001: Operational Oceanography – a perspective from the private sector. 2001	E only
59	Monitoring and Management Strategies for Harmful Algal Blooms in Coastal Waters. 2001	E only
60	Interdisciplinary Approaches to Geoscience on the North East Atlantic Margin and Mid-Atlantic Ridge (10^{th} training-through-research cruise, July-August 2000). 2001	E only
61	Forecasting Ocean Science? Pros and Cons, Potsdam Lecture, 1999. 2002	E only
62	Geological Processes in the Mediterranean and Black Seas and North East Atlantic (11^{th} training-through-research cruise, July- September 2001). 2002	E only
63	Improved Global Bathymetry – Final Report of SCOR Working Group 107. 2002	E only
64	R. Revelle Memorial Lecture, 2006: Global Sea Levels, Past, Present and Future. 2007	E only

(continued)

No.	Title	Languages
65	Bruun Memorial Lectures, 2003: Gas Hydrates – a potential source of energy from the oceans. 2003	E only
66	Bruun Memorial Lectures, 2003: Energy from the Sea: the potential and realities of Ocean Thermal Energy Conversion (OTEC). 2003	E only
67	Interdisciplinary Geoscience Research on the North East Atlantic Margin, Mediterranean Sea and Mid-Atlantic Ridge (12th training-through-research cruise, June-August 2002). 2003	E only
68	Interdisciplinary Studies of North Atlantic and Labrador Sea Margin Architecture and Sedimentary Processes (13th training-through-research cruise, July-September 2003). 2004	E only
69	Biodiversity and Distribution of the Megafauna / Biodiversité et distribution de la mégafaune. 2006 Vol.1 The polymetallic nodule ecosystem of the Eastern Equatorial Pacific Ocean / Ecosystème de nodules polymétalliques de l'océan Pacifique Est équatorial Vol.2 Annotated photographic Atlas of the echinoderms of the Clarion-Clipperton fracture zone / Atlas photographique annoté des échinodermes de la zone de fractures de Clarion et de Clipperton	E F
70	Interdisciplinary geoscience studies of the Gulf of Cadiz and Western Mediterranean Basin (14th training-through-research cruise, July-September 2004). 2006	E only
71	Indian Ocean Tsunami Warning and Mitigation System, IOTWS. Implementation Plan, July-August 2006. 2006	E only
72	Deep-water Cold Seeps, Sedimentary Environments and Ecosystems of the Black and Tyrrhenian Seas and the Gulf of Cadiz (15th training-through-research cruise, June–August 2005). 2007	E only
73	Implementation Plan for the Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and Connected Seas (NEAMTWS), 2007–2011. 2007 *(electronic only)*	E only
74	Bruun Memorial Lectures, 2005: The Ecology and Oceanography of Harmful Algal Blooms – Multidisciplinary approaches to research and management. 2007	E only
75	National Ocean Policy. The Basic Texts from: Australia, Brazil, Canada, China, Colombia, Japan, Norway, Portugal, Russian Federation, United States of America. (Also Law of Sea Dossier 1). 2008	E only
76	Deep-water Depositional Systems and Cold Seeps of the Western Mediterranean, Gulf of Cadiz and Norwegian Continental margins (16th training-through-research cruise, May–July 2006). 2008	E only
77	Indian Ocean Tsunami Warning and Mitigation System (IOTWS) – 12 September 2007 Indian Ocean Tsunami Event. Post-Event Assessment of IOTWS Performance. 2008	E only
78	Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (CARIBE EWS) – Implementation Plan 2008. 2008	E only
79	Filling Gaps in Large Marine Ecosystem Nitrogen Loadings Forecast for 64 LMEs – GEF/LME global project Promoting Ecosystem-based Approaches to Fisheries Conservation and Large Marine Ecosystems. 2008	E only
80	Models of the World's Large Marine Ecosystems. GEF/LME Global Project Promoting Ecosystem-based Approaches to Fisheries Conservation and Large Marine Ecosystems. 2008	E only
81	Indian Ocean Tsunami Warning and Mitigation System (IOTWS) – Implementation Plan for Regional Tsunami Watch Providers (RTWP). 2008	E only
82	Exercise Pacific Wave 08 – A Pacific-wide Tsunami Warning and Communication Exercise, 28–30 October 2008. 2008	E only
83.	*Under preparation*	

(continued)

No.	Title	Languages
84.	Global Open Oceans and Deep Seabed (GOODS) Bio-geographical Classification *(under preparation)*	
85.	Tsunami Glossary	E, F, S
86	Pacific Tsunami Warning System (PTWS) Implementation Plan *(under preparation)*	
87.	Operational Users Guide for the Pacific Tsunami Warning and Mitigation System (PTWS) – January 2009	E only