Intergovernmental Oceanographic Commission
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87

OPERATIONAL USERS GUIDE FOR THE PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM (PTWS)

Second edition

UNESCO

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Executive Summary

The Pacific Tsunami Warning and Mitigation System (PTWS) was founded in 1965 by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, following five major destructive Pacific tsunamis in the previous 19 years, to help reducing 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 Centre (PTWC), the NOAA West Coast / Alaska Tsunami Warning Centre (WCATWC) and the Japan Meteorological Agency's (JMA) Northwest Pacific Tsunami Advisory Centre (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 Centres, while Sections 4 to 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 Centres, an overview of the seismic and sea level monitoring networks used by the Centres, 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 Centres, 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 Centres are sent to the official PTWS Tsunami Warning Focal Points (TWFPs) of each country, as submitted to the Intergovernmental Oceanographic 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.

Résumé exécutif

Le Système d'alerte aux tsunamis et de mitigation dans le Pacifique (PTWS) a été créé en 1965 par la Commission océanographique intergouvernementale (COI) de l'UNESCO pour aider à réduire les pertes matérielles et en vies humaines dues à ce risque naturel après cinq tsunamis destructeurs dans le Pacifique au cours des 19 années précédentes.

Le Guide opérationnel à l'intention des utilisateurs du Système d'alerte aux tsunamis et de mitigation dans le Pacifique (PTWS) recense les services concernant les messages relatifs aux tsunamis fournis au PTWS par le Centre d'alerte aux tsunamis dans le Pacifique (PTWC) de la *National Oceanic and Atmospheric Administration* (NOAA) des États-Unis, le Centre d'alerte aux tsunamis de la Côte Ouest et de l'Alaska (WCATWC) de la NOAA et le Centre consultatif sur les tsunamis dans le Pacifique Nord-Ouest (NWPTAC) de l'Office météorologique japonais (JMA). Cette version 2009 du document initialement intitulé *Communications Plans for the Tsunami Warning System in the Pacific* (Plan de communication pour le Système d'alerte aux tsunamis dans le Pacifique) a été intégralement révisé afin d'inclure dans le corps principal du texte des descriptions des activités de ces trois centres et des informations techniques complémentaires dans les annexes. Le Guide est destiné aux organismes responsables du PTWS dans chaque pays, qui sont les destinataires des messages relatifs aux tsunamis envoyés par les Centres internationaux.

La Section 1 indique les buts et objectifs du présent Guide. La Section 2 décrit les procédures administratives, les organisations participantes et la manière de souscrire aux services offerts. La Section 3 présente succinctement les trois Centres opérationnels et les Sections 4 à 6 détaillent les services fournis par chacun d'eux. Les Annexes donnent des informations générales complémentaires sur les tsunamis, les caractéristiques des sources sismiques, le calcul des temps de parcours et les prévisions concernant les vagues.

L'objectif premier du Guide est de récapituler les procédures opérationnelles des Centres, de présenter dans leurs grandes lignes les réseaux de surveillance sismiques et de surveillance du niveau de la mer qu'ils utilisent, d'indiquer selon quels critères les messages relatifs aux tsunamis sont émis et par quelles méthodes ils sont envoyés.

Les trois Centres coopèrent étroitement pour garantir la fourniture en temps voulu de messages relatifs aux tsunamis contenant des informations cohérentes. Bien qu'ils aient recours à des méthodes et des réseaux de données légèrement différents, leurs analyses et évaluations sont généralement très similaires. En cas de réelle divergence, il est toutefois recommandé aux organismes nationaux responsables de se fonder sur l'hypothèse la plus prudente pour prendre des décisions concernant la sécurité des vies humaines.

Les messages relatifs aux tsunamis émis par les Centres sont adressés aux points focaux officiels pour l'alerte aux tsunamis (TWFP) de chaque pays indiqués à la Commission océanographique intergouvernementale. Pour éviter toute confusion que pourrait entraîner la diffusion d'informations contradictoires par de multiples instances, il est indispensable de désigner un (des) point(s) focal(aux) officiel(s) pour l'alerte aux tsunamis et une seule autorité responsable.

Resumen dispositivo

En 1965, después de cinco devastadores tsunamis en 19 años que afectaron al Pacífico, la Comisión Oceanográfica Intergubernamental (COI) de la UNESCO estableció el Sistema de Alerta contra los Tsunamis en el Pacífico y Atenuación de sus Efectos (PTWS) con el objetivo de ayudar a reducir las pérdidas de vidas humanas y bienes materiales causadas por este peligroso fenómeno natural.

La Guía operacional para los usuarios del Sistema de Alerta contra los Tsunamis en el Pacífico y Atenuación de sus Efectos (PTWS) contiene un resumen del servicio de mensajes sobre tsunamis que actualmente prestan al PTWS el Centro de Alerta contra los Tsunamis en el Pacífico (PTWC) de la Administración Nacional Oceánica y Atmosférica (NOAA) estadounidense, el Centro de Alerta contra los Tsunamis de Alaska y la Costa Occidental (WCATWC) de la NOAA y el Centro de Asesoramiento sobre los Tsunamis del Pacífico Noroccidental (NWPTAC) del Organismo Meteorológico del Japón (JMA). Esta versión de 2009 del anteriormente llamado Plan de Comunicaciones para el Sistema de Alerta contra los Tsunamis en el Pacífico, tras ser objeto de una exhaustiva revisión, incluye ahora en el cuerpo del texto descripciones del funcionamiento de esos tres centros, así como información técnica complementaria en los anexos. La Guía está dirigida a los organismos responsables de cada país del PTWS, que son los receptores de los mensajes sobre tsunamis procedentes de los centros internacionales.

En la Sección 1 se exponen los objetivos y fines de la Guía. En la Sección 2 se describen los procedimientos administrativos, las organizaciones participantes y el modo de suscribirse a los servicios que presta el Sistema. En la Sección 3 se describen sumariamente los tres centros operacionales, mientras que en las secciones 4 a 6 se exponen en detalle los servicios que ofrece cada uno de ellos. En los anexos se presenta información básica complementaria sobre tsunamis, caracterizaciones del origen de un seísmo, interpretación de los mensajes y respuesta de emergencia, mediciones del nivel del mar, cálculos del tiempo de desplazamiento y predicciones del oleaje.

La Guía tiene por propósito principal ofrecer una visión general de los procedimientos operacionales de los centros, de sus redes de vigilancia de seísmos y del nivel del mar, de los criterios para emitir mensajes sobre tsunamis y de los métodos empleados para difundir esos mensajes.

Los tres centros internacionales trabajan en estrecha coordinación para asegurar que la difusión de mensajes sobre tsunamis se realiza oportunamente y que éstos contienen información coherente. Los análisis y evaluaciones que facilitan los centros, pese a ligeras diferencias en las redes de datos y los métodos utilizados, son por lo general muy similares. Aún así, se recomienda a los organismos nacionales responsables que, en caso de eventuales discrepancias, se basen en la hipótesis más conservadora para adoptar decisiones que puedan tener consecuencias sobre la seguridad de las personas.

Los mensajes sobre tsunamis procedentes de los centros se envían a los puntos focales oficiales de alerta contra los tsunamis (TWFP) de cada país propuestos a la Comisión Oceanográfica Intergubernamental. Para evitar la confusión que se podría generar si distintas autoridades distribuyeran información contradictoria, es fundamental la designación de uno o varios puntos focales de carácter oficial y de un solo organismo que en cada país sea el responsable de difundir la información.

Рабочее резюме

Система предупреждения о цунами и смягчения их последствий в Тихом океане (СПЦТО) была создана в 1965 г. Межправительственной океанографической комиссией (МОК) ЮНЕСКО после пяти сильных, разрушительных цунами, произошедших в Тихом океане за предыдущие 19 лет, в целях содействия сокращению числа жертв и материального ущерба от этого опасного природного явления.

В Оперативном руководстве для пользователей по Системе предупреждения о цунами и смягчения их последствий в Тихом океане (СПЦТО) представлена краткая информация об услугах по оповещению о цунами, предоставляемых в настоящее время СПЦТО Центром предупреждения о цунами в Тихом океане (PTWC) при Национальном управлении по океану и атмосфере (НОАА) США, Центром предупреждения о цунами на Западном побережье и Аляске (WC/ANWC) при НОАА и Консультативным центром по цунами для северо-западной части Тихого океана (NWPTAC) при Японском метеорологическом агентстве (ЯМА). Версия 2009 г., ранее именовавшаяся Коммуникационным планом Системы предупреждения о цунами в Тихом океане, была полностью пересмотрена с целью включения в основную часть Руководства описания операций этих трех центров с дополнительной технической информацией, которая приводится в приложениях. Руководство предназначено для использования компетентными учреждениями в каждой стране СПЦТО, которые получают сообщения о цунами от международных центров.

В Разделе 1 изложены задачи и цели Руководства. В Разделе 2 описываются административные процедуры, участвующие организации, и то, каким образом можно подписаться на предлагаемые услуги. В Разделе 3 представлен обзор трех оперативных центров, а в разделах 4-6 подробно описываются услуги, предоставляемые каждым из них. В приложениях приводится дополнительная информация о цунами, характеристиках цунамигенных зон, интерпретации сообщений и чрезвычайных мерах реагирования, измерении уровня моря, расчетах времени подхода волны и волновых моделях.

Основная цель Руководства заключается в представлении краткой информации об оперативных процедурах центров, обзора используемых центрами сетей для мониторинга сейсмических явлений и уровня моря, критериев направления сообщений о цунами и методов отправления сообщений.

Эти три международных центра работают в тесном взаимодействии в целях обеспечения своевременной передачи сообщений о цунами с согласованной информацией. Анализы и оценки, предоставляемые центрами, обычно соответствуют друг другу, несмотря на небольшие различия используемых методов и сетей данных. Однако в случае выявления расхождений рекомендуется, чтобы ответственные национальные учреждения использовали наиболее консервативный вариант при принятии решений, касающихся безопасности людей.

Сообщения центров о цунами направляются официальным национальным координаторам по предупреждению о цунами (КПЦ) СПЦТО в каждой стране, представленным Межправительственной океанографической комиссии. Назначение официального(ых) национального(ых) координатора(ов) по предупреждению о цунами и единственного учреждения в каждой стране, ответственного за распространение такой информации, играет важную роль, позволяя избегать путаницы, которая может возникнуть в результате распространения противоречивой информации различными учреждениями.

1. INTRODUCTION

1.1 OBJECTIVE

The primary purpose of the Operational 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 Centre (PTWC), the West Coast/Alaska Tsunami Warning Centre (WC/ATWC), and the Japan Meteorological Agency/Northwest Pacific Tsunami Advisory Centre (JMA/ NWPTAC). The Guide includes a summary of the operational procedures, monitoring and detection data networks that are used by the warning centres, 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 Coordination Unit, ITIC, and the PTWS international tsunami centres, and how to subscribe to bulletins from those centres through the designation of Tsunami Warning Focal Points. Section 3 provides an overview of the PTWS Tsunami Advisory Centres, including brief explanations on the global seismographic network, the PTWS sea level network, communications tests, and methods of alert dissemination. Sections 4 to 6 describe 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 Operational 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 calculations are carried out, their accuracy, and how estimated and observed arrival times are reported. Annex VI describes wave forecasting methods, and how this information are used and interpreted. Annex VII 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 defence 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 centres.

1.3 TSUNAMI WARNING CENTRES (TWC) – AN OVERVIEW

The mission of a Tsunami Warning Centre 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 monitors real-time data from local and global seismographic networks in order to detect, 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 communication 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 PTWS Operational Users Guide provides information on the services provided by international TWCs.

When a large earthquake occurs, TWC personnel determine the earthquake's hypocentre, the initial rupture point of the earthquake, and its magnitude. If the hypocentre 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 TWC issues a local tsunami warning or advisory to areas located near the epicentre. A regional (sometimes ocean-wide, if the earthquake is significantly large) tsunami watch or advisory is also issued to areas located further from the epicentre 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 lives and reduce property damage.

Current operational weaknesses of tsunami warning centres 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.

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 Coordination Group for the PTWS (ICG/PTWS). Appendix 2.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 at least every 2 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 defence 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 2.4.

2.1.2 IOC Tsunami Unit (TSU)

The IOC Tsunami Unit (TSU) 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 TSU 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 TSU (a.i.) is:

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Acting Head of the IOC TSU
1 Rue Miollis
75732 Paris Cedex 15
Paris, FRANCE
Tel: +33 1 45 68 40 19
Fax: +33 1 45 68 58 10
E-mail: t.aarup@unesco.org

2.1.3 International Tsunami Information Centre (ITIC)

The UNESCO/IOC-NOAA International Tsunami Information Centre (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. The *Servicio Hidrográfico y Oceanográfico 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 provided one technical professional staff from 2007 to 2009.

As part of its mandate and functions under IOC Resolution X-23 (1977), the ITIC assists countries in establishing warning centres and improving tsunami preparedness. ITIC also works to monitor and improve warning services globally, and serves as an information resource for tsunami events (with WDC-MGG tsunamis), clearinghouse for education and awareness materials, and encourages research to improve mitigation practices.

The contact information for UNESCO/IOC-NOAA ITIC is:

Dr Laura KONG
Director, International Tsunami Information Centre
737 Bishop Street, Suite 2200
Honolulu, Hawaii 96813
U.S.A.
Tel: +1 808 532 6422
Fax: +1 808 532 5576
E-mail: laura.kong@noaa.gov
URL: http://www.tsunamiwave.info

2.2 PTWS OPERATIONS: INTERNATIONAL TSUNAMI WARNING CENTRES

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

2.2.1 United States of America

The U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS) operates and administers the tsunami warning centres for the U.S. These are the Pacific Tsunami Warning Centre in Ewa Beach, Hawaii and the West Coast/Alaska Tsunami Warning Centre in Palmer, Alaska. U.S. tsunami warning operations are managed by the NWS Office of Climate, Water, and Weather Services Tsunami Program Manager

(TPM). Tsunami warning centre 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 TPM is:

Ms Jane Hollingsworth
Tsunami Program Director
Meteorological Services Division
NOAA/NWS OCWWS
2350 Raggio
Pkwy Reno, NV USA
89512-3900
Tel: 301-713-1677 x 176
Email: jane.hollingsworth@noaa.gov

2.2.2 Pacific Tsunami Warning Centre (PTWC)

The PTWC started in 1949 following an unwarned tsunami from Alaska in 1946 that killed 159 persons 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 centre 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 Centre 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 Centre
91-270 Fort Weaver Road
Ewa Beach, Hawaii 96706
U.S.A.
Tel: 1-808-689-8207
Fax: 1-808-689-4543
Email: charles.mccreery@noaa.gov, ptwc@ptwc.noaa.gov
URL: http://www.weather.gov/ptwc/

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

The WC/ATWC started in 1967 after the 1964 Alaska earthquake and tsunami as the tsunami warning centre for Alaska. Its area of responsibility 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 Centre for all US states except Hawaii;
- US and International Tsunami Warning Centre for Puerto Rico and the Virgin Islands;
- International Tsunami Warning Centre 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
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Email: paul.whitmore@noaa.gov, wcatwc@noaa.gov
URL: http://wcatwc.arh.noaa.gov/

2.2.4 Japan

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

Japan Meteorological Agency (JMA)

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

- National tsunami warning centre (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 Centre 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 Centre is:

Mr Takeshi KOIZUMI
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: t-koizumi@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 Operational Users Guide. The PTWS Secretariat is responsible for the dissemination of the PTWS Operational Users Guide and the issuance of changes thereto. All changes and comments concerning the Operational Users Guide should be submitted to the ICG/PTWS Secretariat for inclusion in the next revision to the Operational Users Guide. Copies may be obtained from the PTWS Secretariat or from the IOC TSU web site www.ioc-tsunami.org .

The following organizations should maintain up-to-date copies of the Operational Users Guide: Tsunami Warning Focal Points and all designated operational contact points for receiving

international tsunami bulletins; PTWC, WC/ATWC, JMA, ITIC; IOC Tsunami Unit, Paris; Tsunami National Contacts; communication centres 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 NWPTAC 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 Appendix 2.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:

- Minister of Foreign Affairs,
- Head of UNESCO National Commission,
- Permanent Delegate to UNESCO,
- 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, and 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 centres through the ICG/PTWS Secretariat to officially include the TWFP dissemination in their customer list.

APPENDIX 2.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-centred mitigation activities will help to build tsunami resiliency.

Information sheets on the PTWS and the ITIC can be downloaded from www.ioc-tsunami.org

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-eastern 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, three Vice-Chairpersons) along with the members of the Steering Committee composed by the elected Officers (Chair and Vice-Chairs), the current inter-sessional Working Group Chairs, the Directors of PTWC, NWPTAC and ITIC or their representatives and other members' representatives by invitation of the Chair. 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 defence 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 centres.

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

Tsunami Unit (TSU)–IOC Secretariat

The IOC TSU 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 TSU 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 TSU 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. It oversees in coordination with the PTWS Officers the arrangement, conduct, and reporting of the ICG's sessions and other meetings. It also 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 centres (PTWC, WC/ATWC, NWPTAC) and the ITIC. The PTWS Technical Secretary is part of the IOC’s Tsunami Unit

International Tsunami Information Centre (ITIC)

The ITIC serves as the operational capacity building and system implementation centre assisting all PTWS Member States to develop new or strengthen existing national and sub-regional warning and mitigation systems. ITIC information services cover warning centre operations, training and

technology transfer, education and public awareness, mitigation and countermeasures, historical tsunami catalogues and post-tsunami surveys.

Pacific Tsunami Warning Centre (PTWC)

The PTWC serves as the international operational tsunami warning headquarters for the PTWS. Sub-regional centres in Alaska (WC/ATWC), USA and Japan (NWPTAC) work closely with the PTWC. The centres 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 ICG/PTWS Working Groups and/or 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, NWPTAC and the ICG/PTWS Secretariat, has established many cooperation 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). Regional and specialized organizations include the Association of Southeast Asian Nations (ASEAN), Coordinating Centre for the Prevention of Natural Disasters in Central America (CEPREDENAC), the Permanent Commission for the South Pacific (CPPS), the International Union of Geodesy and Geophysics Tsunami Commission (IUGG-TC), the Pacific Islands Applied Geoscience Commission (SOPAC) and the Pacific Regional Environmental Programme (SPREP).

Operational Users Guide for the PTWS (formerly PTWS Communications Plan)

The Guide is intended for use by National Tsunami Warning Focal Points as customers receiving the advisories from the tsunami warning centres. 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 reviewed and updated, if necessary, at least annually.

APPENDIX 2.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 centres. 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 four letter GTS Location Indicators used in the abbreviated headings, the eight letters 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 four letter location indicator and four 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 centres, but bulletins may reach their destinations at different times depending on the communication method.

Primary: ____

Alternate 1: ____

Alternate 2: ____

Alternate 3: ____

Please specify telephone number for voice communication, in a priority order. In general, due to language barriers, the operational warning centres 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: ______________________________

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 centres of the PTWS provide tsunami information and warnings to officially designated Tsunami Warning Focal Points of the countries of the PTWS. The centres 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 centres 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, communication, and dissemination facilities operated by many nations throughout the Pacific Region. To achieve its objective, the PTWS 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 centre for the PTWS; sub-regional Centres in Japan and Alaska work with PTWC to provide international warnings and advisories for the Pacific and its marginal seas. The above centres 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 analysis 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 generally 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 for some of the threatened areas. 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 Centres have been earlier established in a number of countries. For example, in the Russian Federation the Sakhalin and Kamchatka Tsunami Warning Centres started after the 1952 Kamchatka tsunami. In Japan, the Japan Meteorological Agency started its domestic tsunami operations in 1952. In Chile, the Hydrographic and Oceanographic Service of the Navy (SHOA) operates the National Tsunami Warning System (SNAM) from 1964, after the 1960 Chilean tsunami. In Tahiti, France, operates the Centre Polynésien de Prévention des Tsunamis (CPPT) which started in 1965 after the 1964 Alaska tsunami, providing tsunami warnings for French Polynesia which encompasses a large geographic area of the south Pacific.

3.3 AREAS OF RESPONSIBILITY

The coastal 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 TWCs

coordinate their earthquake parameters prior to official bulletin issuance using agreed-upon rules of procedures, and use identical earthquake parameters in their first issued bulletin.

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 happens within a few minutes of the occurrence of any earthquake in the Pacific region with a magnitude above 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 epicentre, 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 may continue, expand, or cancel the warning based on a combination of updated seismic parameters, sea level readings, numerical forecast model results, and historical data.

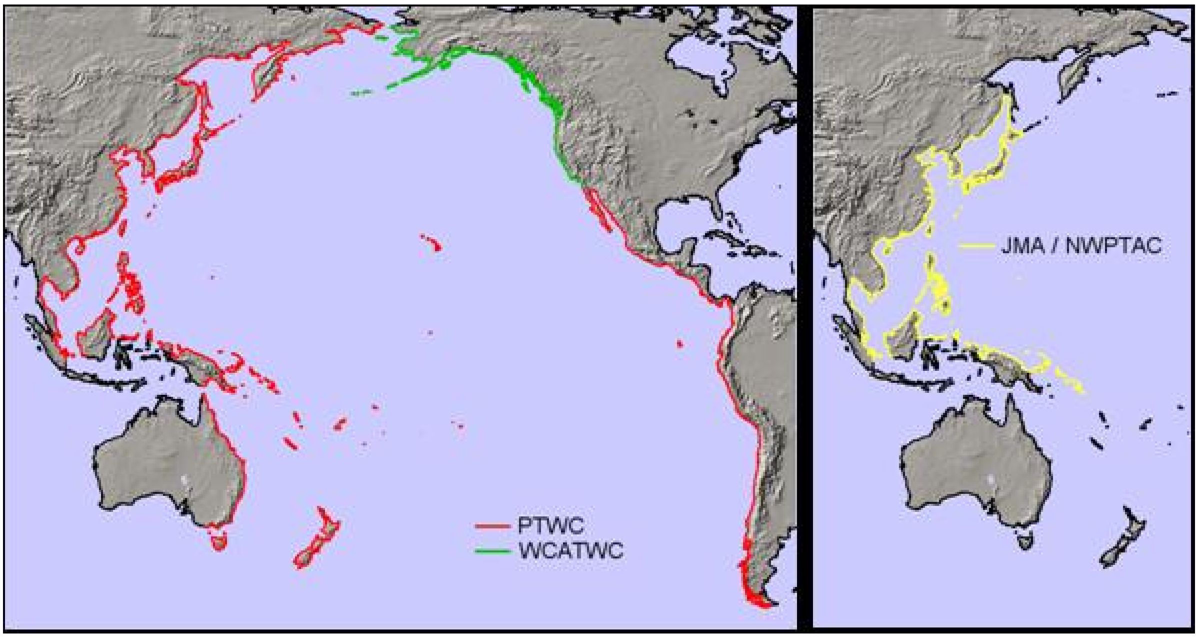


Figure 3.1 Coastal areas of responsibility of PTWC, WC/ATWC, and JMA/NWPTAC in the PTWS

A general summary of the criteria used by PTWC, WC/ATWC, and NWPTAC for the issuance of initial bulletins is given below (Table 3.1). 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 with preliminary earthquake parameters NWPTAC: No Observatory Message issued.
Pacific region event, Mw greater than or equal to 6.5, but less than or equal to 7.5. Or an earthquake that is larger but is deep inside the earth, clearly inland with no tsunamigenic possibility, 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. Indicate small possibility of a local tsunami if appropriate. WC/ATWC: Issue a Tsunami Information Statement. However, in the case of an Mw 7.1 to 7.5 shallow undersea earthquakes near the WC/ATWC coastal AOR a Tsunami Warning or Advisory is issued to nearby coasts. NWPTAC: (a).Shallow undersea NW Pacific event, Mw 6.5 to 7.0: Very small possibility of destructive local tsunami; (b).Shallow undersea NW Pacific event, Mw 7.1 to 7.5: Possible destructive tsunami within 100 km of epicentre.
Shallow undersea Pacific Basin event, Mw 7.6 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 epicentre. Update hourly until sea level gauge readings confirm no further threat. WC/ATWC: Issue a Tsunami Information Statement, a Tsunami Advisory, or a Tsunami Warning depending upon the threat to the WC/ATWC coastal AOR. NWPTAC: Issue an Advisory stating the possibility of destructive regional tsunami within 1000 km of the epicentre.
Shallow undersea Pacific Basin event, Mw > 7.8	PTWC: Issue Expanding Tsunami Warning and Watch putting coastal areas within 3 hours tsunami ETA into a Warning and areas within 3 to 6 hours tsunami ETA into a Watch. WC/ATWC: Issue a Tsunami Information Statement, an Advisory, or a Warning depending upon the threat to the WC/ATWC coastal AOR. 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 Pacific coastal areas in a Warning

Table 3.1 Criteria used by PTWC, WC/ATWC and NWPTAC
for the issuance of initial bulletins

Whenever there is a strong tsunami threat potential, the TWC will continuously check sea level data from stations located near the epicentre 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.

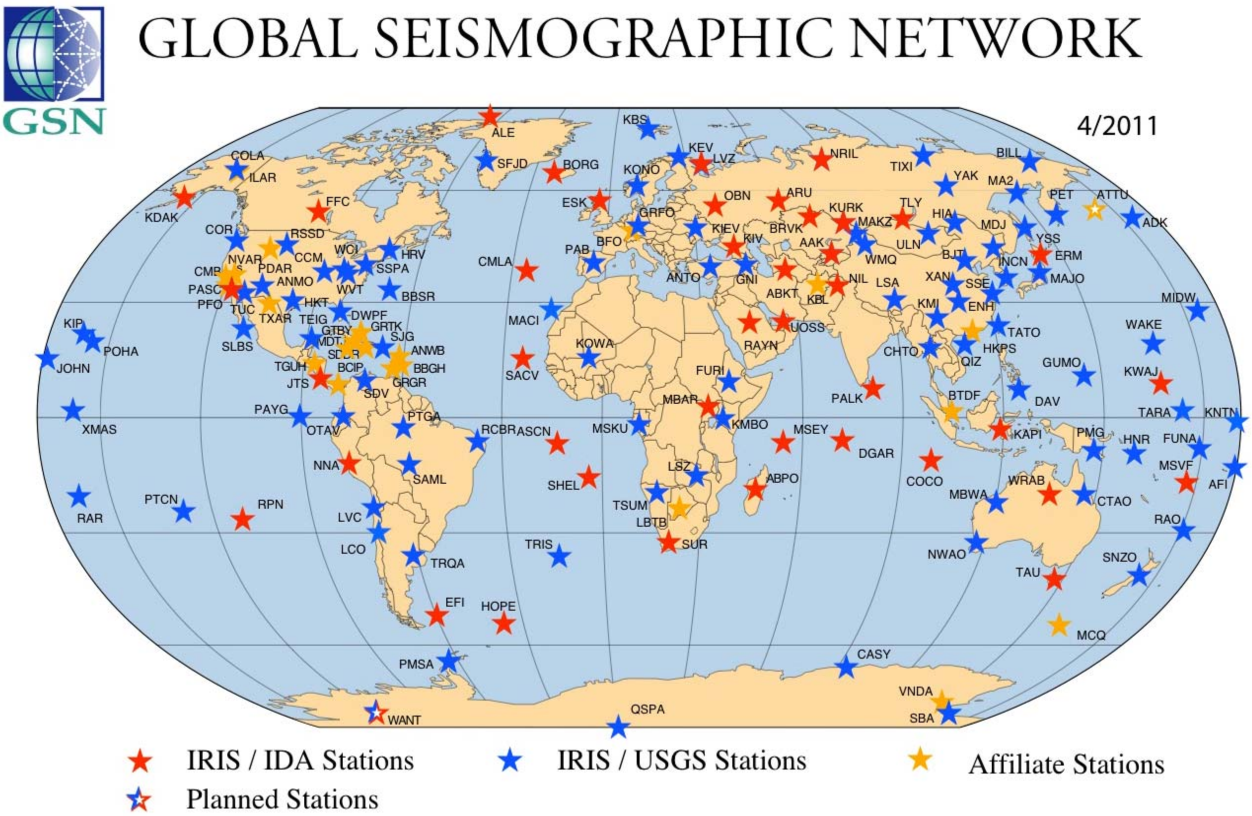
3.5 DETECTION NETWORKS

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 epicentres and magnitudes determined by the TWC. Much 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 (April 2011) network of the GSN is shown by the figure below (Figure 3.2).



F

Figure 3.2 Global Seismographic Network (GSN)

The current (August 2011) network of seismic stations in the Pacific region from all sources that are monitored by PTWC, including stations of the GSN, the International Monitoring System of the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO), and stations from many other national and regional networks is given below (Figure 3.3). WC/ATWC and JMA/NWPTAC monitor similar networks with a focus on their respective coastal areas of responsibility.

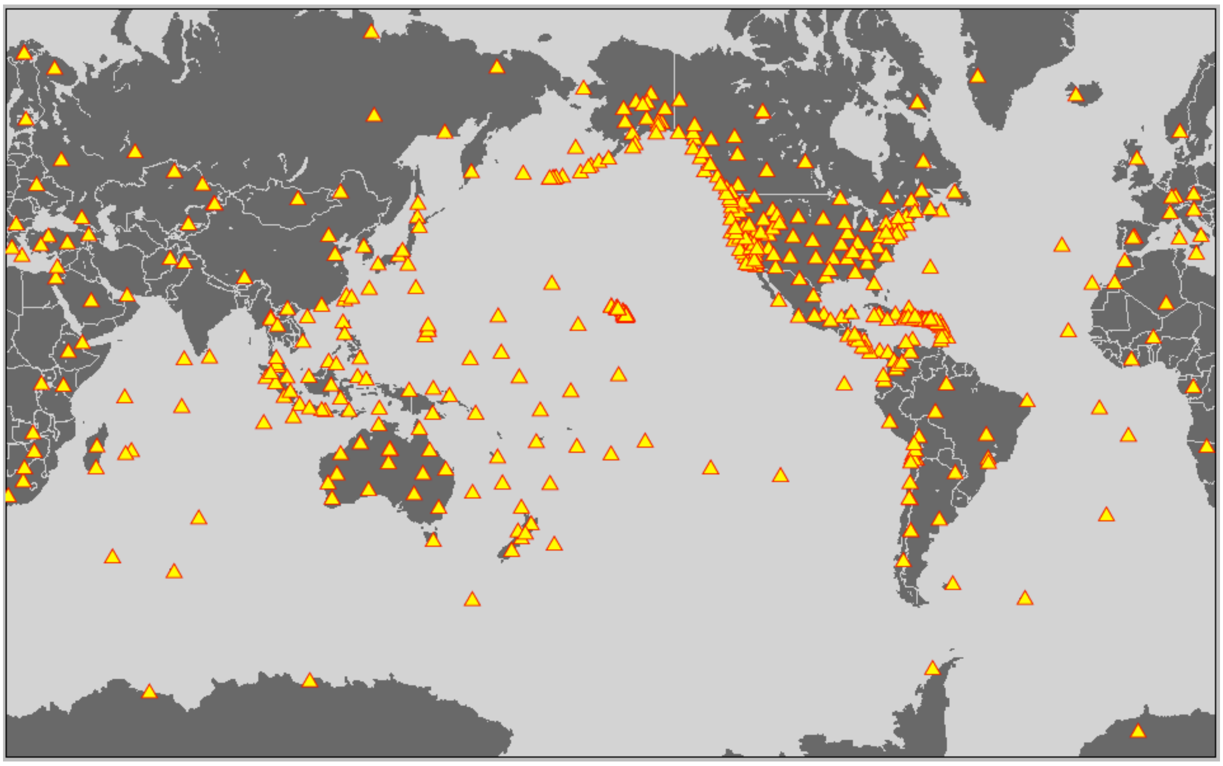


Figure 3.3 Seismic stations in the Pacific region monitored by PTWC for the detection and evaluation of large, potentially tsunamigenic earthquakes. August 2011.

SEISMIC ANALYSIS

Seismic Alarms

The incoming seismic data streams are continually monitored by computers. Whenever a large earthquake occurs, the signals it produces on nearby seismic stations are detected and processed. If they meet certain criteria, then the duty analysts are notified by a paging system. The analysts typically begin their interactive analyses of a large earthquake within a few minutes of its occurrence.

Hypocentre Determination

Earthquake hypocentres (the 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 hypocentre 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 hypocentre 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 to 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) of the IOC that shares their data for tsunami warning purposes. These data are transmitted in near real-time through geostationary meteorological satellites, the WMO GTS and through other dedicated communications links to reach the TWCs. Data transmission intervals range from near real-time to 60 min intervals. Data from up to 300 coastal sea level stations are received by the TWCs. In order to quickly confirm tsunami generation, and to improve on the accuracy of tsunami warnings, most of the coastal sea level stations transmit their data at intervals of 6 minutes or less. In addition, the TWCs receives data from up to 36 deep-ocean stations called DARTs (Deep-ocean Assessment and Reporting of Tsunamis) located off the major seismic zones on the Pacific. The DART systems routinely transmit their data only every 6 hours with a 15 minute sample rate but are activated to transmit every few minutes at a higher sampling rate if a tsunami is approaching the gauge.

The current (August 2011) set of sea level stations whose data are available to the international TWCs are shown in the map below (Figure 3.4).

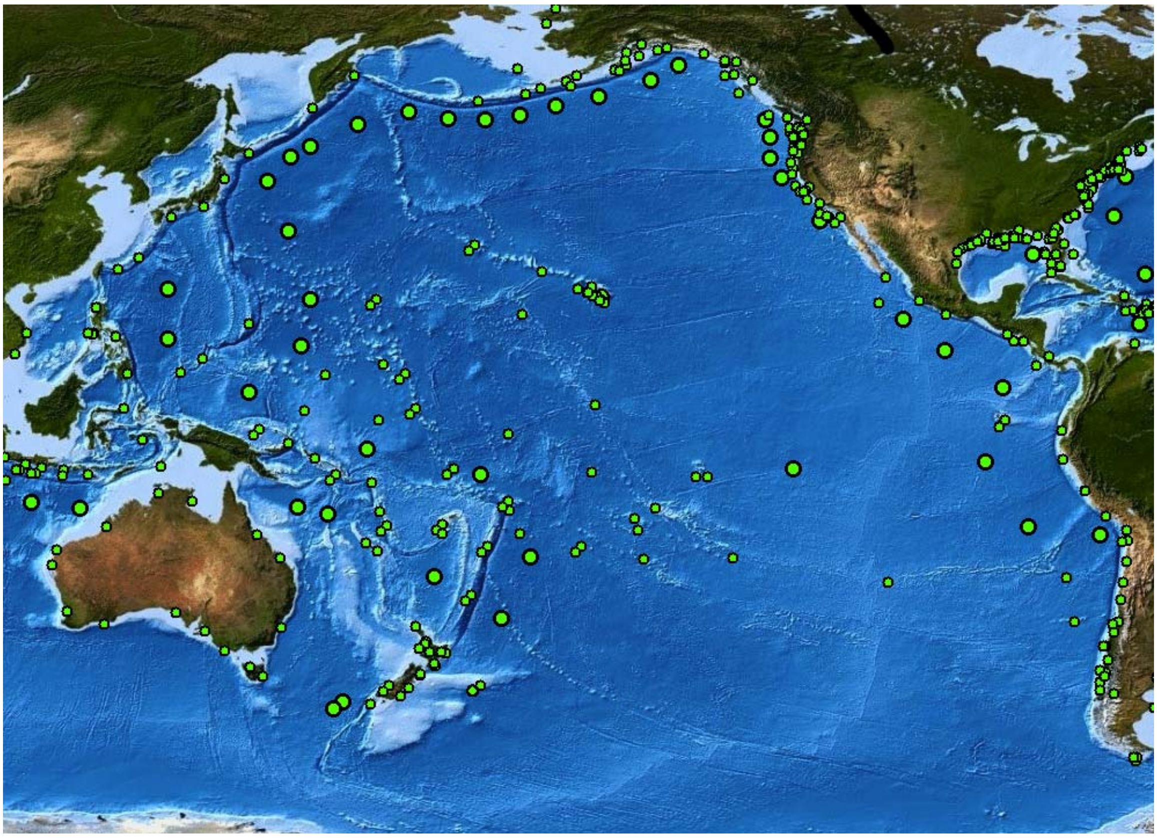


Figure 3.4 Coastal sea level stations (small dots) and deep ocean sea level stations (larger dots) in the Pacific that are monitored by PTWC and WCATWC for the detection and measurement of tsunamis. August 2011.

SEA LEVEL ANALYSIS

Sea Level Alarms

In general, the TWCs begin to monitor the sea level gauges following any earthquake with a tsunamigenic potential. Within the operations centre, computer screens continuously display sea level data as they are received. The Pacific DART buoys are monitored continuously by TWC software for automatic tsunami-triggered transmissions. If such transmissions are detected, then TWC 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 time of arrival (ETA) of the tsunami is computed for all sea level gauges. Sea level gauges with the earliest ETAs are closely monitored. If tsunami waves are observed, 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. Therefore, they are the most important readings for tsunami evaluation and forecasting. Selected sea level measurements may be reported in TWCs 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. A forecasting tool developed at WC/ATWC in the 1990s that is based on pre-run numerical models is in use at both WC/ATWC and PTWC. In addition, PTWC and WC/ATWC have begun using a new tsunami forecast system called SIFT that uses pre-computed unit-source scenarios constrained by DART signals to forecast the deep-ocean tsunami, and coastal inundation models to forecast impacts at the coast. PTWC has also developed its own deep-ocean model that is run in real time based upon the seismic parameters of the earthquake. The operational goal of the TWCs is to provide the best estimate of tsunami impacts based on all seismic and sea level data available at the time, as well as any historical data. JMA/NWPTAC includes its wave height forecasts in its products for any significant tsunami threat. PTWC and WC/ATWC may include wave height forecasts as well in their products. However, given the uncertainties involved, a conservative approach is still taken by the TWCs.

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 epicentre.
- **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 messages for the U.S. Pacific coastal states of Alaska, Washington, Oregon, and California, and for the west coast of Canada.

- **Tsunami Warning**: A tsunami warning is issued when a tsunami with the potential to generate widespread inundation is imminent, expected, or occurring.
- **Tsunami Advisory**: A tsunami advisory is issued when a tsunami with the potential to generate strong currents or waves dangerous to those in or very near the water is imminent, expected, or occurring.

- **Tsunami Watch**: A Tsunami Watch is issued by the Tsunami Warning Centres to alert emergency management officials and the public of an event, which may later impact the Watch area.
- **Information Statement**: A tsunami information statement is issued to inform emergency management officials and the public that an earthquake has occurred, or that a tsunami warning, watch or advisory has been issued for another section of the ocean. In most cases, information statements are issued to indicate there is no threat of a destructive tsunami and to prevent unnecessary evacuations as the earthquake may have been felt in coastal areas.
- **Tsunami Communication Test Dummy Message**: A test message issued by WC/ATWC at unannounced times to test communications of the tsunami warning system.

The NWPTAC issues only one kind of message, the Northwest Pacific Tsunami Advisory (NWPTA). 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 Centres (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 and wave amplitude forecasts for the forecast points.

The PTWC uses 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.

The WC/ATWC uses the wave amplitude forecasts to determine whether a region should be placed in a Warning, Advisory, or Watch status when a tsunami has been generated distant to the region. When a a major earthquake has occurred within the WC/ATWC Area-of-Responsibility, pre-defined criteria are used to select which areas are placed in a Warning, Advisory, or Watch status.

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.

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

Table 3.2 Tsunami Product Codes – WMO Headers (May 2010),
NOAA Pacific Tsunami Warning Centre (PTWC, PHEB),
NOAA West Coast/Alaska Tsunami Warning Centre (WC/ATWC, PAAQ),
Japan Meteorological Agency (JMA, RJTD).

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 centres.

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 2.II of the Section 2 of this document.

Functions 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 lives 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 3 m or greater, "Tsunami Warning" for 1 m and 2 m, and "Tsunami Attention" for 0.5 m or less. Local governments, who are responsible for giving directions to the public, usually recommend people to evacuate when JMA issues a "Warning." An "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, 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 Global Telecommunications System (GTS) of the World Meteorological Organization (WMO), Aeronautical Fixed Telecommunications System (AFTN) of the International Civil Aviation Organization (ICAO), and other more common systems such as facsimile transmission over telephone circuits, and internet e-mail and web postings. Facsimile and internet e-mail 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 TWCs. The GTS and AFTN are dedicated private communication methods that guarantee timely receipt of bulletins within several minutes, whereas facsimile and e-mail may incur delays of tens of minutes. Thus, while all dissemination methods are made simultaneously by the issuing centres, bulletins may reach their destinations at different times depending on the communication method used.

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

<table>
<tr><th></th><th>Service</th><th>Communication Link</th><th>User Audience</th></tr>
<tr><td rowspan="6">PTWC and WCATWC Methods</td><td>GTS</td><td>Dedicated GTS Circuit</td><td>U.S. and other nations’ Meteorological Services.</td></tr>
<tr><td>AFTN</td><td>Dedicated AFTN Circuit</td><td>Designated U.S. and other nations’ Airfield Facilities; U.S. Federal Aviation Administration and International affiliates.</td></tr>
<tr><td>EMWIN</td><td>GOES Satellite</td><td>Openly Available; U.S. and International Weather Forecast Subscribers, including National Disaster Management Offices unable to access GTS or AFTN-transmitted messages.</td></tr>
<tr><td>FAX</td><td>Standard Telephone Line</td><td>Many national government agencies.</td></tr>
<tr><td>EMAIL</td><td>Standard Internet Connection</td><td>Designated national government agencies.</td></tr>
<tr><td>WEB</td><td>Standard Internet Connection</td><td>Available to all PTWS Users.</td></tr>
</table>

Table 3.3 PTWC and WC/ATWC communications services

The NWPTAC recommends the use of the GTS as its 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, e-mail, 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 e-mail over the internet by high speed links to lists of designated recipients. E-mail should only be used as a primary method of receipt for agencies that do not have access to the preferred communication services. Otherwise, e-mail 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.weather.gov/ptwc
- NWPTAC http://www.jma.go.jp/en/distant_tsunami/WEPA40/index.html
- WC/ATWC http://wcatwc.arh.noaa.gov

COMMUNICATION TESTS

Tsunami communications tests are made to verify designated communication pathways between the International TWC and the TWFP and the timeliness of message delivery over those pathways. The PTWC and WC/ATWC send communications tests at unannounced times. The NWPTAC provides a courtesy notification to TWFP prior to their 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 reports results of their Communications Tests to the ICG and to ITIC to help monitor the performance of the PTWS.

3.8 REFERENCES

Japan Meteorological Agency. (1965).*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.

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

Intergovernmental Oceanographic Commission. (2004) *ITSU Master* Plan. Paris, United Nations Educational, Scientific and Cultural Organization.(IOC/INF 1124 (rev 2004))

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. Paris, L'institut Geographique National.

Intergovernmental Oceanographic Commission website: http://www.ioc-tsunami.org/

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 centre 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 issue 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 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 Bering Sea, Sea of Okhotsk, Sea of Japan, East China Sea, Moluccas Sea, and Banda Sea although an informational bulletin with appropriate cautionary information 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 happen 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 epicentre, 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 monitor the incoming data 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 key 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.

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 shallow undersea 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 epicentre. 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 shallow undersea 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 appropriately expand the Warning and Watch areas based on the time criteria above. 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 a 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 Table 4.1.

Earthquake Moment Magnitude	Earthquake Depth	Epicentre 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

Table 4.1 PTWC criteria for the issuance of different types of products

Whenever any kind of Warning is issued, as well as for any near-warning-level events, PTWC continuously monitors water level data from the sea level stations located nearest the epicentre 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 5 to 15 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 or other criteria 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 determined from the recorded seismic signals. 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 earthquake parameters including earthquake magnitude; and 4) there are many more earthquakes with magnitudes near the conservative threshold than ones far above where a destructive tsunami is more certain.

4.4.2 Initial Estimated Time of Arrival (ETA)

PTWC's initial estimated times of arrival are typically computed from the epicentre 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 epicentre. For great earthquakes, the ones most likely to produce a tsunami, the earthquake rupture will start at the epicentre but it can extend for tens or even hundreds of kilometres away from the epicentre. As a consequence, the tsunami source may not be like a point and it may not be located at the epicentre. The second limitation is that the fastest path from the epicentre to the forecast point may not a path over which much energy has travelled. 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 in a research 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 currently 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 kilometres of the source of a potentially destructive tsunami (under a Regional Fixed Tsunami Warning); 2) the area is within 3 hours of a potentially destructive tsunami ETA for a warning or within 3 to 6 hours of ETA for a watch (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, improved numerical forecast models for the deep ocean, and with a capability to provide a comprehensive coastal forecast, then warnings can be based on expected tsunami amplitudes instead of expected arrival times or distances from the epicentre. 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 type of bulletin is issued 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 epicentre. A Regional Fixed Tsunami Warning will be followed by additional bulletins at least once an hour until the warning is either upgraded or cancelled. 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 epicentre 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 cancelled 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 at fixed or unannounced times to verify designated communication pathways to the TWFPs, to determine delay times for those pathways, and to verify rapid recognition of the message by the TWFP. For communication tests to be effective, it is important that TWFPs respond as quickly as possible with information about when the message was received over each designated communications method (GTS, AFTN, EMWIN, fax, email, etc.). It is also important that TWFP reviews their own contact information, updates it as necessary by procedures outlined in Section 2 above, and ensures that test messages are received at the TWFP by each of the designated methods. Communication tests will take place at fixed times once a month on the same day and at the same time. PTWC will also conduct twice yearly unannounced communication tests. WC/ATWC may also issue communication tests to exercise their backup role. Results of communication tests will be provided to the ICG and to ITIC for 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 cancelled. 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 cancelled 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 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 epicentre (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. Supplemental tsunami information may be issued if, for example, a sea level reading showing a tsunami signal is received.

4.6.4 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 two 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 harbours, wave resonance along continental shelves, and strong currents in channels and harbours 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 a 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 Centre. 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 CENTRE/NOAA/NWS
ISSUED AT 2232Z 24 JUN 2007
```

4.8.2 Coverage Area (CA)

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 centimetres 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 Centres.

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 EPICENTRE. 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 Time of Arrival (ETA)

If a tsunami has been generated the time of tsunami arrival (also called arrival time) at some fixed location, as estimated from modelling the speed and refraction of the tsunami waves, as they travel from the source, is provided.

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 Centres' 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 Centres' 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 CENTRE 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**	**ETA**	**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

Table 4.2 PTWC bulletin elements

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 Table 4.3. For a Fixed Regional Tsunami Warning, if any forecast point of a country is within 1000 km of the earthquake epicentre, 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 3 hours to its estimated tsunami arrival time, then that country is named in the warning, and if 3 to 6 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.

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
AMERICAN SAMOA	PAGO PAGO	-14.300	-170.700
ANTARCTICA	THURSTON ISLAND	-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
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 ISLAND	-10.800	-165.860
	PENRYN ISLAND	-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 ISLAND	-27.150	-109.450
	CALDERA	-27.100	-70.800
	ANTOFAGASTA	-23.320	-70.430
	IQUIQUE	-20.200	-70.100
	ARICA	-18.500	-70.300

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
CHINA	HONG KONG	22.300	114.200
	HONG KONG	22.300	114.200
CHUUK	CHUUK ISLAND	7.445	151.845
ECUADOR	LA LIBERTAD	-2.190	-81.230
	BALTRA ISLAND	-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 ISLAND	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
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 ISLAND	-0.370	-160.050
JOHNSTON IS.	JOHNSTON ISLAND	16.738	-169.525
KERMADEC IS	RAOUL ISLAND	-29.210	-177.940
KIRIBATI	FLINT ISLAND	-11.400	-151.820
	MALDEN ISLAND	-3.940	-154.900
	KANTON ISLAND	-2.820	-171.670
	TARAWA ISLAND	1.500	173.000
	CHRISTMAS ISLAND	1.980	-157.480
KOSRAE	KOSRAE ISLAND	5.500	163.000
MALAYSIA	BINTULU	3.200	113.000
	K TERENGGANU	5.300	103.200
	SANDAKAN	5.900	118.100
MARCUS IS.	MARCUS ISLAND	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

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
	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 ISLAND	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 DEL SUR	11.200	-85.900
	PUERTO SANDINO	12.200	-86.800
	CORINTO	12.500	-87.200
NIUE	NIUE IS.	-19.000	-170.000
PALMYRA IS.	PALMYRA ISLAND	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 ISLAND	-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

COUNTRY OR OTHER ENTITY	NAME OF FORECAST POINT	LATITUDE (+N,-S)	LONGITUDE (+E,-W)
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 ISLAND	-25.080	-130.080
POHNPEI	POHNPEI ISLAND	7.000	158.218
RUSSIA	URUP ISLAND	46.120	150.540
	SEVERO KURILSK	50.830	156.070
	PETROPAVLOVSK K	53.230	159.580
	MEDNNY ISLAND	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
TOKELAU	NUKUNONU ISLAND	-9.160	-171.830
TONGA	NUKUALOFA	-21.020	-175.230
TUVALU	FUNAFUTI ISLAND	-7.880	178.500
VANUATU	ANATOM ISLAND	-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 ISLAND	19.300	166.600
WALLIS-FUTUNA	WALLIS ISLAND	-13.250	-176.250
YAP	YAP ISLAND	9.500	138.100

Table 4.3 PTWC Tsunami Forecast Points

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

Table 4.4 PTWC communication services

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 centres. 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.

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]

Table 4.5 WMO product identifier

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 Table 4.5. 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.

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 E-MAIL

PTWC sends its messages by e-mail 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 Table 4.5. 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 defence, 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 Centre 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 Defence, National Guard, Law Enforcement and NWS Offices. The circuit is supported by FEMA and Hawaii State Civil Defence. 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 CENTRE/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 EPICENTRE. AUTHORITIES IN THE REGION OF THE EPICENTRE 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 CENTRE 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 CENTRE/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 EPICENTRE. 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 CENTRE 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 CENTRE/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 EPICENTRE WITHIN MINUTES TO HOURS. AUTHORITIES IN THE REGION SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTRE 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 CENTRE 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 CENTRE/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 EPICENTRE. AUTHORITIES IN THE REGION SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTRE 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 CENTRE 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 CENTRE/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 CENTRE 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 EPICENTRE. 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 CENTRE.

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

THE WEST COAST/ALASKA TSUNAMI WARNING CENTRE WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
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4.11.6 Regional Expanding Tsunami Warning – Initial (WEPA40 PHEB)

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TSUNAMI BULLETIN NUMBER 001
PACIFIC TSUNAMI WARNING CENTRE/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 EPICENTRE WITHIN MINUTES AND MORE DISTANT COASTLINES WITHIN HOURS. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTRE 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

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                  ACAPULCO           16.8N 100.0W    0736Z 31 AUG
                  MANZANILLO         19.0N 104.5W    0823Z 31 AUG
                  SOCORRO            18.8N 111.0W    0915Z 31 AUG
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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 CENTRE WILL ISSUE PRODUCTS FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.

4.11.7 Regional Expanding Tsunami Warning – Supplement (WEPA40 PHEB)

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TSUNAMI BULLETIN NUMBER 003
PACIFIC TSUNAMI WARNING CENTRE/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
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 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).
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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 EPICENTRE AND COULD ALSO BE A THREAT TO MORE DISTANT COASTS. AUTHORITIES SHOULD TAKE APPROPRIATE ACTION IN RESPONSE TO THIS POSSIBILITY. THIS CENTRE 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 CENTRE 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 CENTRE/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 CENTRE 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

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 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.
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EVALUATION

SEA LEVEL READINGS INDICATE A TSUNAMI WAS GENERATED. IT MAY HAVE BEEN DESTRUCTIVE ALONG COASTS NEAR THE EARTHQUAKE EPICENTRE. 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 CENTRE...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 CENTRE 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 CENTRE/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 CENTRE 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 CENTRE 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 CENTRE/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 CENTRE 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 CENTRE 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 CENTRE/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 CENTRE 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 CENTRE...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 CENTRE WILL ISSUE PRODUCTS
FOR ALASKA...BRITISH COLUMBIA...WASHINGTON...OREGON...CALIFORNIA.
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4.11.12 Communication Test (WEPA40 PHEB)

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

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

FROM - NOAA/NWS PACIFIC TSUNAMI WARNING CENTRE
       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 CENTRE
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 CENTRE 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.
```

5. WEST COAST/ALASKA TSUNAMI WARNING CENTRE (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, the U.S. Virgin Islands, and the British Virgin Islands. WC/ATWC collaborates with the Pacific Tsunami Warning Centre (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

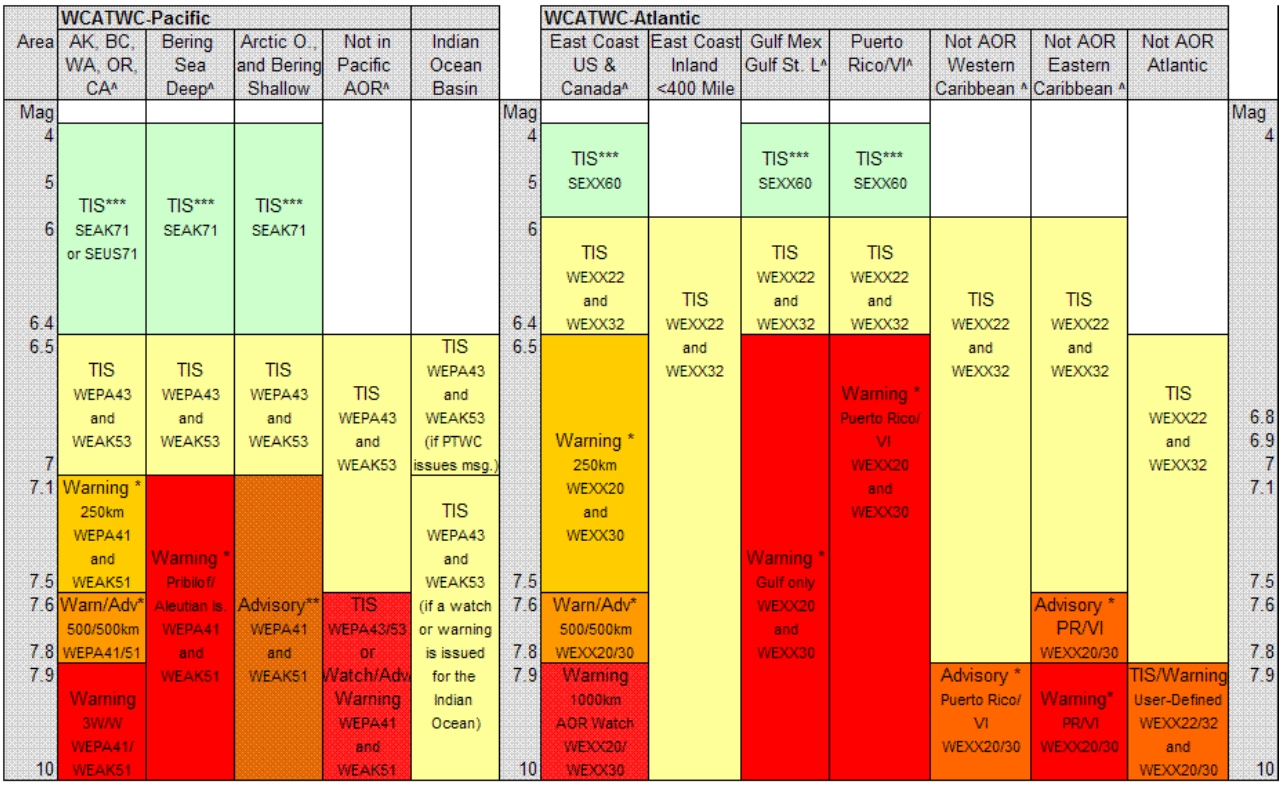
To accomplish its mission of providing accurate and timely tsunami bulletins to its AOR, WC/ATWC detects, locates, sizes, and analyzes earthquakes throughout the world. The Center is staffed on a 24x7 basis with at least two scientists. Earthquakes that activate the centre's alarm system initiate an 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 tsunami forecast models; and disseminating information to the appropriate emergency management officials. Initial messages are based on seismic analysis, while supplemental messages are based on further evaluation of the seismic data as well as sea level observations, forecast models, and historic tsunami information.

5.4 WARNING CRITERIA

WC/ATWC warning, advisory, and watch criteria are organized by the source's geographic region and magnitude. The basic criteria used by the Center 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, advisory, or watch bulletins are issued every 30 to 60 minutes.

Note that at WC/ATWC, a pre-defined threat database is checked for warning/watch/advisory regions. If the source region, magnitude, and depth are defined in the database, the warning, watch, and advisory region are taken from the database. (For example, if a shallow, magnitude 7.3 earthquake occurs within the Puget Sound of Washington, only the Puget Sound NWS public zones are placed in a tsunami warning.)

In situations where the earthquake epicentre is onshore and a tsunami warning, watch, or advisory is required, WCATWC may elect to issue a Tsunami Information Statement if the onshore distance is too great for the earthquake to generate a tsunami.



*** 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

3W/W => warning for area impacted within 3 hours and watch for rest of AOR

TIS = Tsunami Information Statement

WMO product IDs listed under message type

** For Arctic; Advisory if south of 75N and west of 138W; else TIS

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 were revised in 2011.

5.5.1 Information Statement

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

5.5.2 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 advisory – or cancelled – 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.

5.5.3 Tsunami Advisory

A tsunami advisory is issued when a tsunami with the potential to generate strong currents or waves dangerous to those in or very near the water is imminent, expected, or occurring. The threat may continue for several hours after initial arrival, but significant inundation is not expected for areas under an advisory. Appropriate actions to be taken by local officials may include closing beaches, evacuating harbours 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.

5.5.4 Tsunami Warning

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

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. Table 5.1 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, advisory, and warning sections separated by Universal Generic Codes (for watch, advisory, and warning messages). The 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. WC/ATWC creates and issues web-based products to its website and through RSS feeds. The web-based products are written in an html format with embedded links to related information and graphics, 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

Table 5.1 NWS products described by WMO Header and NWS AWIPS ID

5.6.2 WC/ATWC Product Dissemination

Message dissemination routes used by the WC/ATWC are summarized in Figure 5.2 and described in greater detail in Section 3.7. Primary routes are the National Warning System (NAWAS), the NOAA Weather Wire (NWWS), NWS private circuits to the NWS Telecommunications Gateway and AWIPS system, and the Federal Aviation Administration's (FAA) NADIN2 communication system. The NWS Telecommunications Gateway is the conduit to WMO's Global Telecommunications System and many other communication routes. Secondary routes are the Centre's website, e-mail, RSS feeds, cell phone text messaging, USGS dissemination systems, and telephone calls. The WC/ATWC also utilizes the Federal Emergency Management Agency's National Warning System (NAWAS) to alert primary customers.

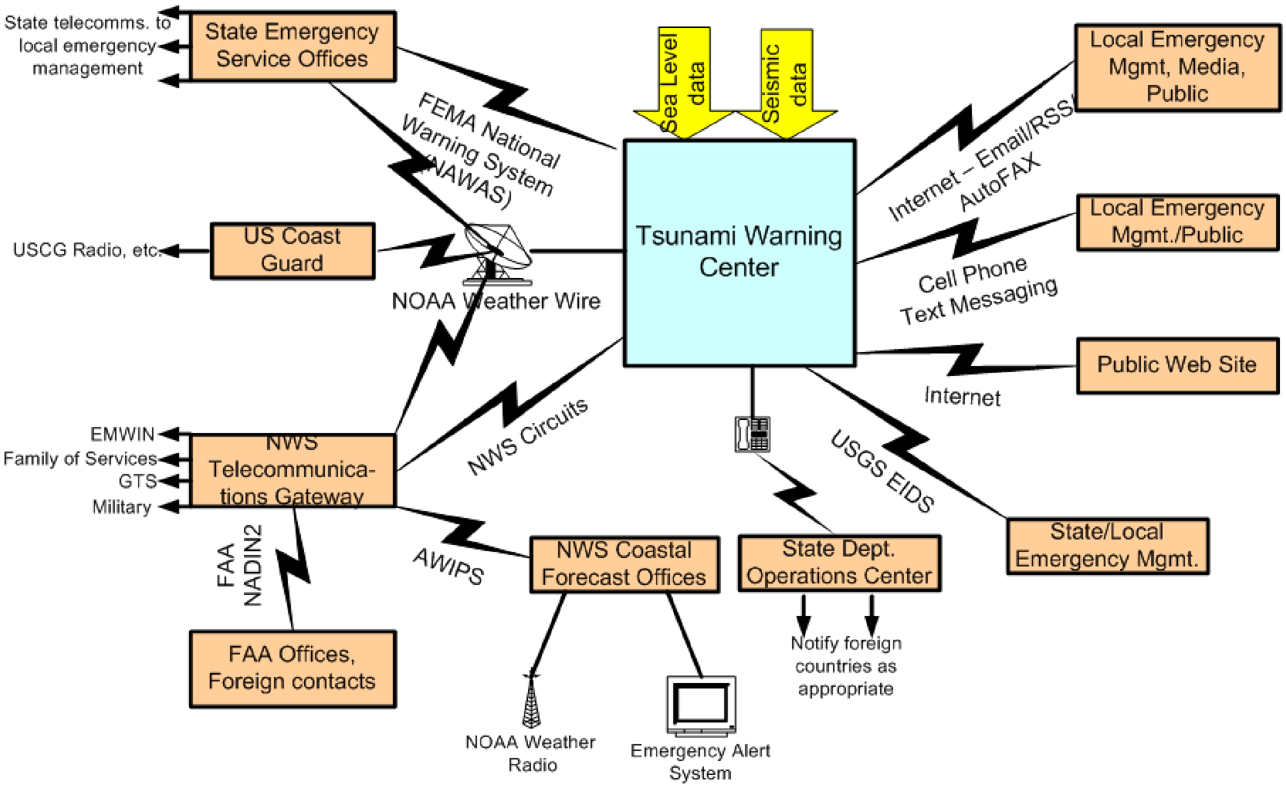


Figure 5.2 WC/ATWC message dissemination

5.7 WC/ATWC TEXT PRODUCT FORMAT AND CONTENT

WC/ATWC text products are composed of the following key elements.

5.7.1 Product Header

Product header contains both a WMO code and an AWIPS identifier.

Examples:

```
WEPA41 PAAQ 272039
TSUWCA
```

5.7.2 Mass News Disseminator (MND) Header

The standard NWS MND header is used for WC/ATWC products.

Examples:

```
BULLETIN
TSUNAMI MESSAGE NUMBER 1
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
139 PM PDT TUE JUL 27 2010
```

5.7.3 Changes since last message (if a supplemental message)

Short description of changes in message since the last message.

Examples:

```
UPDATES IN THIS MESSAGE INCLUDE A REVISED MAGNITUDE.
```

5.7.4 Headline(s)

Lists areas under tsunami warning, advisory, watch, of information only.

Examples:

```
...A TSUNAMI WARNING IS NOW IN EFFECT WHICH INCLUDES THE
   COASTAL AREAS OF CALIFORNIA AND OREGON FROM RAGGED POINT
   CALIFORNIA/45 MILES NW OF SAN LUIS OBISPO/ TO CASCADE HEAD
   OREGON/70 MILES SW OF PORTLAND/...
```

```
...A TSUNAMI ADVISORY IS NOW IN EFFECT WHICH INCLUDES THE
   COASTAL AREAS OF CALIFORNIA FROM THE CALIFORNIA-MEXICO
   BORDER TO RAGGED POINT CALIFORNIA/45 MILES NW OF SAN LUIS
   OBISPO/...
```

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

5.7.5 Recommended Actions or Evaluation

This section deflines the likelihood of a tsunami and any recommended actions.

Examples:

```
RECOMMENDED ACTIONS
 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 ADVISORY COASTAL AREAS SHOULD MOVE OUT OF THE
   WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.
```

```
EVALUATION
 BASED ON MAGNITUDE... LOCATION 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.
```

5.7.6 Tsunami Warning, Advisory, and/or Watch definition

The appropriate definitions are required in warning, advisory, and watch products.

Examples:

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

5.7.7 Reference to PTWC Actions

A brief reference to PTWC actions and AOR.

Examples:

```
PACIFIC COASTAL REGIONS OUTSIDE CALIFORNIA/ OREGON/ WASHINGTON/
BRITISH COLUMBIA AND ALASKA SHOULD REFER TO THE PACIFIC TSUNAMI
WARNING CENTER MESSAGES FOR INFORMATION ON THIS EVENT AT
WWW.WEATHER.GOV/PTWC.
```

5.7.8 Supplemental message information

This section indicates when the next message will be issued and where to go for more information.

Examples:

```
THIS MESSAGE WILL BE UPDATED IN 30 MINUTES OR SOONER IF
THE SITUATION WARRANTS. THE TSUNAMI MESSAGE WILL REMAIN IN EFFECT
UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.
```

5.7.9 Tsunami Observations and Forecasts

Tsunami observations and forecast arrival times and amplitudes are listed in the main body of all products. Tsunami amplitude is defined as the elevation of the wave above ambient sea level. Listed observation/forecast points are grouped by countries, states, territories, or islands. The forecast amplitude provided is the maximum amplitude expected for the duration of the event. The forecast amplitude column can be removed when no forecasts are to be issued. The observed

amplitudes column can be removed when there are no observations to report. The estimated arrival times column can be removed when the tsunami has passed or in the cancellation product. Products may specify ranges for forecast amplitudes versus exact values and may provide a level of uncertainty.

Examples:

```
MEASUREMENTS AND/OR FORECASTS OF TSUNAMI ACTIVITY

ESTIMATED ARRIVAL TIMES OF THE INITIAL TSUNAMI WAVE AT LOCATIONS
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. FORECAST AMPLITUDES GIVEN BELOW
ARE PRELIMINARY ESTIMATES OF THE MAXIMUM FORECASTED FOR THIS TSUNAMI
AND ARE BASED ON NUMERICAL MODELS.

SITE               LAT   LON     ARRIVAL TIME     FCST AMP   OBS AMP
-------------------------------------------------------------------
CANADA
 HALIFAX-NS        44.7N  63.6W  2018EDT JUL 27  6.6F/2.0M  6.8F/2.1M
 LOCKEPORT-NS      43.7N  65.1W  2244ADT JUL 27             3.3F/1.0M
NEW YORK
 MONTAUK           41.1N  72.0W  2150EDT JUL 27  1.2F/0.4M
VIRGINIA
 VIRGINIA BCH      36.9N  76.0W  2150EDT JUL 27  1.5F/0.5M

 LAT – LATITUDE/ N-NORTH, S-SOUTH/
 LON – LONGITUDE/ E-EAST, W-WEST/
 ARRIVAL TIME – EXPECTED TIME OF INITIAL TSUNAMI ARRIVAL
 FCST AMP – FORECAST TSUNAMI ELEVATION ABOVE AMBIENT SEA LEVEL.
 OBS AMP  – OBSERVED TSUNAMI ELEVATION ABOVE AMBIENT SEA LEVEL.
            IT IS ...NOT... CREST-TO-TROUGH WAVE HEIGHT.
            VALUES ARE GIVEN IN BOTH METERS/M/ AND FEET/F/.
```

5.7.10 Earthquake Parameters

Preliminary earthquake parameters.

Examples:

```
 ORIGIN TIME - 1207 AKDT 27 JUL 2010
               1307  PDT 27 JUL 2010
               2007  UTC 27 JUL 2010
 COORDINATES - 40.0 NORTH 124.5 WEST
 DEPTH       - 9 MILES/15 KM
 LOCATION    - 55 MILES/89 KM SW OF EUREKA CALIFORNIA, or
               OFF THE COAST OF NORTHERN CALIFORNIA
 MAGNITUDE   - 7.7
```

5.7.11 Segmentation

WC/ATWC warning, advisory, and watch products are in the NWS segmented format.

Examples:

```
ORZ001-WAZ001-021-510-514>517-503-272139-
/T.NEW.PAAQ.TS.Y.0013.100727T2039Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING CASCADE HEAD OREGON/70
```

```
MILES SW OF PORTLAND/ TO THE NORTH TIP OF VANCOUVER ISLAND
BRITISH COLUMBIA
139 PM PDT TUE JUL 27 2010

...A TEST TSUNAMI ADVISORY IS NOW IN EFFECT WHICH INCLUDES THE
   COASTAL AREAS OF OREGON - WASHINGTON AND BRITISH COLUMBIA
   FROM CASCADE HEAD OREGON/70 MILES SW OF PORTLAND/ TO THE
   NORTH TIP OF VANCOUVER ISLAND BRITISH COLUMBIA...

PERSONS IN TSUNAMI ADVISORY AREAS SHOULD MOVE OUT OF THE
WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.

TSUNAMI ADVISORIES MEAN THAT A TSUNAMI CAPABLE OF PRODUCING
STRONG CURRENTS OR WAVES DANGEROUS TO PERSONS IN OR VERY NEAR
WATER IS IMMINENT... EXPECTED OR OCCURING. SIGNIFICANT WIDESPREAD
INUNDATION IS NOT EXPECTED FOR AREAS IN AN ADVISORY. 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 ADVISORY ARE PROVIDED BELOW.

THIS MESSAGE WILL BE UPDATED IN 30 MINUTES OR SOONER IF
THE SITUATION WARRANTS. THE TSUNAMI MESSAGE WILL REMAIN IN EFFECT
UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.

$$
```

5.8 EXAMPLE MESSAGES

Representative example products are shown below.

5.8.1 WC/ATWC Tsunami Warning/Watch/Advisory (WEPA41)

```
WEPA41 PAAQ 272039
TSUWCA

BULLETIN
TSUNAMI MESSAGE NUMBER 1
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
139 PM PDT TUE JUL 27 2010

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

...A TEST TSUNAMI WARNING IS NOW IN EFFECT WHICH INCLUDES THE
   COASTAL AREAS OF CALIFORNIA AND OREGON FROM RAGGED POINT
   CALIFORNIA/45 MILES NW OF SAN LUIS OBISPO/ TO CASCADE HEAD
   OREGON/70 MILES SW OF PORTLAND/...

...A TEST TSUNAMI ADVISORY IS NOW IN EFFECT WHICH INCLUDES THE
   COASTAL AREAS OF CALIFORNIA FROM THE CALIFORNIA-MEXICO
   BORDER TO RAGGED POINT CALIFORNIA/45 MILES NW OF SAN LUIS
   OBISPO/...

...A TEST TSUNAMI ADVISORY IS NOW IN EFFECT WHICH INCLUDES THE
   COASTAL AREAS OF OREGON - WASHINGTON AND BRITISH COLUMBIA
   FROM CASCADE HEAD OREGON/70 MILES SW OF PORTLAND/ TO THE
   NORTH TIP OF VANCOUVER ISLAND BRITISH COLUMBIA...

...THIS MESSAGE IS INFORMATION ONLY FOR COASTAL AREAS OF
```

BRITISH COLUMBIA AND ALASKA FROM THE NORTH TIP OF VANCOUVER ISLAND BRITISH COLUMBIA TO ATTU ALASKA...

RECOMMENDED ACTIONS

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 ADVISORY AREAS SHOULD MOVE OUT OF THE WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.

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

PACIFIC COASTAL REGIONS OUTSIDE CALIFORNIA/ OREGON/ WASHINGTON/ BRITISH COLUMBIA AND ALASKA SHOULD REFER TO THE PACIFIC TSUNAMI WARNING CENTER MESSAGES FOR INFORMATION ON THIS EVENT AT WWW.WEATHER.GOV/PTWC.

THIS MESSAGE WILL BE UPDATED IN 30 MINUTES OR SOONER IF THE SITUATION WARRANTS. THE TSUNAMI MESSAGE WILL REMAIN IN EFFECT UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.

&&

MEASUREMENTS AND/OR FORECASTS OF TSUNAMI ACTIVITY

SITE	LAT	LON	ARRIVAL TIME	FCST AMP	OBS AMP
CALIFORNIA					
CRESCENT CITY	41.7N	124.2W	1307PDT JUL 27		
SAN FRANCISCO	37.8N	122.5W	1345PDT JUL 27		
SANTA BARBARA	34.4N	119.7W	1443PDT JUL 27		
SAN PEDRO	33.7N	118.3W	1459PDT JUL 27		
LA JOLLA	32.9N	117.3W	1513PDT JUL 27		
OREGON					
CHARLESTON	43.3N	124.3W	1333EDT JUL 27		
SEASIDE	46.0N	123.9W	1449PDT JUL 27		
WASHINGTON					
WESTPORT	46.9N	124.1W	1500PDT JUL 27		
NEAH BAY	48.4N	124.6W	1510PDT JUL 27		
BRITISH COLUMBIA					
TOFINO	49.2N	125.9W	1520PDT JUL 27		

LAT – LATITUDE/ N-NORTH, S-SOUTH/
LON – LONGITUDE/ E-EAST, W-WEST/
ARRIVAL TIME – EXPECTED TIME OF INITIAL TSUNAMI ARRIVAL

```
 FCST AMP – FORECAST TSUNAMI ELEVATION ABOVE AMBIENT SEA LEVEL.
 OBS AMP - OBSERVED TSUNAMI ELEVATION ABOVE AMBIENT SEA LEVEL.
           IT IS ...NOT... CREST-TO-TROUGH WAVE HEIGHT.
           VALUES ARE GIVEN IN BOTH METERS/M/ AND FEET/F/.

&&

PRELIMINARY EARTHQUAKE PARAMETERS

 ORIGIN TIME - 1207 AKDT 27 JUL 2010
               1307  PDT 27 JUL 2010
               2007  UTC 27 JUL 2010
 COORDINATES - 40.0 NORTH 124.5 WEST
 DEPTH       - 9 MILES/15 KM
 LOCATION    - 55 MILES/89 KM SW OF EUREKA CALIFORNIA
               190 MILES/306 KM NW OF SAN FRANCISCO CALIFORNIA
 MAGNITUDE   - 7.7

PZZ530-CAZ529-530-006-505>509-002-001-ORZ021-022-002-272139-
/T.NEW.PAAQ.TS.W.0013.100727T2039Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING RAGGED POINT
CALIFORNIA/45 MILES NW OF SAN LUIS OBISPO/ TO CASCADE HEAD
OREGON/70 MILES SW OF PORTLAND/
139 PM PDT TUE JUL 27 2010

...A TEST TSUNAMI WARNING IS NOW IN EFFECT WHICH INCLUDES THE
   COASTAL AREAS OF CALIFORNIA AND OREGON FROM RAGGED POINT
   CALIFORNIA/45 MILES NW OF SAN LUIS OBISPO/ TO CASCADE HEAD
   OREGON/70 MILES SW OF PORTLAND/...

PERSONS IN TSUNAMI WARNING COASTAL AREAS SHOULD MOVE INLAND TO
HIGHER GROUND.

TSUNAMI WARNINGS MEAN THAT A TSUNAMI WITH SIGNIFICANT WIDESPREAD
INUNDATION IS IMMINENT... EXPECTED OR OCCURING.  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.

THIS MESSAGE WILL BE UPDATED IN 30 MINUTES OR SOONER IF
THE SITUATION WARRANTS. THE TSUNAMI MESSAGE WILL REMAIN IN EFFECT
UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.

$$

CAZ042-043-040-041-087-039-034-035-272139-
/T.NEW.PAAQ.TS.Y.0013.100727T2039Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING THE CALIFORNIA-MEXICO
BORDER TO RAGGED POINT CALIFORNIA/45 MILES NW OF SAN LUIS
OBISPO/
139 PM PDT TUE JUL 27 2010

...A TEST TSUNAMI ADVISORY IS NOW IN EFFECT WHICH INCLUDES THE
   COASTAL AREAS OF CALIFORNIA FROM THE CALIFORNIA-MEXICO
   BORDER TO RAGGED POINT CALIFORNIA/45 MILES NW OF SAN LUIS
   OBISPO/...

PERSONS IN TSUNAMI ADVISORY AREAS SHOULD MOVE OUT OF THE
WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.
```

TSUNAMI ADVISORIES MEAN THAT A TSUNAMI CAPABLE OF PRODUCING
STRONG CURRENTS OR WAVES DANGEROUS TO PERSONS IN OR VERY NEAR
WATER IS IMMINENT... EXPECTED OR OCCURING. SIGNIFICANT WIDESPREAD INUNDATION
IS NOT EXPECTED FOR AREAS IN AN ADVISORY. 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 ADVISORY ARE PROVIDED BELOW.

THIS MESSAGE WILL BE UPDATED IN 30 MINUTES OR SOONER IF
THE SITUATION WARRANTS. THE TSUNAMI MESSAGE WILL REMAIN IN EFFECT
UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.

$$

ORZ001-WAZ001-021-510-514>517-503-272139-
/T.NEW.PAAQ.TS.Y.0013.100727T2039Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING CASCADE HEAD OREGON/70
MILES SW OF PORTLAND/ TO THE NORTH TIP OF VANCOUVER ISLAND
BRITISH COLUMBIA
139 PM PDT TUE JUL 27 2010

...A TEST TSUNAMI ADVISORY IS NOW IN EFFECT WHICH INCLUDES THE
COASTAL AREAS OF OREGON - WASHINGTON AND BRITISH COLUMBIA
FROM CASCADE HEAD OREGON/70 MILES SW OF PORTLAND/ TO THE
NORTH TIP OF VANCOUVER ISLAND BRITISH COLUMBIA...

PERSONS IN TSUNAMI ADVISORY AREAS SHOULD MOVE OUT OF THE
WATER... OFF THE BEACH AND OUT OF HARBORS AND MARINAS.

TSUNAMI ADVISORIES MEAN THAT A TSUNAMI CAPABLE OF PRODUCING
STRONG CURRENTS OR WAVES DANGEROUS TO PERSONS IN OR VERY NEAR
WATER IS IMMINENT... EXPECTED OR OCCURING. SIGNIFICANT WIDESPREAD
INUNDATION IS NOT EXPECTED FOR AREAS IN AN ADVISORY. 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 ADVISORY ARE PROVIDED BELOW.

THIS MESSAGE WILL BE UPDATED IN 30 MINUTES OR SOONER IF
THE SITUATION WARRANTS. THE TSUNAMI MESSAGE WILL REMAIN IN EFFECT
UNTIL FURTHER NOTICE. REFER TO THE INTERNET SITE
WCATWC.ARH.NOAA.GOV FOR MORE INFORMATION.

$$

5.8.2 WC/ATWC Cancellation (WEPA41)

WEPA41 PAAQ 272053
TSUWCA

BULLETIN
TSUNAMI MESSAGE NUMBER 2
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
153 PM PDT TUE JUL 27 2010

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

...THE TEST TSUNAMI ADVISORY IS CANCELED FOR THE COASTAL AREAS
OF CALIFORNIA FROM THE CALIFORNIA-MEXICO BORDER TO RAGGED
POINT CALIFORNIA/45 MILES NW OF SAN LUIS OBISPO/...

...THE TEST TSUNAMI WARNING IS CANCELED FOR THE COASTAL AREAS OF
CALIFORNIA AND OREGON FROM RAGGED POINT CALIFORNIA/45 MILES
NW OF SAN LUIS OBISPO/ TO CASCADE HEAD OREGON/70 MILES SW
OF PORTLAND/...

...THE TEST TSUNAMI ADVISORY IS CANCELED FOR THE COASTAL AREAS
OF OREGON - WASHINGTON AND BRITISH COLUMBIA FROM CASCADE
HEAD OREGON/70 MILES SW OF PORTLAND/ TO THE NORTH TIP OF
VANCOUVER ISLAND BRITISH COLUMBIA...

EVALUATION
NO DESTRUCTIVE TSUNAMI HAS BEEN RECORDED. NO TSUNAMI DANGER
EXISTS FOR ALASKA/ BRITISH COLUMBIA/ WASHINGTON/ OREGON OR
CALIFORNIA. LOCAL AUTHORITIES CAN ASSUME ALL CLEAR UPON
RECEIPT OF THIS MESSAGE.

PACIFIC COASTAL REGIONS OUTSIDE CALIFORNIA/ OREGON/ WASHINGTON/
BRITISH COLUMBIA AND ALASKA SHOULD REFER TO THE PACIFIC TSUNAMI
WARNING CENTER MESSAGES FOR INFORMATION ON THIS EVENT AT
WWW.WEATHER.GOV/PTWC.

THIS WILL BE THE LAST WEST COAST/ALASKA TSUNAMI WARNING CENTER
MESSAGE ISSUED FOR THIS EVENT. THIS INFORMATION IS ALSO POSTED
AT WCATWC.ARH.NOAA.GOV.

PRELIMINARY EARTHQUAKE PARAMETERS

```
 ORIGIN TIME - 1200 AKDT 27 JUL 2010
               1300  PDT 27 JUL 2010
               2000  UTC 27 JUL 2010
 COORDINATES - 40.0 NORTH 124.5 WEST
 DEPTH       - 9 MILES/15 KM
 LOCATION    - 55 MILES/89 KM SW OF EUREKA CALIFORNIA
               190 MILES/306 KM NW OF SAN FRANCISCO CALIFORNIA
 MAGNITUDE   - 7.7
```

CAZ042-043-040-041-087-039-034-035-272253-
/T.CAN.PAAQ.TS.Y.0013.000000T0000Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING THE CALIFORNIA-MEXICO
BORDER TO RAGGED POINT CALIFORNIA/45 MILES NW OF SAN LUIS
OBISPO/
153 PM PDT TUE JUL 27 2010
...THE TEST TSUNAMI ADVISORY IS CANCELED FOR THE COASTAL AREAS
OF CALIFORNIA FROM THE CALIFORNIA-MEXICO BORDER TO RAGGED
POINT CALIFORNIA/45 MILES NW OF SAN LUIS OBISPO/...

THIS WILL BE THE LAST WEST COAST/ALASKA TSUNAMI WARNING CENTER
MESSAGE ISSUED FOR THIS EVENT. THIS INFORMATION IS ALSO POSTED
AT WCATWC.ARH.NOAA.GOV.

$$

PZZ530-CAZ529-530-006-505>509-002-001-ORZ021-022-002-272253-
/T.CAN.PAAQ.TS.W.0013.000000T0000Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING RAGGED POINT
CALIFORNIA/45 MILES NW OF SAN LUIS OBISPO/ TO CASCADE HEAD
OREGON/70 MILES SW OF PORTLAND/
153 PM PDT TUE JUL 27 2010

...THE TEST TSUNAMI WARNING IS CANCELED FOR THE COASTAL AREAS OF

```
   CALIFORNIA AND OREGON FROM RAGGED POINT CALIFORNIA/45 MILES
   NW OF SAN LUIS OBISPO/ TO CASCADE HEAD OREGON/70 MILES SW
   OF PORTLAND/...

THIS WILL BE THE LAST WEST COAST/ALASKA TSUNAMI WARNING CENTER
MESSAGE ISSUED FOR THIS EVENT.  THIS INFORMATION IS ALSO POSTED
AT WCATWC.ARH.NOAA.GOV.

$$

ORZ001-WAZ001-021-510-514>517-503-272253-
/T.CAN.PAAQ.TS.Y.0013.000000T0000Z-000000T0000Z/
COASTAL AREAS BETWEEN AND INCLUDING CASCADE HEAD OREGON/70
MILES SW OF PORTLAND/ TO THE NORTH TIP OF VANCOUVER ISLAND
BRITISH COLUMBIA
153 PM PDT TUE JUL 27 2010

...THE TEST TSUNAMI ADVISORY IS CANCELED FOR THE COASTAL AREAS
   OF OREGON - WASHINGTON AND BRITISH COLUMBIA FROM CASCADE
   HEAD OREGON/70 MILES SW OF PORTLAND/ TO THE NORTH TIP OF
   VANCOUVER ISLAND BRITISH COLUMBIA...

THIS WILL BE THE LAST WEST COAST/ALASKA TSUNAMI WARNING CENTER
MESSAGE ISSUED FOR THIS EVENT.  THIS INFORMATION IS ALSO POSTED
AT WCATWC.ARH.NOAA.GOV.

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

$$
```

5.8.3 WC/ATWC Tsunami Information Statement (WEPA43)

```
WEPA43 PAAQ 272103
TIBWCA

TSUNAMI INFORMATION STATEMENT NUMBER 1
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
103 PM AKDT TUE JUL 27 2010

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

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

NO WARNING... NO WATCH AND NO ADVISORY IS IN EFFECT FOR
THE STATES AND PROVINCES PREVIOUSLY LISTED.

EVALUATION
 BASED ON MAGNITUDE... LOCATION 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.

PACIFIC COASTAL REGIONS OUTSIDE CALIFORNIA/ OREGON/ WASHINGTON/
BRITISH COLUMBIA AND ALASKA SHOULD REFER TO THE PACIFIC TSUNAMI
WARNING CENTER MESSAGES FOR INFORMATION ON THIS EVENT AT
WWW.WEATHER.GOV/PTWC.
```

```
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.

&&

PRELIMINARY EARTHQUAKE PARAMETERS

 ORIGIN TIME - 1300 AKDT 27 JUL 2010
               1400  PDT 27 JUL 2010
               2100  UTC 27 JUL 2010
 COORDINATES – 54.3 NORTH 160.8 WEST
 DEPTH       - 21 MILES/33 KM
 LOCATION    - 70 MILES/113 KM S OF SAND POINT ALASKA
               625 MILES/1006 KM SW OF ANCHORAGE ALASKA
 MAGNITUDE   - 6.8

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

5.8.4 Alaska Information Statement (SEAK71)

```
SEAK71 PAAQ 272107
EQIAKX

TSUNAMI SEISMIC INFORMATION STATEMENT
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
107 PM AKDT TUE JUL 27 2010

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

...THIS IS AN INFORMATION STATEMENT...

EVALUATION
 AT 105 PM ALASKAN DAYLIGHT TIME ON JULY 27 AN EARTHQUAKE WITH
 PRELIMINARY MAGNITUDE 6.0 OCCURRED 50 MILES/80 KM WEST OF
 CAPE YAKATAGA ALASKA.  NO TSUNAMI IS EXPECTED.

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 WILL BE THE ONLY WCATWC MESSAGE ISSUED FOR THIS EVENT.

&&

PRELIMINARY EARTHQUAKE PARAMETERS

 ORIGIN TIME - 1305 AKDT 27 JUL 2010
               1405  PDT 27 JUL 2010
               2105  UTC 27 JUL 2010
 COORDINATES – 60.1 NORTH 143.8 WEST
 DEPTH       - 21 MILES/33 KM
 LOCATION    - 50 MILES/80 KM W OF CAPE YAKATAGA ALASKA
               220 MILES/354 KM SE OF ANCHORAGE ALASKA
 MAGNITUDE   - 6.0
```

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

$$
```

5.8.5 BC/U.S. West Coast Information Statement (SEUS71)

```
SEUS71 PAAQ 272109
EQIWOC

TSUNAMI SEISMIC INFORMATION STATEMENT
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTER PALMER AK
209 PM PDT TUE JUL 27 2010

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

...THIS IS AN INFORMATION STATEMENT...

EVALUATION
 AT 107 PM ALASKAN DAYLIGHT TIME ON JULY 27 AN EARTHQUAKE WITH
 PRELIMINARY MAGNITUDE 5.9 OCCURRED 45 MILES/72 KM SOUTHWEST OF
 MONTEREY CALIFORNIA.  NO TSUNAMI IS EXPECTED.

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 WILL BE THE ONLY WCATWC MESSAGE ISSUED FOR THIS EVENT.

&&

PRELIMINARY EARTHQUAKE PARAMETERS

 ORIGIN TIME - 1307 AKDT 27 JUL 2010
               1407  PDT 27 JUL 2010
               2107  UTC 27 JUL 2010
 COORDINATES – 36.0 NORTH 122.2 WEST
 DEPTH       - 21 MILES/33 KM
 LOCATION    - 45 MILES/72 KM SW OF MONTEREY CALIFORNIA
               125 MILES/201 KM S OF SAN FRANCISCO CALIFORNIA
 MAGNITUDE   - 5.9

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

5.8.6 Communications Test (WEPA41)

```
WEPA41 PAAQ 021600
TSUWCA

TEST...TSUNAMI MESSAGE NUMBER 1...TEST
NWS WEST COAST/ALASKA TSUNAMI WARNING CENTRE PALMER AK
900 AM PDT MON AUG 2 2010

...THIS_MESSAGE_IS_FOR_TEST_PURPOSES_ONLY...

...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 - BETHEL - NOME -
   KOTZEBUE - BARROW AND ST. PAUL AND USAF
   11TH RESCUE COORDINATION CENTRE AT ELMENDORF AFB.

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 CENTRES 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. USE LOWER CASE FOR WEB SITE.

WEB - HTTP://WCATWC.ARH.NOAA.GOV/COMMTEST/INDEX.HTML
EMAIL ADDRESS   - WCATWC-AT SIGN-NOAA.GOV
AFTN ADDRESS   - PAAQYQYX
FAX   - 907-745-6071

PKZ310-041-031>036-042-043-011>013-021-022-051-052-053-125>129-
121-120-130-140-141-136>138-132-150-155-170>172-175-176-PZZ750-
655-650-673-670-565-535-530-545-560-455-540-450-356-310-350-255-
250-210-110-156-153-150-130>135-AKZ017>029-135-131-125-121-145-
171-181-185-187-191-WAZ503-506>511-001-514>517-021-ORZ001-002-
021-022-CAZ039>043-087-034-035-530-006-506-508-509-529-505-002-
001-021700-
/T.NEW.PAAQ.TS.W.0014.100802T1600Z-100802T1700Z/
ALASKA/ BRITISH COLUMBIA/ WASHINGTON/ OREGON/ AND CALIFORNIA
COASTAL AREAS
900 AM PDT MON AUG 2 2010

...THIS_MESSAGE_IS_FOR_TEST_PURPOSES_ONLY...

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

$$

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 centres 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 fourteenth session of ICG/ITSU (Tokyo, 1993) that a centre could be assumed by the Japan Meteorological Agency (JMA). This triggered a feasibility study in ICG/ITSU to set up the regional centre for the Northwest Pacific.

At the Seventeenth session of the ICG/ITSU (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 centre 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 centre, JMA submitted a report at the Nineteenth session of the ICG/ITSU (Wellington, 2003) to demonstrate its readiness for the operation of the centre. In 2004, Executive Council of the Intergovernmental Oceanographic Commission (IOC), at its Thirty-seventh session (Paris, 2004), adopted a resolution to start the services of the regional centre at JMA by March 2005.

On such an international consensus, JMA initiated the operation of the regional centre in the Tsunami Forecast Centre in the Headquarters of the Agency to provide tsunami advisories to the countries in the Northwest Pacific in March 2005. At the Twentieth session of the ICG/ITSU (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

(i) 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 6.1), which includes the north-western and a portion of the south-western Pacific and, on an interim basis, the South China Sea regions.

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

(iii) 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 CONTENT 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 Sections 6.7 and 6.8.

6.3.1 Earthquake information

- Origin time.
- Coordinates (latitude and longitude) of the epicentre.
- Location (name of geographical area).
- Depth (only for the earthquake at a depth of 100 km or deeper).
- Magnitude (Moment magnitude. In case it is JMA Magnitude (Mjma), “(MJMA)” is attached. See the JMA part in Annex II, V, and VI).

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>M>7.5	Possibility of a destructive regional tsunami within 1,000 km of the epicentre.
7.5>M>7.0	Possibility of a destructive local tsunami within 100 km of the epicentre.
7.0>M>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 6.1 and Table 6.1). 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 “0.5 m.”; “1 m.”; “2 m.”; “3 m.”; “4 m.”; “6 m.”; “8 m.”; and “OVER 10 m”. 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@eqvol2.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 hypocentre 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 this 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 EPICENTRE:LAT LL.L[NORTH][SOUTH] LON LLL.LEAST
  Geographical Area (Regional Scale)
  Geographical Area (Wider Scale)
 MAG:M.M[MJMA]

EVALUATION                                                     <--- (4)
 Tsunamigenic Potential

THIS BULLETIN IS FOR                                           <--- (5)
 Coastal Block 1
 Coastal Block 2
 Coastal Block 3
 ...

ESTIMATED TSUNAMI ARRIVAL TIME AND ESTIMATED TSUNAMI WAVE      <--- (6)
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

Remarks                                                        <--- (7)
```

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 epicentre, respectively. As for the latitude, either **"NORTH"** or "**SOUTH"** is added while the longitude is always "EAST". **Geographical Area** is the region of the epicentre 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 Section 6.3.2

6.7.5 Coastal Blocks

If 0.5 m. or greater tsunami is expected for any forecast points (FPs), the **Coastal Blocks** 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 Section 6.7.6 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. For 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).

6.8 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 EPICENTRE: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 EPICENTRE, 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 EPICENTRE: 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 EPICENTRE, 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 EPICENTRE: 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 EPICENTRE: 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 EPICENTRE: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 EPICENTRE, 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

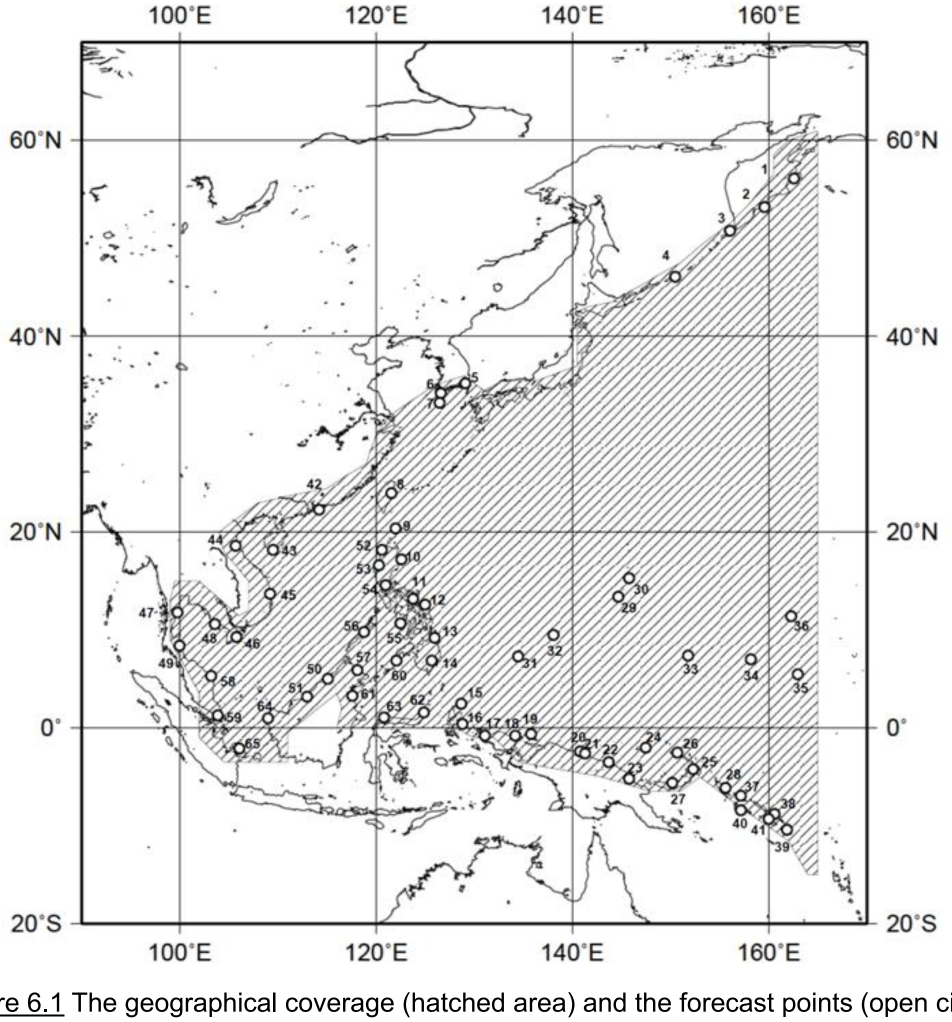


Figure 6.1 The geographical coverage (hatched area) and the forecast points (open circle) of the NWPTA. The numbers at each point correspond with those in the right column of Table 6.1.

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

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

Table 6.1 Forecast points and coastal blocks of NWPTAC

6.10 EXCERPTS FROM SUMMARY REPORTS OF RELEVANT SESSIONS OF THE ICG/PTWS

Summary Report of the ICG/ITSU-XIV Session (1993) (IOC/ITSU-XIV/3)

90 The Representative of Korea proposed the establishment of the Far East Tsunami Warning Centre. One of the possible locations for the Centre 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 Centre and obtain additional tide

and seismic data from and improve communications with the concerned countries in the area 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 Centre. 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) (IOC/ITSU-XV/3)

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) (IOC/ITSU-XVI/3)

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 hypocentres. 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) (IOC/ITSU-XVII/3)

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 six 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) (IOC/ITSU-XVIII/3)

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 North-western 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 hypocentres 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) (IOC/ITSU-XIX/3)

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 hypocentre 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) (IOC/ITSU-XX/3)

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-XXI Session (2006) (IOC/ICG-PTWS-XXI/3)

81 Mr Osamu Kamigaichi, a representative from Japan, 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 Centre 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.

ANNEX I

TERMINOLOGY

TSUNAMI

"Tsunami" is the Japanese term meaning harbour 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 epicentre, 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 hypocentre are known. Thus, the location and depth of the earthquake can be determined by finding the hypocentre 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 kilometres per hour (300 to 600 miles per hour), and the distance between successive wave crests can be as much as 500 to 650 kilometres (300 to 400 miles). However, in the deep ocean, the height of potentially destructive tsunami waves may be no more than a few centimetres (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 kilometres 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 centres 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 harbours, 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 passages 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. One hundred and seventeen 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 per cent: 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.

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ANNEX II

EARTHQUAKE SOURCE CHARACTERIZATION

A. HYPOCENTRAL DETERMINATION

Pacific Tsunami Warning Centre (PTWC)

PTWC estimates the hypocentre of earthquakes by both automatic and interactive processes. As seismic data from each station arrive at the centre, they are monitored by PTWC computers for signals characteristic of the initial vibrations from an earthquake called the P-waves. If the timing of several such P-waves meets the criteria for an earthquake, then a hypocentre (the latitude, longitude and depth of the start of the rupture) is automatically computed. The methodology of hypocentre determination is based on finding the hypocentre that minimizes differences between the measured arrival time of the initial vibrations at each seismic station and the calculated arrival times based on a reference seismic velocity model of the interior of the earth. Given this hypocentre, earthquake magnitudes are then automatically computed from the amplitude of the vibrations. The hypocentre and magnitudes are automatically refined as additional data arrive from seismic stations located further from the earthquake. The automatic processes used for the initial hypocentre determination are identical to those used by WC/ATWC and are described in detail in the WC/ATWC section below.

At the same time that the automatic determinations are taking place, PTWC duty staff review the automatic P-wave picks on graphical displays of the waveforms and adjust them if necessary. They may also add additional picks missed by the automatic processes. Further, they may measure the arrival times of an additional seismic phase called the P-wave that is very sensitive to the earthquake depth. They then recompute the hypocentre, allowing the depth parameter to be free, or to be fixed based on other geophysical considerations, or to be constrained by P-wave arrivals. Because tsunamigenesis is also very sensitive to the earthquake depth, this parameter is important to determine accurately if the data allow.

For each hypocentre determination, the duty staff reviews several quality control parameters. These include the standard deviation between the measured and calculated arrival times, the azimuth gap to judge if the hypocentre is constrained from all sides, and the distance to the closest station. When the duty staff is satisfied that the hypocentre is sufficiently constrained, then it is finalized for the computation of magnitudes and for estimating tsunamigenic potential.

West Coast / Alaska Tsunami Warning Centre (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 five 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 five picks, the hypocentre 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 quadripartite 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 Centre. 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 10 km 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 50 km.

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.

Japan Meteorological Agency (JMA)

For forecasting of tsunamis, information on the hypocentres such as location and magnitude of earthquakes are essentially required. To determine hypocentres, 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 hypocentres 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 hypocentre 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 Accelerometers, http://ida.ucsd.edu/

B. MAGNITUDES CALCULATED BY TSUNAMI WARNING CENTRES AND THE WORLD DATA CENTRE FOR SEISMOLOGY (August 2007)

This document summarizes the magnitude calculation methods used by presently existing tsunami warning centres 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 centres 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.

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PACIFIC TSUNAMI WARNING CENTRE (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 $M_b=\log(A/T)+Q(h, \Delta)$ 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 $M_l=\log A+f(\Delta)$.

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

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

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:

$$Mw=(\log Mo-9.1)/1.5.$$

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

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 CENTRE (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:

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

Where:

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

Theoretically, Mb 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:

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

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 epicentre (Sindorf, 1972).

For stations less than Δ =1.65 degrees epicentral distance,

$$ML = \log (A/T) + 0.8*\log (\Delta **2) – 0.066.$$

For stations 1.65 degree to 9 degree epicentral distance,

$$ML = \log (A/T) + 1.5*\log (\Delta **2) – 0.364,$$

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:

Mw = (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 hypocentre 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)
- Hypocentre and magnitude are determined in certain level of accuracy.

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Funasaki, J. and Earthquake Prediction Information Division. 2004. Revision of the JMA velocity magnitude. *Quarterly Journal of Seismology*, 67. Japan, 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(Δ/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 $20° \leq \Delta \leq 80°$.

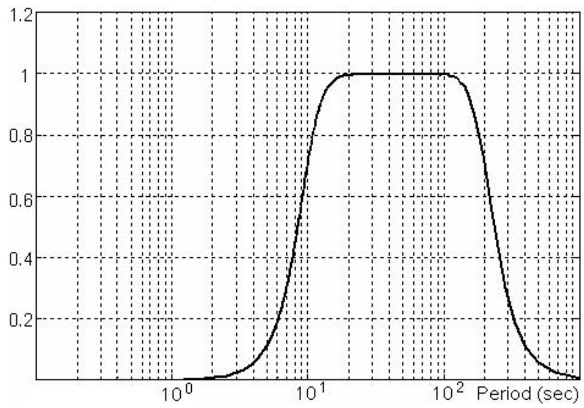

Figure II-1 Band-pass filter for calculation of Mwp (Nishimnae)

As for Tsuboi Mwp, see reference below.

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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 hypocentre 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 hypocentre and magnitude determination as more data becomes available. Accordingly, EEWs are disseminated repeatedly with improved accuracy and reliance with time.

CENTRE POLYNESIEN DE PREVENTION 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 $\mathbf{M_m}$ is provided in the explanation of magnitudes used in PTWC and ATWC sections.

US GEOLOGICAL SURVEY – NATIONAL EARTHQUAKE INFORMATION CENTRE
WORLD DATA CENTRE – SEISMOLOGY
MAGNITUDE DEFINITIONS

<u>REFERENCES:</u>

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.
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 epicentre) 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°

Type	Name	Formula
		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 millimetres recorded on a standard short-period seismometer and **log Ao** is a standard value as a function of distance where distance <= 600 kilometres.

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://siovizcentre.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 epicentre and station and focal depth, h (in kilometres), 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 X 10^{30} dyn cm (dyne·centimeters) for the 1960 Chile earthquake (M_S 8.5; M_W 9.6) and 7.5 X 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:

(i) Rapid enactment of emergency response procedures.

(ii) Delegated decision-making regarding the ordering of evacuations and other protective measures, notification of authorities and recall of disaster response personnel.

(iii) If warranted, rapid and comprehensive notification of the public at risk.

(iv) Emergency procedures for evacuations including establishment of evacuation zones, routes, and public shelters.

(v) 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.

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 Fixed Tsunami Warning**
Mw > 7.8	**Regional Expanding Warning / Watch**
Confirmed Teletsunami	**Pacific-Wide Warning**

Note: These earthquake criteria are based on a shallow hypocentre (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.

(i) **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.

(ii) **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 epicentre in an hourly rate.

(iii) **Regional Fixed Tsunami Warning**: The area placed in a fixed regional tsunami warning encompasses coastal regions within 1000 km of the earthquake epicentre. 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 THEWATER 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 EPICENTRE 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 (or a water depth specified by local or national officials) 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 (or a water depth specified by local or national officials) 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 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 epicentre (usually within 100–

300 km). Because it takes about 8–15 minutes for PTWC initial bulletins to be issued, the international TWC alerts may not be timely for local tsunamis that can be onshore in just minutes. In such situations, local authorities should not wait for the international alerts and instead immediately initiate alerts based on their own judgement.

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 EPICENTRE 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. MODERATE EARTHQUAKE MAY CAUSE UNDERWATER LANDSLIDES THAT GENERATE TSUNAMIS.

REFERENCES

National Oceanic and Atmospheric Administration, National Weather Service. 2010.*Users Guide for the Tsunami Warning System in the West Coast/Alaska Tsunami Warning Centre Area-of-Responsibility*, Version 6.2.Alaska. National Oceanic and Atmospheric Administration, National Weather Service.

Weinstein S. A. 2009*. PTWC Operations, Systems and Procedures Manual*, Ed.1.12. National Oceanic and Atmospheric Administration.

ANNEX IV

SEA LEVEL MEASUREMENT

Tsunami bulletins are issued by the PTWS TWCs (PTWC, WC/ATWC, and NWPTAC) based on the earthquake information at 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 centres 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 measurements confirm that a "tsunami is actually coming." The PTWS centres may revise their tsunami forecast using tsunami observation data if necessary and adequate.

However, each PTWS centre may measure the tsunami signal from a gauge in a slightly different way and at slightly different times so the measurements reported in the bulletins from different centres may not always be equal. Further, the measurements may change as additional tsunami waves arrive at each gauge. Figures IV.1, IV.2 and IV.3 are samples of the tsunami sea level measurement part of the PTWC, WC/ATWC and NWPTAC products. Figures IV.4 and IV.5 illustrate the signal processing and measurement methods of the centres. National Tsunami Warning Centres (NTWCs) and National Disaster Management Organizations (NDMOs) are requested to be aware of these 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 (Figure IV.4). Then the following parameters are measured (also see Figure IV.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 of the measured tsunami amplitude showed in the 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 the elevation above ambient 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.
```

Figure IV.1 Tsunami Observation Section of a PTWC Bulletin

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MEASUREMENTS AND/OR FORECASTS OF TSUNAMI ACTIVITY

SITE              LAT   LON     ARRIVAL TIME    FCST AMP    OBS AMP
--------------------------------------------------------------------
PUERTO RICO
 SAN JUAN         18.5N  66.1W  1724AST JUL 27  3.6F/1.1M  4.0F/1.3M
 MAYAGUEZ         18.2N  67.2W  1735AST JUL 27  6.6F/2.0M  6.8F/2.1M
VIRGIN ISLANDS
 CHRISTIANSTED    17.8N  64.7W  1754AST JUL 27  6.6F/2.0M  6.8F/2.1M
 CHARLOTTE AMALIE 18.3N  64.9W  1807AST JUL 27  6.6F/2.0M
NORTH CAROLINA
 CAPE HATTERAS    18.5N  66.1W  2018EDT JUL 27  3.0F/0.9M
VIRGINIA
 VIRGINIA BEACH   17.8N  64.7W  2152EDT JUL 27  2.1F/0.6M
NEW YORK
 MONTAUK          41.1N  72.0W  2150EDT JUL 27  1.1F/0.3M
 MANHATTAN        40.7N  74.0W  2315EDT JUL 27  2.1F/0.6M
NOVA SCOTIA
 LOCKEPORT        43.7N  65.1W  2244ADT JUL 27  1.0F/0.3M
 SCATARIE ISLAND  46.0N  59.7W  2340ADT JUL 27  2.1F/0.6M

 LAT – LATITUDE/ N-NORTH, S-SOUTH/
 LON – LONGITUDE/ E-EAST, W-WEST/
 ARRIVAL TIME – EXPECTED TIME OF INITIAL TSUNAMI ARRIVAL
 FCST AMP – FORECAST TSUNAMI ELEVATION ABOVE AMBIENT SEA LEVEL.
 OBS AMP – OBSERVED TSUNAMI ELEVATION ABOVE AMBIENT SEA LEVEL.
           IT IS ...NOT... CREST-TO-TROUGH WAVE HEIGHT.
           VALUES ARE GIVEN IN BOTH METERS/M/ AND FEET/F/.
```

Figure IV.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
```

Figure IV.3 Tsunami Observation Section of a NWPTA Bulletin

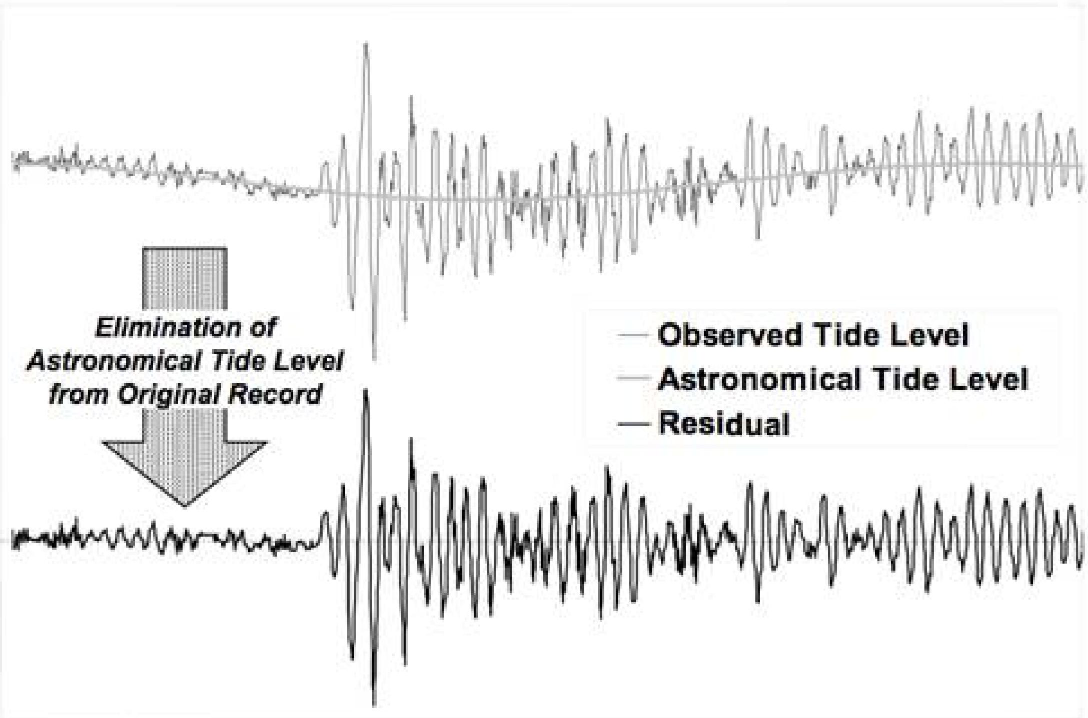


Figure IV.4 Elimination of Astronomical Tide Level from Observed Sea Level Record

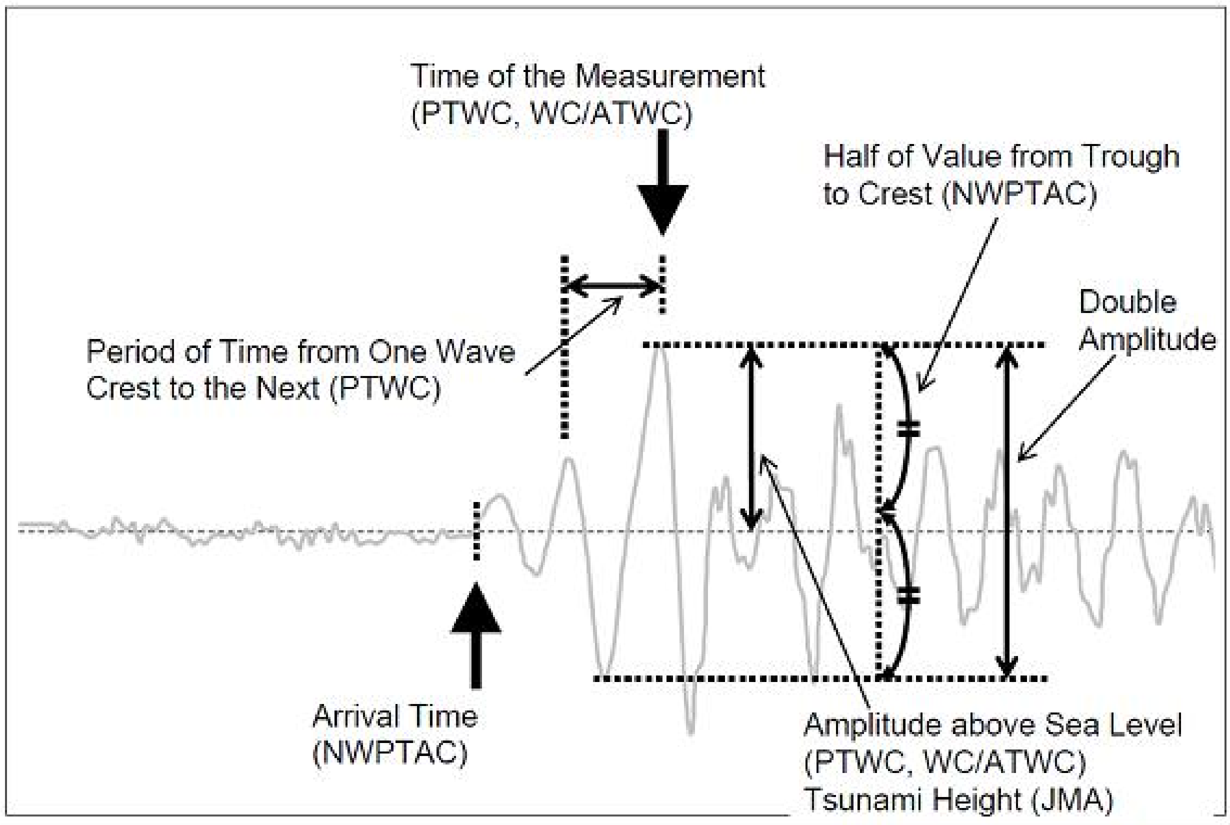


Figure IV.5 Tsunami Observation Parameter on PTWS Centres' Bulletin

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.

Wave height and period

Relevant Points:

(i) Tsunamis are a series of waves that continue for many hours.

(ii) The 1st wave height may not be the largest.

(iii) The largest wave may not occur at the station closest to the earthquake's epicentre.

(iv) 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.

(v) Tsunami wave periods can vary from minutes (5–10) to one hour.

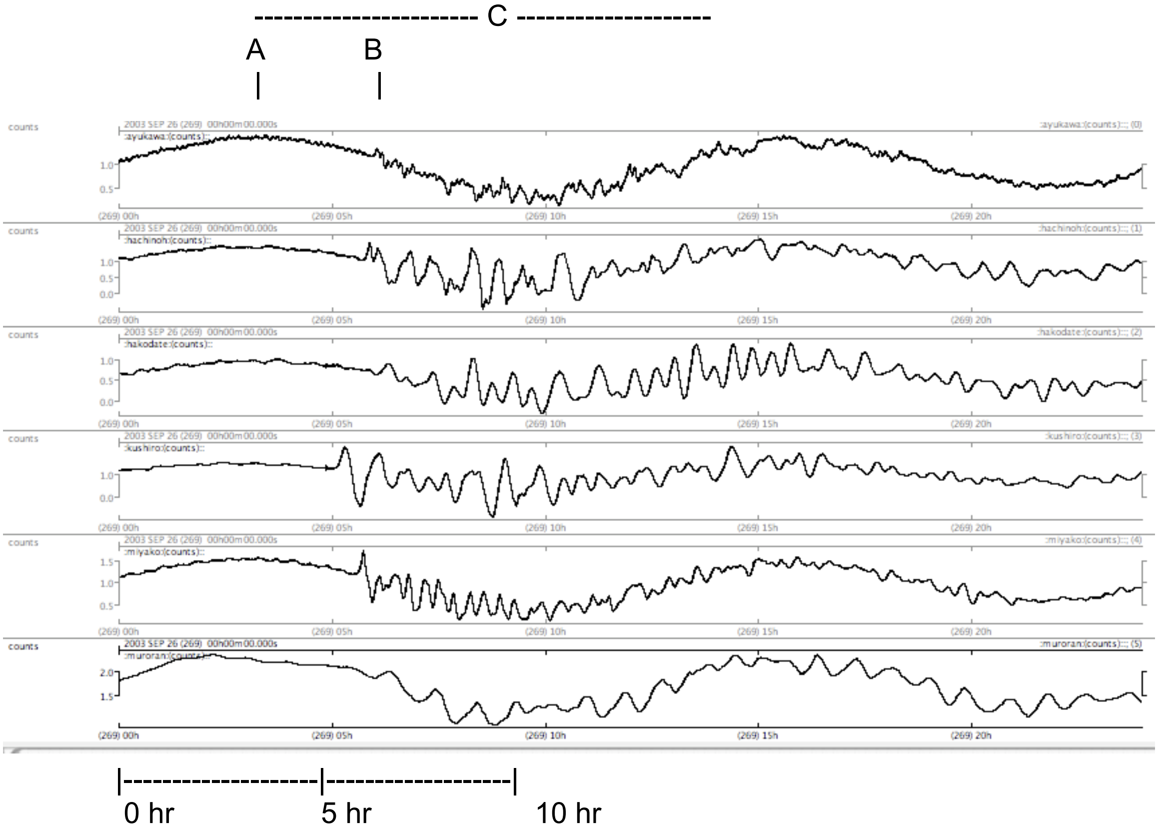


Figure IV.6 M8.0 Tokachi-oki earthquake and tsunami, 26 September 2003.

Notes:

(i) 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 hour cycle).

(ii) 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.

(iii) Tsunami warnings are cancelled when signals become small on many stations. In this example, it would be cancelled after about 12 hours

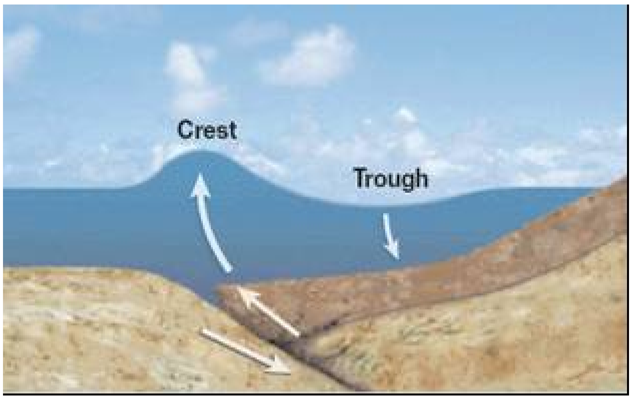
Character of leading waves: When is the 1st wave a receding wave?
Predictions based on theory vs actual

Relevant Points:

(i) The earthquake rupture determines the initial character of the tsunami wave.

(ii) 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.

(iii) 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).



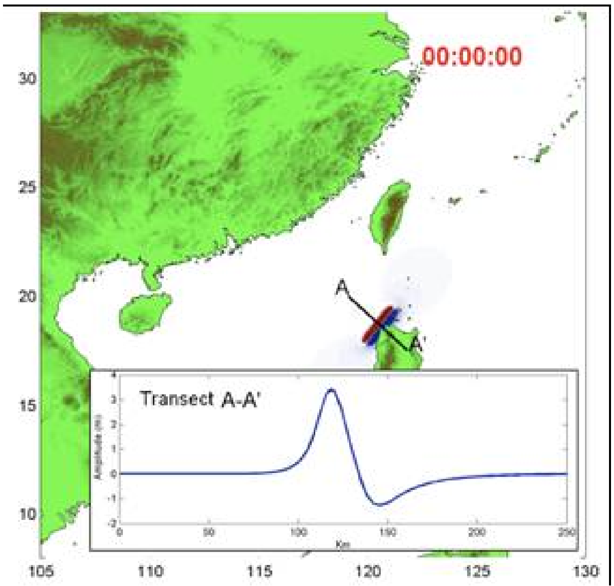


Figure IV.7 Instantaneous push of ocean column upwards during thrust earthquake. Initial water displacement is advancing crest (red) and trough (blue).

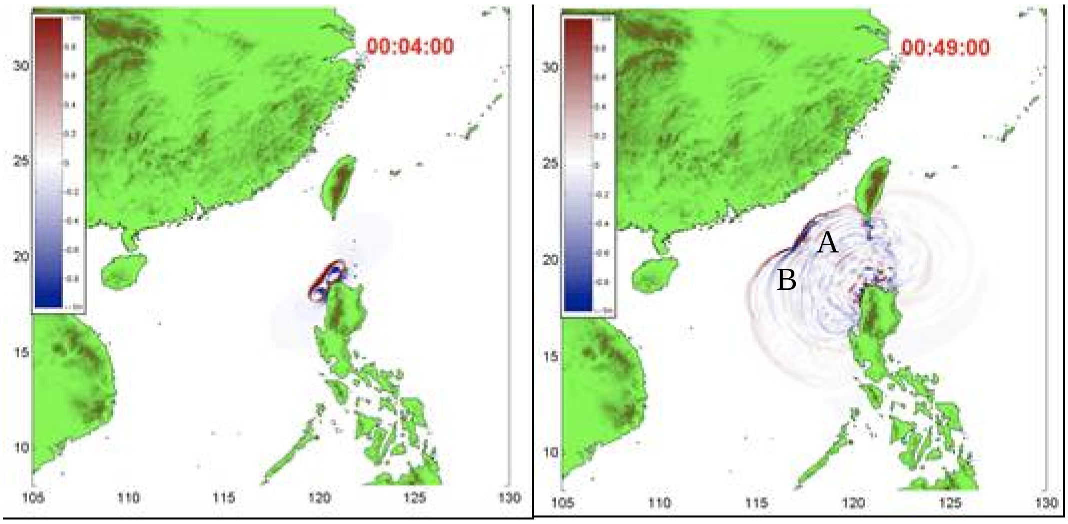


Figure IV.8 Left: The 1st tsunami wave arrival will be an advancing wave (wall of water) toward China, and a receding wave at Luzon, Philippines.

Figure IV.8 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/NWPTAC

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 travelling. 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:

(i) The bathymetry is not accurate in the vicinity of the epicentre.

(ii) The epicentre is not well located, or its origin time is uncertain.

(iii) The epicentre is on land and a pseudo-epicentre off the coast must be selected.

(iv) The bathymetry is not accurate in the vicinity of the reporting station.

(v) Nonlinear propagation effects may be important in shallow water.

(vi) 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 Centres (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 centre’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 centre'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 Huygens's Principle. The principle states that all points on a wave front are point sources for secondary spherical waves. Minimum travel times are computed over the grid starting at the point of interest (e.g. earthquake epicentre). 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:

$$v(x,y) = \sqrt{g(y) \cdot d(x,y)} \qquad (1)$$

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 epicentre to all nodes on the grid, i.e., we must add up increments of the form:

$$\Delta t(r) = \int_0^r \frac{dx}{v(x)} = \int_0^r s(x)dx \qquad (2)$$

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.

The WC/ATWC has recently updated the technique so that for events magnitude 7.9 and greater, extended sources are taken into account. Fault length is taken into account based on an empirical relation with magnitude while fault strike is taken from the nearest pre-computed tsunami model. The minimum tsunami travel time from points along the fault extent to all forecast points is taken as the travel time.

DESCRIPTION OF JMA METHODS IN COMPARISON TO PTWC METHODS

The Japan Meteorological Agency (JMA) uses different methods than the Pacific Tsunami Warning Centre (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 Centre. Furthermore, the following factors can also contribute to differences between the PTWC and JMA arrival time estimates:

(i) For JMA, the nearest hypothetical fault model to the calculated epicentre is picked from the database. So, the difference between the centre of the hypothetical fault (=assumed epicentre) and calculated epicentre 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 epicentre as the tsunami source.

(ii) For JMA, the mesh interval of the bathymetry data is five 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. Huygens' 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.

(i) The finiteness of the fault is taken into account by JMA. An elliptic tsunami source area centred at the calculated epicentre 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 epicentre.

(ii) The mesh size is five arc minutes for JMA as compared to 1 arc minute for PTWC.

(iii) 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.

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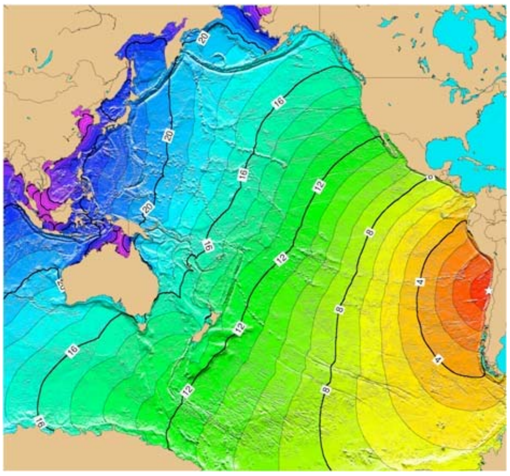
TSUNAMI TRAVEL TIME (TTT) SOFTWARE PACKAGE
VERSION 2.21, JANUARY 2009

TTT_Readme.doc

NOAA's National Geophysical Data Centre, as the World Data Centre (WDC-MGG) for Geophysics and Marine Geology – Tsunamis, and the International Tsunami Information Centre (ITIC), a NOAA-UNESCO/IOC Partnership, 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 Geoware.



The Tsunami Travel Time software (TTT SDK v 3.2) was developed by Dr Paul Wessel (Geoware, http://www.geoware-online.com), and is used by the NOAA Pacific Tsunami Warning Centre. The ITIC and NGDC have purchased the TTT license to permit widespread free distribution. The public domain mapping software Generic Mapping Tools (GMT) was developed by Drs Paul Wessel and Walter Smith (http://gmt.soest.hawaii.edu/). For this PC-environment distribution, the NGDC and ITIC are also providing easy-to-use, sample scripts for running the software and producing maps such as shown to the right.

The software included in this distribution is for systems using a Microsoft Windows XP and Vista operating system. The software code available is not platform-specific, so NGDC/ ITIC is able to provide other distributions, such as for Linux, UNIX or Mac OSX, upon request.

<u>Components included on this CD:</u>

- TTT (Tsunami Travel Time) software, TTT SDK version 3.2. Copyright Paul Wessel, Geoware, 2008. http://www.geoware-online.com. Licensed to NOAA/ITIC for redistribution.
- Global bathymetry grids derived from NGDC's ETOPO1 at varying resolutions (60, 30, 20, 15, 10, 5, and 2 arc-minute and 1 arc-minute grids for the Pacific, Atlantic, and Indian Oceans.
- Easy-to-use scripts for automatically calculating and making a travel time maps.
- Historical Earthquake and sea level station data sets. Historical Tsunamis TTT maps.
- Hands-on exercises to illustrate how to make Indian Ocean, South China Sea, Pacific, and Caribbean region tsunami travel times maps.
- GMT (Generic Mapping Tools), version 4.3.1. Released under the GNU General Public License (GPL). http://gmt.soest.hawaii.edu/
- Ghostscript, version 8.63. Released under the Aladdin Free Public License (AFPL). http://www.cs.wisc.edu/~ghost/

For technical questions, please email Paula Dunbar (Paula.Dunbar@noaa.gov) or Jesse Varner (Jesse.Varner@noaa.gov) at NGDC. For general questions or copies, please email Laura Kong (l.kong@unesco.org) at ITIC.

Funding: NOAA Pacific Region Integrated Data Enterprise Program ITIC: FY05 Project "Analysis of Extreme Events and Trends in Pacific Ocean Water Level Data and its Application to Risk and Vulnerability Assessment (M. Merrifield, L. Kong, J. Marra)." NGDC: FY06 Project "Integrated Pacific Region Tsunami-related Data and Information Products (P. Dunbar)" and FY07 NGDC tsunami project money.

ANNEX VI

TSUNAMI WAVE FORECASTING

JMA/NWPTAC 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 hypocentre locations (presumed epicentres are shown in Figure VI.1). Once an earthquake occurs and its hypocentre 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 epicentre up to points (“calculation points”) of several to several ten kilometres 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 epicentre, 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.

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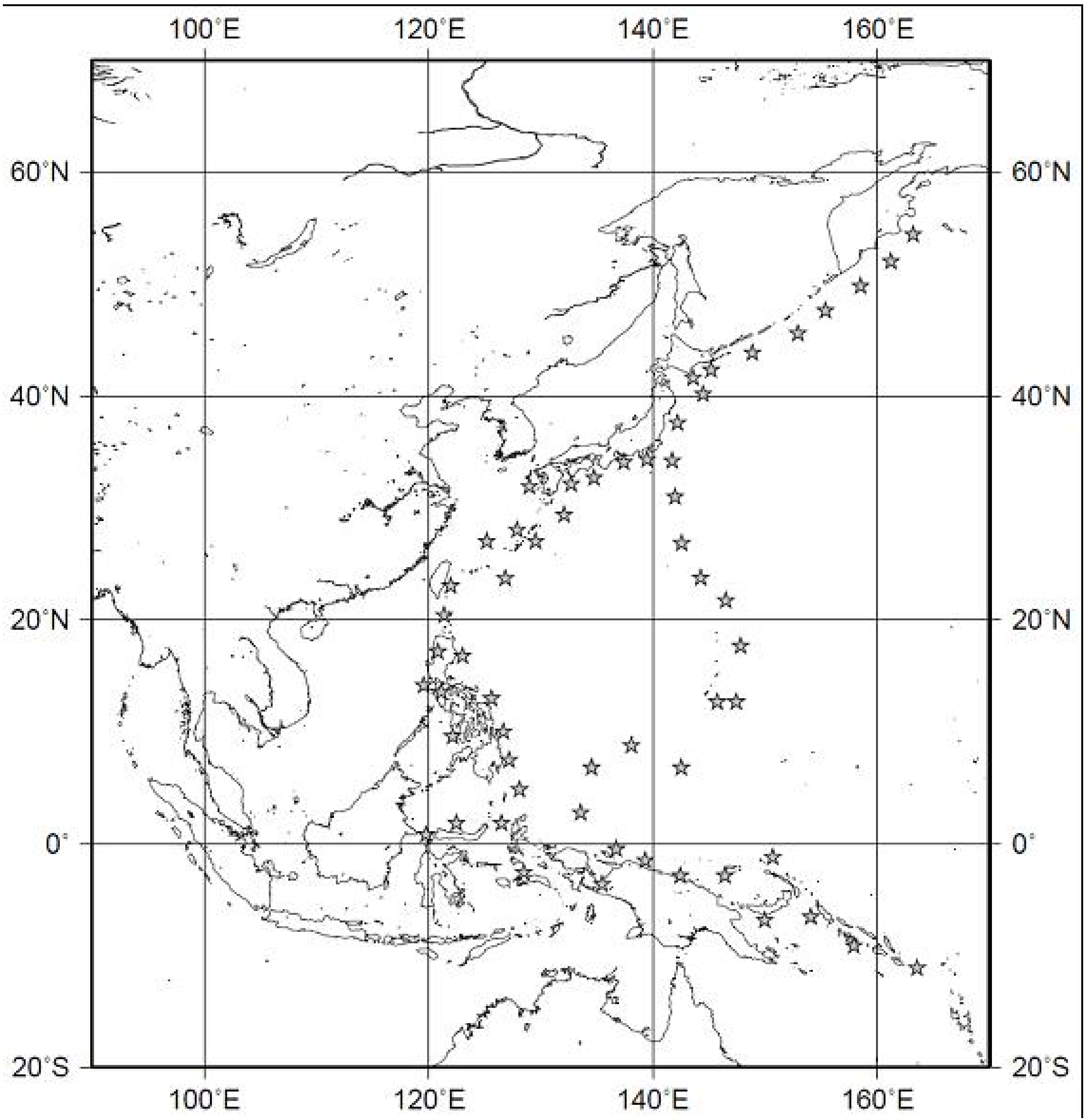

Figure VI.1. Simulation points (star) stored on the NWPTA database

ANNEX VII

GLOSSARY OF TSUNAMI TERMS

The following definitions are referenced from Tsunami Glossary 2008: Intergovernmental Oceanographic Commission. 2008. Tsunami Glossary, 2008. Paris, UNESCO. IOC Technical Series, No 85. (English, Spanish).

1. TSUNAMI CLASSIFICATION

Local or near-field tsunami

A tsunami from a nearby source for which its destructive effects are confined to coasts within about 100 km (or, alternatively, less than 1 hour travel tsunami travel time) from its source. A local tsunami is usually generated by an earthquake, but can also be caused by a landslide or a pyroclastic flow from a volcanic eruption.

Meteorological tsunami (Meteotsunami)

Tsunami-like phenomena generated by meteorological or atmospheric disturbances. These waves can be produced by atmospheric gravity waves, pressure jumps, frontal passages, squalls, gales, typhoons, hurricanes and other atmospheric sources. Meteotsunamis have the same temporal and spatial scales as tsunami waves and can similarly devastate coastal areas, especially in bays and inlets with strong amplification and well-defined resonant properties (e.g. Ciutadella Inlet, Baleric Islands; Nagasaki Bay, Japan; Longkou Harbour, China; Vela Luka, Stari Grad and Mali Ston Bays, Croatia). Sometimes referred to as rissaga.

Paleotsunami

Tsunami occurring prior to the historical record or for which there are no written observations.

Paleotsunami research is based primarily on the identification, mapping, and dating of tsunami deposits found in coastal areas, and their correlation with similar sediments found elsewhere locally, regionally, or across ocean basins. In one instance, the research has led to a new concern for the possible future occurrence of great earthquakes and tsunamis along the northwest coast of North America. In another instance, the record of tsunamis in the Kuril-Kamchatka region is being extended much further back in time. As work in this field continues it may provide a significant amount of new information about past tsunamis to aid in the assessment of the tsunami hazard.

Regional tsunami

A tsunami capable of destruction in a particular geographic region, generally within 1,000 km. or 1-3 hours tsunami travel time from its source. Regional tsunamis also occasionally have very limited and localized effects outside the region.

Most destructive tsunami can be classified as local or regional. It follows many tsunami related casualties and considerable property damage also comes from these tsunamis. Between 1975 and 2007 there were 34 local or regional tsunamis that resulted in deaths and property damage; 23 of these were in the Pacific and adjacent seas.

For example, a regional tsunami in 1983 in the Sea of Japan severely damaged coastal areas of Japan, Korea, and Russia, causing more than $800 million in damage, and more than 100 deaths. Then, after nine years with only one event causing one fatality, 11 locally destructive tsunamis occurred in just a seven-year period from 1992 to 1998, resulting in over 5,300 deaths and

hundreds of millions of dollars in property damage. In most of these cases, tsunami mitigation efforts in place at the time were unable to prevent significant damage and loss of life. However, losses from future local or regional tsunamis can be reduced if a denser network of warning centres, seismic and water-level reporting stations, and better communications are established to provide a timely warning, and if better programs of tsunami preparedness and education can be put in place.

Seiche

A seiche may be initiated by a standing wave oscillating in a partially or fully enclosed body of water. It may be initiated by long period seismic waves (an earthquake), wind and water waves, or a tsunami.

Seismic sea wave

Tsunamis are sometimes referred to as seismic sea waves because they are most often generated by earthquakes.

Teletsunami or Distant Tsunami

A tsunami originating from a far away source, generally more than 1,000 km or more than 3 hours tsunami travel time from its source.

Less frequent, but more hazardous than regional tsunamis, are ocean-wide or distant tsunamis. Usually starting as a local tsunami that causes extensive destruction near the source, these waves continue to travel across an entire ocean basin with sufficient energy to cause additional casualties and destruction on shores more than a 1,000 kilometres from the source. In the last 200 years, there have been at least 26 destructive ocean-wide tsunamis and 9 have caused fatalities more than 1,000 kilometres from the source.

The most destructive Pacific-wide tsunami of recent history was generated by a massive earthquake off the coast of Chile on 22 May 1960. All Chilean coastal towns between the 36th and 44th parallels were either destroyed or heavily damaged by the action of the tsunami and the earthquake. The combined tsunami and earthquake toll included 2,000 killed, 3,000 injured, two million homeless, and $550 million damage. Off the coast of Corral, Chile, the waves were estimated to be 20 metres (67 feet) high. The tsunami caused 61 deaths in Hawaii, 20 in the Philippines, and 139 in Japan. Estimated damages were US $50 million in Japan, US $24 million in Hawaii and several millions of dollars along the west coast of the United States and Canada. Distant wave heights varied from slight oscillations in some areas to 12 metres (40 feet) at Pitcairn Island, 11 metres at Hilo, Hawaii, and 6 metres at some places in Japan.

The worst tsunami catastrophe in history occurred in the Indian Ocean on 26 December 2004, when a M9.3 earthquake off of the northwest coast of Sumatra, Indonesia produced an ocean-wide tsunami that hit Thailand and Malaysia to the east, and Sri Lanka, India, the Maldives, and Africa to the west as it traversed across the Indian Ocean. Nearly 228,000 people lost their lives and more than a million people were displaced, losing their homes, property, and their livelihoods. The magnitude of death and destructiveness caused immediate response by the world's leaders and led to the development of the Indian Ocean tsunami warning and mitigation system in 2005. The event also raised awareness of tsunami hazards globally, and new systems were established in the Caribbean, the Mediterranean and Atlantic.

Tidal wave

1. The wave motion of the tides.
2. Often incorrectly used to describe a tsunami, storm surge, or other unusually high and therefore destructive water levels along a shore that are unrelated to the tides.

Tsunami

Japanese term meaning wave ("nami") in a harbour ("tsu"). A series of travelling waves of extremely long length and period, usually generated by disturbances associated with earthquakes occurring below or near the ocean floor. (Also called seismic sea wave and, incorrectly, tidal wave). Volcanic eruptions, submarine landslides, and coastal rockfalls can also generate tsunamis, as can a large meteorite impacting the ocean. These waves may reach enormous dimensions and travel across entire ocean basins with little loss of energy. They proceed as ordinary gravity waves with a typical period between 10 and 60 minutes. Tsunamis steepen and increase in height on approaching shallow water, inundating low-lying areas, and where local submarine topography causes the waves to steepen, they may break and cause great damage. Tsunamis have no connection with tides; the popular name, tidal wave, is entirely misleading.

Tsunami bore

A steep, turbulent, rapidly moving tsunami wave front, typically occurring in a river mouth or estuary.

Tsunami edge wave

Wave generated by a tsunami that travels along the coast.

Tsunami earthquake

An earthquake that produces an unusually large tsunami relative to the earthquake magnitude (Kanamori, 1972). Typical characteristics of tsunami earthquakes include long rupture durations for the magnitude of the earthquake, rupture on the very shallow part of the plate interface (inferred from a location near the trench and a low-angle thrust mechanism), and high energy release at low frequencies. They are also slow earthquakes, with slippage along their faults occurring more slowly than would occur in normal earthquakes. The last events of this type were in 1992 (Nicaragua), 1994 (Java), 1996 (Chimbote, Peru) and 2006 (Java).

Tsunami sediments

Sediments deposited by a tsunami. The finding of tsunami sediment deposits within the stratigraphic soil layers provides information on the occurrence of historical and paleotsunamis. The discovery of similarly-dated deposits at different locations, sometimes across ocean basins and far from the tsunami source, can be used to map and infer the distribution of tsunami inundation and impact.

Tsunamigenic

Capable of generating a tsunami. For example: a tsunamigenic earthquake, a tsunamigenic landslide.

2. GENERAL TSUNAMI TERMS: GENERATION, MODELLING, MITIGATION

Evacuation map

A drawing or representation that outlines danger zones and designates limits beyond which people must be evacuated to avoid harm from tsunami waves. Evacuation routes are sometimes designated to ensure the efficient movement of people out of the evacuation zone to evacuation shelters.

Historical tsunami data

Historical data are available in many forms and at many locations. These forms include published and unpublished catalogs of tsunami occurrences, personal narratives, marigraphs, tsunami amplitude, run-up and inundation zone measurements, field investigation reports, newspaper accounts, film, or video records.

Tsunami damage

Loss or harm caused by a destructive tsunami. More specifically, the damage caused directly by tsunamis can be summarized into the following: 1) deaths and injuries; 2) houses destroyed, partially destroyed, inundated, flooded, or burned; 3) other property damage and loss; 4) boats washed away, damaged or destroyed; 5) lumber washed away; 6) marine installations destroyed, and; 7) damage to public utilities such as railroads, roads, electric power plants, water supply installations, etc. Indirect secondary tsunami damage can be: 1) Damage by fire of houses, boats, oil tanks, gas stations, and other facilities; 2) environmental pollution caused by drifting materials, oil, or other substances; 3) outbreak of disease of epidemic proportions, which could be serious in densely populated areas.

Tsunami generation

Tsunamis are most frequently caused by earthquakes, but can also result from landslides, volcanic eruptions, and very infrequently by meteorites or other impacts upon the ocean surface. Tsunamis are generated primarily by tectonic dislocations under the sea which are caused by shallow focus earthquakes along areas of subduction. The upthrusted and downthrusted crustal blocks impart potential energy into the overlying water mass with drastic changes in the sea level over the affected region. The energy imparted into the water mass results in tsunami generation, i.e. energy radiating away from the source region in the form of long period waves.

Tsunami generation theory

The theoretical problem of generation of the gravity wave (tsunami) in the layer of elastic liquid (an ocean) occurring on the surface of elastic solid half-space (the crust) in the gravity field can be studied with methods developed in the dynamic theory of elasticity. The source representing an earthquake focus is a discontinuity in the tangent component of the displacement on some element of area within the crust. For conditions representative of the Earth's oceans, the solution of the problem differs very little from the joint solution of two more simple problems: the problem of generation of the displacement field by the given source in the solid elastic half-space with the free boundary (the bottom) considered quasi-static and the problem of the propagation of gravity wave in the layer of heavy incompressible liquid generated by the known (from the solution of the previous problem) motion of the solid bottom. There is the theoretical dependence of the gravity wave parameters on the source parameters (depth and orientation). One can roughly estimate the quantity of energy transferred to the gravity wave by the source. In general, it corresponds to the

estimates obtained with empirical data. Also, tsunamis can be generated by other different mechanisms such as volcanic or nuclear explosions, landslides, rock falls, and submarine slumps.

Tsunami hazard

The probability that a tsunami of a particular size will strike a particular section of coast.

Tsunami hazard assessment

Documentation of tsunami hazards for a coastal community is needed to identify populations and assets at risk, and the level of that risk. This assessment requires knowledge of probable tsunami sources (such as earthquakes, landslides, and volcanic eruptions), their likelihood of occurrence, and the characteristics of tsunamis from those sources at different places along the coast. For those communities, data of earlier (historical and paleotsunamis) tsunamis may help quantify these factors. For most communities, however, only very limited or no past data exist. For these coasts, numerical models of tsunami inundation can provide estimates of areas that will be flooded in the event of a local or distant tsunamigenic earthquake or a local landslide.

Tsunami impact

Although infrequent, tsunamis are among the most terrifying and complex physical phenomena and have been responsible for great loss of life and extensive destruction to property. Because of their destructiveness, tsunamis have important impacts on the human, social, and economic sectors of societies. Historical records show that enormous destruction of coastal communities throughout the world has taken place and that the socio-economic impact of tsunamis in the past has been enormous. In the Pacific Ocean where the majority of these waves have been generated, the historic record shows tremendous destruction with extensive loss of life and property.

In Japan, which has one of the most populated coastal regions in the world and a long history of earthquake activity, tsunamis have destroyed entire coastal populations. There is also a history of severe tsunami destruction in Alaska, the Hawaiian Islands, and South America, although records for these areas are not as extensive. The last major Pacific-wide tsunami occurred in 1960. Many other local and regional destructive tsunamis have occurred with more localized effects.

Tsunami numerical modelling

Mathematical descriptions that seek to describe the observed tsunami and its effects.

Often the only way to determine the potential run-up's and inundation from a local or distant tsunami is to use numerical modelling, since data from past tsunamis is usually insufficient. Models can be initialized with potential worst case scenarios for the tsunami sources or for the waves just offshore to determine corresponding worst case scenarios for run-up and inundation. Models can also be initialized with smaller sources to understand the severity of the hazard for the less extreme but more frequent events. This information is then the basis for creating tsunami evacuation maps and procedures. At present, such modelling has only been carried out for a small fraction of the coastal areas at risk. Sufficiently accurate modelling techniques have only been available in recent years, and these models require training to understand and use correctly, as well as input of detailed bathymetric and topographic data in the area being modelled.

Numerical models have been used in recent years to simulate tsunami propagation and interaction with land masses. Such models usually solve similar equations but often employ different numerical techniques and are applied to different segments of the total problem of tsunami propagation from generation regions to distant areas of run-up. For example, several numerical models have been used to simulate the interaction of tsunamis with islands. These models have

used finite difference, finite element, and boundary integral methods to solve the linear long wave equations. These models solve these relatively simple equations and provide reasonable simulations of tsunamis for engineering purposes.

Historical data are often very limited for most coastlines. Consequently, numerical modelling may be the only way to estimate potential risk. Techniques now exist to carry out this assessment. Computer software and the training necessary to conduct this modelling are available through programmes such as the IOC Tsunami Inundation Modelling Exchange (TIME) Programme.

Tsunami preparedness

Readiness of plans, methods, procedures, and actions taken by government officials and the general public for the purpose of minimizing potential risk and mitigating the effects of future tsunamis. The appropriate preparedness for a warning of impending danger from a tsunami requires knowledge of areas that could be flooded (tsunami inundation maps) and knowledge of the warning system to know when to evacuate and when it is safe to return.

Tsunami propagation

Tsunamis travel outward in all directions from the generating area, with the direction of the main energy propagation generally being orthogonal to the direction of the earthquake fracture zone. Their speed depends on the depth of water, so that the waves undergo accelerations and decelerations in passing over an ocean bottom of varying depth. In the deep and open ocean, they travel at speeds of 500 to 1,000 km per hour (300 to 600 miles per hour). The distance between successive crests can be as much as 500 to 650 km. (300 to 400 miles). However, in the open ocean, the height of the waves is generally less than a meter (three feet) even for the most destructive teletsunamis, and the waves pass unnoticed. Variations in tsunami propagation result when the propagation impulse is stronger in one direction than in others because of the orientation or dimensions of the generating area and where regional bathymetric and topographic features modify both the waveform and rate of advance. Specifically, tsunami waves undergo a process of wave refraction and reflection throughout their travel. Tsunamis are unique in that the energy extends through the entire water column from sea surface to the ocean bottom. It is this characteristic that accounts for the great amount of energy propagated by a tsunami.

Tsunami risk

The probability of a particular coastline being struck by a tsunami multiplied by the likely destructive effects of the tsunami and by the number of potential victims. In general terms, risk is the hazard multiplied by the exposure.

Tsunami simulation

Numerical model of tsunami generation, propagation, and inundation.

Tsunami source

Point or area of tsunami origin, usually the site of an earthquake, volcanic eruption, or landslide that caused large-scale rapid displacement of the water to initiate the tsunami waves.

3. SEA LEVEL AND TSUNAMI MEASUREMENTS AND INSTRUMENTS

Crest length

The length of a wave along its crest. Sometimes called crest width.

Deep-ocean Assessment and Reporting of Tsunamis (DART®)

An instrument for the early detection, measurement, and real-time reporting of tsunamis in the open ocean. Developed by the US NOAA Pacific Marine Environmental Laboratory, the DART® system consists of a seafloor bottom pressure recording system capable of detecting tsunamis as small as one centimetre and a moored surface buoy for real-time communications. An acoustic link is used to transmit data from the seafloor to the surface buoy. The data are then relayed via a satellite link to ground stations, which demodulate the signals for immediate dissemination to the NOAA tsunami warnings centres. The DART® data, along with state-of-the-art numerical modelling technology, are part of a tsunami forecasting system package that will provide site-specific predictions of tsunami impact on the coast.

Flow depth

Run-up at a certain inundation.

Initial rise

Time of the first minimum of the tsunami waves.

Inundation or Inundation-distance

The horizontal distance inland that a tsunami penetrates, generally measured perpendicularly to the shoreline.

Inundation line

Inland limit of wetting, measured horizontally from the mean sea level (MSL) line. The line between living and dead vegetation is sometimes used as a reference. In tsunami science, the landward limit of tsunami run-up.

Leading wave

First arriving wave of a tsunami. In some cases, the leading wave produces an initial depression or drop in sea level, and in other cases, an elevation or rise in sea level. When a drop in sea level occurs, sea level recession is observed.

Mareogram or Marigram

1. Record made by a mareograph.
2. Any graphic representation of the rise and fall of the sea level, with time as abscissa and height as ordinate, usually used to measure tides, may also show tsunamis.

Mean sea level

The average height of the sea surface, based upon hourly observation of tide height on the open coast or in adjacent waters which have free access to the sea. These observations are to have been made over a “considerable” period of time. In the United States, mean sea level is defined as

the average height of the surface of the sea for all stages of the tide over a 19-year period. Selected values of mean sea level serve as the sea level datum for all elevation surveys in the United States. Along with mean high water, mean low water, and mean lower low water, mean sea level is a type of tidal datum.

Mean height

Average height of a tsunami measured from the trough to the crest after removing the tidal variation.

Post-tsunami survey

Tsunamis are relatively rare events and most of their evidence is perishable. Therefore, it is very important that reconnaissance surveys be organized and carried out quickly and thoroughly after each tsunami occurs, to collect detailed data valuable for hazard assessment, model validation, and other aspects of tsunami mitigation.

In recent years, following each major destructive tsunami, a post-tsunami reconnaissance survey has been organized to make measurements of run-ups and inundation limits and to collect associated data from eyewitnesses such as the number of waves, arrival time of waves, and which wave was the largest. The surveys have been organized primarily on an ad-hoc basis by international academic tsunami researchers. A Post-Tsunami Survey Field Guide (http://ioc3.unesco.org/itic/contents.php?id=28) has been prepared by the PTWS to help with preparations of surveys, to identify measurements and observations to be taken, and to standardize data collections. The Tsunami Bulletin Board e-mail service has also been used for quickly organizing international surveys and for sharing of the observations from impacted areas.

Reference sea level

The observed elevation differences between geodetic benchmarks are processed through least-squares adjustments to determine orthometric heights referred to a common vertical reference surface, which is the reference sea level. In this way, height values of all benchmarks in the vertical control portion of a surveying agency are made consistent and can be compared directly to determine differences of elevation between benchmarks in a geodetic reference system that may not be directly connected by lines of geodetic levelling. The vertical reference surface in use in the United States, as in most parts of the world, approximates the geoid. The geoid was assumed to be coincident with local mean sea level at 26 tidal stations to obtain the Sea Level Datum of 1929 (SLD 290). National Geodetic Vertical Datum of 1929 (NGVD 29) became a name change only; the same vertical reference system has been in use in the United States since 1929. This important vertical geodetic control system is made possible by a universally accepted, reference sea level.

Run-up

1. Difference between the elevation of maximum tsunami penetration (inundation line) and the sea level at the time of the tsunami. In practical terms, run-up is only measured where there is a clear evidence of the inundation limit on the shore.
2. Elevation reached by seawater measured relative to some stated datum such as mean sea level, mean low water, sea level at the time of the tsunami attack, etc., and measured ideally at a point that is a local maximum of the horizontal inundation. Where the elevation is not measured at the maximum of horizontal inundation this is often referred to as the inundation-height or flow depth.

Sea level

The height of the sea at a given time measured relative to some datum, such as mean sea level.

Sea level station

A system consisting of a device such as a tide gauge for measuring the height of sea level, a data collection platform (DCP) for acquiring, digitizing, and archiving the sea level information digitally, and often a transmission system for delivering the data from the field station to a central data collection centre. The specific requirements of data sampling and data transmission are dependent on the application. The GLOSS programme maintains a core network of sea level stations. For local tsunami monitoring, one-second sampled data streams available in real time are required. For distant tsunamis, warning centres may be able to provide adequate warnings using data acquired in near-real time (one-minute sampled data transmitted every 15 minutes). Sea level stations are also used for sea level rise and climate change studies, where an important requirement is for the very accurate location of the station as acquired through surveying techniques.

Sieberg tsunami intensity scale

A descriptive tsunami intensity scale, which was later modified into the Sieberg-Ambraseys tsunami intensity scale described below (Ambraseys 1962).

Modified Sieberg sea-wave intensity scale

1. Very light. Wave so weak as to be perceptible only on tide-gauge records.
2. Light. Wave noticed by those living along the shore and familiar with the sea. On very flat shores generally noticed.
3. Rather strong. Generally noticed. Flooding of gently sloping coasts. Light sailing vessels or small boats carried away on shore. Slight damage to light structures situated near the coast. In estuaries reversal of the river flow some distance upstream.
4. Strong. Flooding of the shore to some depth. Light scouring on man-made ground. Embankments and dikes damaged. Light structures near the coasts damaged. Solid structures on the coast injured. Big sailing vessels and small ships carried inland or out to sea. Coasts littered with floating debris.
5. Very strong. General flooding of the shore to some depth. Breakwater walls and solid structures near the sea damaged. Light structures destroyed. Severe scouring of cultivated land and littering of the coast with floating items and sea animals. With the exception of big ships, all other type of vessels carried inland or out to sea. Big bores in estuary rivers. Harbour works damaged. People drowned. Wave accompanied by strong roar.
6. Disastrous. Partial or complete destruction of man-made structures for some distance from the shore. Flooding of coasts to great depths. Big ships severely damaged. Trees uprooted or broken. Many casualties.

Spreading

When referring to tsunami waves, it is the spreading of the wave energy over a wider geographical area as the waves propagate away from the source region. The reason for this geographical spreading and reduction of wave energy with distance travelled, is the sphericity of the earth. The tsunami energy will begin converging again at a distance of 90 degrees from the source. Tsunami waves propagating across a large ocean undergo other changes in configuration primarily due to

refraction, but geographical spreading is also very important depending upon the orientation, dimensions, and geometry of the tsunami source.

Tide

The rhythmic, alternate rise and fall of the surface (or water level) of the ocean, and of bodies of water connected with the ocean such as estuaries and gulfs, occurring twice a day over most of the Earth and resulting from the gravitational attraction of the moon (and, in lesser degrees, of the sun) acting unequally on different parts of the rotating Earth.

Tide gauge

A device for measuring the height (rise and fall) of the tide. Especially an instrument for automatically making a continuous graphic record of tide height versus time.

Tsunameter

An instrument for the early detection, measurement, and real-time reporting of tsunamis in the open ocean. Also known as a tsunamimeter. The DART® system and cable deep-ocean pressure sensor are tsunameters.

Tsunami amplitude

Usually measured on a sea level record, it is:

1. The absolute value of the difference between a particular peak or trough of the tsunami and the undisturbed sea level at the time,
2. Half the difference between an adjacent peak and trough, corrected for the change of tide between that peak and trough. It is intended to represent the true amplitude of the tsunami wave at some point in the ocean. However, it is often amplitude modified in some way by the tide gauge response.

Tsunami dispersion

Redistribution of tsunami energy, particularly as a function of its period, as it travels across a body of water.

Tsunami intensity

Size of a tsunami based on the macroscopic observation of a tsunami's effect on humans, objects including various sizes of marine vessels, and buildings.

The original scale for tsunamis was published by Sieberg (1923), and later modified by Ambraseys (1962) to create a six-category scale. Papadopoulus and Imamura (2001) proposed a new 12 grade intensity scale which is independent of the need to measure physical parameters like wave amplitude, sensitive to the small differences in tsunami effects, and detailed enough for each grade to cover the many possible types of tsunami impact on the human and natural environment. The scale has 12 categories, similar to the Modified Mercalli Intensity Scale used for macroseismic descriptions of earthquake intensity.

Tsunami magnitude

Size of a tsunami based on the measurement of the tsunami wave on sea level gauges and other instruments.

The scale, originally descriptive and more similar to intensity, quantifies the size by using measurements of wave height or tsunami run-up. Iida et al. (1972) described the magnitude (m) as dependent in logarithmic base 2 on the maximum wave height measured in the field, and corresponding to a magnitude range from –1 to 4:

$$m = \log_2 H_{max}$$

Hatori (1979) subsequently extended this so-called Imamura-Iida scale for far-field tsunamis by including distance in the formulation. Soloviev (1970) suggested that the mean tsunami height may be another good indicator of tsunami size, and the maximum intensity would be that measured nearest to the tsunami source. A variation on this is the Imamura-Soloviev intensity scale I (Soloviev, 1972). Shuto (1993) has suggested the measurement of H as the height where specific types of impact or damage occur, thus proposing a scale which can be used as a predictive quantitative tool for macroscopic effects.

Tsunami magnitudes have also been proposed that are similar in form to those used to calculate earthquake magnitudes. These include the original formula proposed by Abe (1979) for tsunami magnitude, M_t:

$$M_t = \log H + B$$

Where H is the maximum single crest or trough amplitude of the tsunami waves (in metres) and B is a constant, and the far-field application proposed by Hatori (1986) which adds a distance factor into the calculation.

Tsunami period

Amount of time that a tsunami wave takes to complete a cycle. Tsunami periods typically range from 5 to 60 minutes.

Tsunami resonance

The continued reflection and interference of tsunami waves from the edge of a harbour or narrow bay which can cause amplification of the wave heights, and extend the duration of wave activity from a tsunami.

Tsunami velocity or shallow water velocity

The velocity of an ocean wave whose length is sufficiently large compared to the water depth (i.e., 25 or more times the depth) can be approximated by the following expression:

$$c = \sqrt{(gh)}$$

Where:

c: is the wave velocity

g: the acceleration of gravity

h: the water depth.

Thus, the velocity of shallow-water waves is independent of wave length L. In water depths between ½ L and 1/25 L it is necessary to use a more precise expression:

$$c = \sqrt{((gL/2p)[\tanh(2 p h/L)])}$$

Tunami wave length

The horizontal distance between similar points on two successive waves measured perpendicular to the crest. The wave length and the tsunami period give information on the tsunami source. For tsunamis generated by earthquakes, the typical wave length ranges from 20 to 300 km. For tsunamis generated by landslides, the wave length is much shorter, ranging from hundreds of metres to tens of kilometres.

Wave crest

1. The highest part of a wave.
2. That part of the wave above still water level.

Wave trough

The lowest part of a wave.

4. ACRONYMS, ORGANIZATIONS, PTWS TSUNAMI ALERTS

Estimated time of arrival (ETA)

Time of tsunami arrival (also called arrival time) at some fixed location, as estimated from modelling the speed and refraction of the tsunami waves as they travel from the source. ETA is estimated with very good precision if the bathymetry and source are well known (less than a couple of minutes). The first wave is not necessarily the largest, but it is usually one of the first five waves.

Forecast Point

The location where the Tsunami Warning Centre may provide estimates of tsunami arrival time or wave height.

GLOSS

Global Sea-Level Observing System. A component of the Global Ocean Observing System (GOOS). The UNESCO IOC established GLOSS in 1985 originally to improve the quality of sea level data as input to studies of long-term sea level change. It consists of a core network of approximately 300 stations distributed along continental coastlines and throughout each of the world's island groups. The GLOSS network also supports sea level monitoring for tsunami warning with minimum operational standards of 15 minute data transmissions of one minute sampled data.

GTS

Global Telecommunications System of the World Meteorological Organization (WMO) that directly connects national meteorological and hydrological services worldwide. The GTS is widely used for the near real-time transmission of sea level data for tsunami monitoring. The GTS and other robust communications methods are used for the transmission of tsunami warnings.

ICG

Intergovernmental Coordination Group. As subsidiary bodies of the UNESCO/IOC, the ICG meets to promote, organize, and coordinate regional tsunami mitigation activities, including the issuance of timely tsunami warnings. To achieve this objective requires the participation, cooperation and contribution of many national and international seismic, sea level, communication, and

dissemination facilities throughout the region. The ICG is comprised of Member States in the region. Currently, these are ICGs for tsunami warning and mitigation systems in the Pacific, Indian Ocean, Caribbean and adjacent regions, and the north-eastern Atlantic, the Mediterranean and connected seas.

ICG/ITSU

International Coordination Group for the International Tsunami Warning System in the Pacific was established by Resolution IV-6 of the IOC General Assembly at its Fourth Session in 1965. The ICG/ITSU was renamed to the ICG/PTWS in 2005.

ICG/PTWS

Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System was renamed by Resolution ITSU-XX.1 of the ICG/ITSU at its Twentieth Session in 2005. Presently, there are 32 Member States. The ICG/PTWS was formerly the ICG/ITSU. (http://www.ioc-tsunami.org/index.php?option=com_content&view=article&id=11&Itemid=12&lang=en)

ICG Tsunami National Contact (TNC)

The person designated by an ICG Member State government 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 programme. 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.

ICG Tsunami Warning Focal Point (TWFP)

7x24 contact person, or other official point of contact or address, for rapidly receiving and issuing tsunami event information (such as warnings). The Tsunami Warning Focal Point either is the emergency authority (civil defence 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 JMANWPTAC, or other regional warning centres.

IOC

Intergovernmental Oceanographic Commission of UNESCO. The IOC provides Member States of the United Nations with an essential mechanism for global cooperation in the study of the ocean. The IOC assists governments to address their individual and collective ocean and coastal problems through the sharing of knowledge, information and technology and through the coordination of national programmes. (http://ioc-unesco.org/)

ITIC

International Tsunami Information Centre. ITIC was established in November 1965 by the IOC of UNESCO to support the ICG/ITSU in the Pacific. The ITIC also provides technical and capacity building assistance to Member States for the global establishment of tsunami warning and mitigation systems in the Indian and Atlantic Oceans, the Caribbean and Mediterranean Seas, and other oceans and marginal seas. In the Pacific, the ITIC specifically monitors and recommends improvements to the PTWS, coordinates tsunami technology transfer among Member States interested in establishing regional and national tsunami warning systems, acts as a clearinghouse

for risk assessment and mitigation activities, and serves as a resource for the development, publication, and distribution of tsunami education and preparedness materials.
(http://www.tsunamiwave.info)

JMA

Japan Meteorological Agency. JMA established a tsunami warning service in 1952. JMA now serves as a National Tsunami Warning System that continuously monitors 24 hours-a-day all seismic activity in Japan, and issues timely information concerning earthquakes and tsunamis. In 2005, the JMA began operations of the Northwest Pacific Tsunami Advisory Center (NWPTAC). The NWPTAC provides supplementary tsunami information for events in and around Japan and the northwest Pacific, and interim services for the South China Sea region, in close coordination with the PTWC. Since 2005, JMA and PTWC have provided interim services for the Indian Ocean. (http://www.jma.go.jp/jma)

Master Plan

The principal long-term guide for improving the TWS. The Plan provides a summary of the basic elements which comprise the TWS, a description of its existing components, and an outline of the activities, data sets, methods, and procedures that need to be improved in order to reduce tsunami risk. The first edition of the ICG/PTWS Master Plan was released in 1989. The second edition was released in 1999, and the third edition in 2004.
(http://ioc3.unesco.org/itic/files.php?action=viewfile&fid=832&fcat_id=64)

Ocean-wide Tsunami Warning

A warning issued to all participants after there is confirmation of tsunami waves capable of causing destruction beyond the local area. Ocean-Wide Tsunami Warnings contain estimated tsunami arrival times (ETAs) at all Forecast Points. Ocean-Wide Tsunami Warning Bulletins also normally carry information on selected wave heights and other wave reports. The Warning will be cancelled when it is determined that the tsunami threat is over. As local conditions can cause wide variations in tsunami wave action, the all-clear determination should be made by the local action agencies and not the TWC. In general, after receipt of a Tsunami Warning, action agencies can assume all-clear status when their area is free from damaging waves for at least 2 hours, unless additional ETAs have been announced by the TWC (for example for a significant aftershock) or local conditions, that may include continued seiching or particularly strong currents in channels and harbours, warrant the continuation of the Tsunami Warning status.

Operational Users Guide for the Tsunami Warning System

The Guide includes a summary of the administrative and operational services and procedures, including monitoring and detection data networks used by the warning centres, the criteria for the reporting and issuing of tsunami information messages, samples messages, the recipients of the information, and the methods by which the messages are sent. Background information to assist customers in understanding the products that are issued may also be included. Formerly called the Communications Plan for the TWS.

PTWC and WC/ATWC

Established in 1949, the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, serves as the warning operations headquarters for the PTWS and works closely with sub-regional and national centres in monitoring and evaluating potentially tsunamigenic earthquakes. It provides international warning advisories for teletsunamis to countries in the Pacific, and warnings for Hawaii and US Pacific island interests. PTWC has provided interim

services for the Indian Ocean and the wider Caribbean since 2005. Established in 1964, the West Coast and Alaska Tsunami Warning Centre (WC/ATWC) provides warning services to the continental USA, Puerto Rico, the Virgin Islands, and Canada, and serves as a back up to PTWC. (http://www.prh.noaa.gov/ptwc) (http://wcatwc.arh.noaa.gov/).

Regional Expanding Tsunami Watch/Warning Bulletin (RWW)

A PTWC PTWS message issued initially using only seismic information to alert countries of the possibility of a tsunami and advice that a tsunami investigation is underway. In the Pacific, Tsunami Warning status will encompass regions having less than three 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.

Regional Fixed Tsunami Warning Bulletin

A PTWC PTWS message issued initially using only seismic information to alert all participants of the possibility of a tsunami and advise that a tsunami investigation is underway. The area placed in a Tsunami Warning status encompasses coastal regions within 1,000 km. of the earthquake epicentre. A Regional Fixed Tsunami Warning will be followed by additional bulletins without expanding the warning area until it is either upgraded or is cancelled.

Travel time and travel time map

Time required for the first tsunami wave to propagate from its source to a given point on a coastline. A travel time map shows isochrons or lines of equal tsunami travel time calculated from the source outwards toward terminal points on distant coastlines.

Tsunami Bulletin Board (TBB)

TBB is an ITIC-sponsored e-mail service that provides an open, objective scientific forum for the posting and discussion of news and information relating to tsunamis and tsunami research. The ITIC provides the service to tsunami researchers and other technical professionals for the purpose of facilitating the widespread dissemination of information on tsunami events, current research investigations, and announcements for upcoming meetings, publications, and other tsunami-related materials. All members of the TBB are welcome to contribute. Messages are immediately broadcast without modification. The TBB has been very useful for helping to rapidly organize post-tsunami surveys, for distributing their results, and for planning tsunami workshops and symposia. Members of the TBB automatically receive the tsunami bulletins issued by the PTWC, WC/ATWC, and JMA.

Tsunami Emergency Response (TER)

Tsunami Emergency Response (TER) describes the actions taken to ensure public safety by responsible agencies after notification by the Tsunami Warning Focal Point (TWFP), typically the national Tsunami Warning Centre. It includes Standard Operating Procedures and Protocols for emergency response and action, organizations and individuals involved and their roles and responsibilities, contact information, timeline and urgency assigned to action, and means by which both ordinary citizens and special needs populations (physically or mentally handicapped, elderly, transient, and marine populations) will be alerted. For tsunami response, emphasis is placed on the rapidness, efficiency, conciseness, and clarity of the actions and instructions to the public. A Tsunami Emergency Response Plan should also include post-tsunami actions and responsibilities for search and rescue, relief, rehabilitation, and recovery.

Tsunami Information Bulletin (TIB)

TWC message product advising the occurrence of a major earthquake 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 that indicates there is no tsunami threat.

Tsunami Warning

The highest level of tsunami alert. Warnings are issued by the TWCs due to confirmation of a destructive tsunami wave or the threat of an imminent tsunami. Initially the warnings are based only on seismic information without tsunami confirmation as a means of providing the earliest possible alert to at-risk populations. Warnings initially place a restricted area in a condition that requires all coastal areas in the region to be prepared for imminent flooding. Subsequent text products are issued at least hourly or as conditions warrant to continue, expand, restrict, or end the warning. In the event a tsunami has been confirmed which could cause damage at distances greater than 1,000 km from the epicentre, the warning may be extended to a larger area.

Tsunami Warning Centre (TWC)

Centre that issues timely tsunami information messages. The messages can be information, watch, or warning messages, and are based on the available seismological and sea level data as evaluated by the TWC, or on evaluations received by the TWC from other monitoring agencies. The messages are advisory to the official designated emergency response agencies. Regional TWCs monitor and provide tsunami information to Member States on potential ocean-wide tsunamis using global data networks, and can often issue messages within 10–20 minutes of the earthquake. Local TWCs monitor and provide tsunami information on potential local tsunamis that will strike within minutes. Local TWCs must have access to continuous, real-time, densely-spaced data networks in order to characterize the earthquakes within seconds and issue a warning within minutes.

An example of a Regional Tsunami Warning Centre is the Pacific Tsunami Warning Center which provides international tsunami warnings to the Pacific. After the 26 December 2004 tsunami, the PTWC and JMA have acted as an Interim Regional TWC for the Indian Ocean.

Examples of sub-regional TWC's are the NWPTAC operated by the Japan JMA, and the WC/ATWC operated by the US NOAA. In the Pacific, these centres, along with long-time national centres in Chile, France, and Russia, also act as national TWCs providing local tsunami warnings for their countries.

Tsunami Warning Centre Products

Tsunami Warning Centres issue four basic types of messages: 1) information bulletins when a large earthquake has occurred but there is little or no tsunami threat; 2) local, regional, or ocean-wide watch and warning bulletins when there is an imminent tsunami threat; 3) cancellation bulletins when destructive tsunami waves are gone; and 4) tsunami communication test messages to regularly exercise the system. Initial or local evaluations and messages are based only on the faster arriving seismic information, specifically earthquake location, magnitude, and depth. If a tsunami threat is large, estimated tsunami wave arrival times, and possibly wave height forecasts, are reported, and sea level records are examined to confirm tsunami generation. Watch and Warning Bulletins are updated regularly, or as needed, or cancelled when the threat is gone. In the Pacific, the types of messages issued by the PTWC include a Pacific-Wide Tsunami Warning Bulletin, Regional Expanding Tsunami Warning and Watch Bulletin, Regional Fixed Tsunami Warning Bulletin, Warning Cancellation Bulletin, Tsunami Information Bulletin, and Tsunami Communication Test Dummy Message.

Tsunami Bulletins issued by the PTWC for the PTWS

Messages currently issued by PTWC in its role as the operational centre for the PTWS are Tsunami Information Bulletins, Fixed Regional Tsunami Warning Bulletins, Regional Tsunami Warning/Watch Bulletin, and Pacific-wide Tsunami Warning Bulletin.

- ***Tsunami Information Bulletin*:** Message issued by PTWC to advise participants of the occurrence of a major earthquake in the Pacific or near-Pacific area, with the evaluation that a potentially destructive regional or Pacific-wide tsunami was not generated. In some cases there is a small possibility for a local tsunami to have been generated.
- ***Fixed Regional Tsunami Warning Bulletin*:** Message issued by PTWC based only on seismic information to alert all participants of the possibility of a regional tsunami and advise them that a tsunami investigation is underway. Those areas that are within 1000 km. of the earthquake epicentre are placed in a Tsunami Warning status. This warning area does not expand. The initial bulletin will be followed by additional bulletins until it is either upgraded to a Regional Tsunami Warning/Watch Bulletin or to a Pacific-wide Tsunami Warning or until it is cancelled.
- ***Regional Tsunami Warning/Watch Bulletin*:** Message issued by PTWC based only on seismic information to alert all participants of the possibility of a tsunami and advise them that a tsunami investigation is underway. Those areas that are within 0 to 3 hours from the estimated time of arrival of the first wave are placed in a Tsunami Warning status. Those areas within 3 to 6 hours are placed in a Tsunami Watch status. It will be followed by additional bulletins that expand the warning and watch areas appropriately based on the remaining times to ETA until it is either upgraded to a Pacific-wide Tsunami Warning or until it is cancelled.
- ***Pacific-wide Tsunami Warning Bulletin*:** Message issued by PTWC based only on confirmation of tsunami waves that pose a threat to coastlines in the Pacific located far (more than 1000 km.) from the tsunami source that is usually a major earthquake. It will be followed by additional bulletins until the situation is downgraded or the tsunami waves have crossed the entire Pacific and no longer present a threat.

Tsunami Watch

The second highest level of tsunami alert. Watches are issued by the Tsunami Warning Centres (TWCs) based on seismic information without destructive tsunami confirmation. The watch is issued as a means of alerting the affected populations located, for example, for the PTWS by PTWC, the criteria for a Watch is one to three hours tsunami travel time beyond the warned area. Subsequent text products are issued at least hourly to expand the watch and warning area, upgrade all areas to a warning, or cancel the watch and warning. A Tsunami Watch may be included in the text of the message that disseminates a Tsunami Warning.

UNESCO

United Nations Educational, Scientific and Cultural Organization. Established in 1945, UNESCO promotes international cooperation among its Member States in the fields of education, science, culture and communication. Today, UNESCO works as a laboratory of ideas and standard setter to forge universal agreements on emerging ethical issues. The Organization also serves as a clearinghouse that disseminates and shares information and knowledge, while helping Member States to build their human and institutional capacities in diverse fields. The UNESCO Constitution states, “Since wars begin in the minds of men, it is the minds of men that the defences of peace must be constructed.” (http://www.unesco.org/)

WDC(World Data Centre)

The WDC system was created to archive and distribute data collected from the observational programmes of the 1957–1958 International Geophysical Year. Originally established in the United States, Europe, Russia, and Japan, the WDC system has since expanded to other countries and to new scientific disciplines. The WDC system now includes 52 Centres in 12 countries. NGDC is co-located with the World Data Centre for Geophysics and Marine Geology which combines the responsibilities of the former WDC-Marine Geology and Geophysics and WDC-Solid Earth Geophysics into a single new data centre that manages global geophysical, sea floor, and natural hazards data. These data cover time scales ranging from seconds to millennia and they provide baseline information for research in many disciplines.
(http://www.ngdc.noaa.gov/wdc/wdcmain.html)