

ITSU-XX INTERSESSIONAL ACTIVITIES NATIONAL REPORT OF CHILE

Introduction

Chile is Member of the International Co-ordinating Group of the Tsunami Warning System in the Pacific. The local focal point is the Chilean Navy Hydrographic and Oceanographic Service (SHOA), located in Valparaíso. Many tsunamigenic earthquakes have been produced along the Chilean coast. They also have caused destructive effects over several communities through the Pacific. Since the creation of the Chilean Tsunami Warning System, most of the work has focused in the improvement of technology and operational methodology to achieve a better time of response for tsunami warnings. At the same time, Chile has learned about the experiences we had over the time, particularly from the devastating December 26, 2004, Andaman - Nicobar Islands Earthquake (Mw = 9.0) off western coast of northern Sumatra, Indian Ocean region.

BASIC INFORMATION

Note: Telephone numbers starting with 9 (after the country code 56) are emergency mobile phones and can be reached at any time during non-office hours.

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2. Primary Warning Recipient:

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3. Tsunami Advisors:

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Emergency Management:

The National Emergency Office through its local Emergency Committee is in charge of the tsunami mitigation procedures.

4. Local Tsunami Procedures:

SHOA is operating 24 hours per day, 7 days per week and has the responsibility to identify and characterize events that have the potential to generate local tsunami with the help of a TREMORS station, the Seismological Service of the University of Chile, the tide gauge network and a DART system located in the north of Chile, 286 nm offshore Pisagua, mooring at 5010 m of depth.

The threshold for declaring a potential local tsunami emergency is a magnitude $M_s = 7.5$ or a seismic moment (M_o) of $M_o = 5 \times 10^{21}$. When the earthquake occurs in the south part of Peru or north of Chile, a zone of a seismic gap, and DART system is activated, it has been confirmed the generation of tsunami waves. This information is sent to ONEMI also operating on a 24 hours per day basis and to all the Navy authorities, under high priority messages. They act locally in coordination to deal with the emergency.

The emergency situation is terminated when SHOA detects no sea level anomalies at the near-field mareographic stations. SHOA issue a tsunami bulletin: "tsunami warning or tsunami watch is cancelled".

5. Distant Tsunami Procedures:

The organization that identifies and characterizes tsunamigenic events from a distant source is SHOA. SHOA receive all messages from PTWC. Furthermore is able to get seismic moment data coming from the broadband station ELRO (TREMORS system) and location information from several sources through e-mail and web pages, seismic data coming from NEIC, PTWC bulletins, and DART

system and monitors sea level data from the islands stations, where any distant tsunami is recorded before reaching mainland Chile.

If the recorded tsunami waves have amplitudes of 2 meters or more, a Tsunami Warning is transmitted including arrival times to the coast using the Tsunami Travel Time software.

The information provided by PTWC is immediately routed to ONEMI and Maritime (Naval) Authorities who will start operating at a local level if a tsunami watch or warning is declared by the national TWS.

6. Sea Level Stations

<i>Station</i>	<i>Latitude °S</i>	<i>Longitude °W</i>
Arica	18° 29'	70° 19'
Iquique	20° 13'	70° 10'
Antofagasta	23° 39'	70° 25'
I. San Félix	26° 16'	80° 07'
Caldera	27° 04'	70° 50'
I. Pascua	27° 09'	109° 27'
Coquimbo	29° 56'	71° 21'
Valparaíso	33° 02'	71° 38'
San Antonio	33° 35'	71° 38'
I. J. Fernández	33° 37'	78° 50'
Talcahuano	36° 41'	73° 06'
Corral	39° 52'	73° 26'
P. Montt	41° 29'	72° 58'
Ancud	41° 52'	73° 51'
P. Chacabuco	45° 28'	72° 50'
I. San Pedro	47° 43'	74° 54'
P. Arenas	53° 10'	70° 54'
P. Williams	54° 56'	67° 37'

All station are Vaisala 555 C platforms

7. Information on tsunami occurrences during the period

In December, 26, 2004 at 00:58:50 UTC (21:58:50 local time) a great earthquake of magnitude $M_w = 9$ took place with epicentre located in latitude $3^\circ 17' 53''$ N and longitude $95^\circ 46' 44''$ E, offshore of the northwest coastal border of the island of Sumatra, Indonesia.

In Chile, the National Tsunami Warning System (SNAM) was activated immediately. The information was received from two PTWC informative bulletins. The first bulletin gave the event seismic parameters and a first evaluation of the possibility of propagation of a tsunami in the Pacific Ocean region.

In the second bulletin of the PTWC, emitted at 02:04:00 UTC (23:04 local time) it was informed that no tsunami threat existed for the Pacific Ocean. Under these antecedents, SHOA issued the corresponding message to ONEMI and published the information in the SHOA web page (www.shoa.cl).

As it is known, this earthquake produced a destructive tsunami in the southwest area of the Indian Ocean, that affected mainly to the island of Sumatra, Thailand, island of Sri Lanka and the south coast of India.

The December 26, 2004, Sumatra Island tsunami-earthquake was the fourth largest earthquake in the world since 1900 and the largest tsunami to occur after the Corral, Chile tsunami earthquake of 1960.

In Chile, on December 27, 2004, SNAM began to detect the Indian Ocean tsunami in some of the 18 tidal stations. In Corral, the station located more to south of the Chilean coast, the tsunami signal was recorded 26 hours after the Sumatra earthquake. The table shows the maximum amplitudes recorded at the different tide gauges.

	Maximun Amplitude (mts.)
ARICA	0.70
IQUIQUE	0.22
ANTOFAGASTA	0.30
CALDERA	0.20
COQUIMBO	0.42
ISLA SAN FELIX	0.10
ISLA DE PASCUA	0.40
VALPARAISO	0.23
TALCAHUANO	0.65
CORRAL	0.25

SUMMARY

Significant improvements have been made during the period to address tsunami risk in two general areas:

- (1) heightened public awareness of the tsunami threat and
- (2) improvement in communications.

1.1. Education efforts:

Since 1992, SHOA has been publishing educational textbooks on earthquakes and tsunamis with support from IOC. In addition, several tsunami pamphlets for the general public have been printed in Spanish, and English by SHOA, namely "Tsunami: The Great Waves", "Surviving a Tsunami: 11 lessons from the 1960 Chilean tsunami", and the Tsunami Glossary. In addition new colour versions of the educational textbooks for the first two educational levels and a new educational pamphlet called "The Infant buoy" have been published. Both can be found on the SHOA webpage.

Several meetings and seminars with the community and local emergency managers have been organized by SHOA in order to explain the applications of the Tsunami Inundation Maps.

2.1. Communications within the system:

During the intersessional period, regular tsunami test exercises has been performed with the Peruvian Dirección de Hidrografía y Navegación de la Marina de Guerra, the Navy Oceanographic Institute of Ecuador and the local sea level network.

2.2. Communication systems

- Main Network
 - Ministry of Interior Command Network (VHF - HF)
- Secondary Network
 - Maritime Authority Command Telecommunication Network
- SHOA Network
 - SHOA Telecommunication Network: Tsunami Operations room - Director - Oceanographers on Duty.

The National Emergency Office of the Ministry of Interior (ONEMI) is responsible for disseminating Tsunami Watches and Warnings to the general public. SHOA and ONEMI are linked by VHF and HF radios, in addition to the common communication systems. ONEMI and SHOA also work on a 24 hours basis monitoring any and all emergencies occurring in the country through these radio links.

NARRATIVE

A. DEVELOPMENTS OF THE NATIONAL TSUNAMI WARNING SYSTEM.

Tsunami Inundation Charts: Since 1996, after the TIME training course in Chile, the National Tsunami Warning System has been producing inundation charts of the main ports to help the Civil and Maritime Authorities to plan and mitigate the effects of a tsunami. During the period 1997-2004, twenty eight charts have been produced under the project "Processing of Inundation Maps by Tsunamis for the Chilean Coast". The cities included in these charts are: Arica, Iquique, Tocopilla, Mejillones, Antofagasta, Taltal, Caldera, Chañaral, Huasco, Coquimbo, La Serena, Los Vilos, Papudo, Quintero, Valparaíso, Viña del Mar, Algarrobo, San Antonio, Constitución, Talcahuano, Penco, Lirquén, Tomé, San Vicente, Coronel, Lebu, Corral y Ancud.

A second stage to continue with the development of inundation maps, CITSU II project, including far field simulation and wave propagation of coastal tsunami earthquakes toward insular areas of Easter and Juan Fernandez islands, will be carried out during 2006 – 2010 period.

Publications: During the period several publications have been distributed as follows:

Maremoto del 22 de mayo de 1960 en las Costas de Chile, 2ª. Edición, SHOA N° 3012, 2000. (Tsunami of May 22th, 1960 along the coast of Chile)

Instrucciones Generales sobre el Sistema Nacional de Alarma de Maremotos, 4ª. Edición, SHOA N° 3203, 2000. (General Instructions about the National Tsunami Warning System). This publication has been review and updating with new procedures, and is available in SHOA web.

Cómo sobrevivir a un tsunami. Once lecciones del tsunami ocurrido en el sur de Chile el 22 de mayo de 1960. SHOA, 2000. (How to survive a tsunami. Eleven lessons from de May 22, 1960 tsunami at southern Chile). This publication in English version will be distributed during the ITSU XX Session in Viña del Mar Chile and can be found in Spanish version at SHOA web site: <http://www.shoa.cl/shoa/publicacionesespeciales.htm>.

Tsunamis, Las Grandes Olas. Translated from the English version: Tsunami, The Great Waves. This publication can be found at SHOA web site: <http://www.shoa.cl/shoa/publicacionesespeciales.htm>.

ITIC Web page: In cooperation with the Associated Director of ITIC, SHOA have incorporated to the page all the following publications:

Colored version of "Earthquakes and Tsunamis, pre-elementary school textbook", in Spanish.

Colored version of " I invite you to know the Earth I" in Spanish.

The Tsunami Glossary, in English and Spanish.

The Infant Buoy, animated in Spanish.

Instrumental and technical developments.

In order to give the tsunami early warning capability to the NTWS, a DART buoy system was deployed with the help from PMEL and NDBC on board of the R/V Roger Revelle, in November 2003, offshore of the northern coast of Chile (285 nm from Pisagua) where there is a big seismic gap. A second Dart buoy will be deployed in 2006.

B. EXPERIENCES IN THE OPERATION OF THE TWS

Communication tests: once every other month a tsunami dummy exercise is performed with all the tide gauge stations.

Periodically communication tests with Peru's Dirección de Hidrografía y Navegación are performed in order to improve the response of both national systems.

Tsunami Watches and Warnings: No tsunami watches or warnings were declared during the period.

C. MEETINGS, SEMINARS, WORKSHOPS AND OTHERS:

VIII International Congress "Earth Sciences 2004": This congress organized by the Military Geographical Institute was held on 7-11 August, 2004 in Santiago, Chile. One session was dedicated to present the paper: "THE INUNDATION MAP AS TOOL FOR DESIGN AND INSTALL A TSUNAMI EARLY WARNING SYSTEM : ARICA CITY, CHILE". Using the map, Emergency Office of Arica (EOA) it has designed a Hazard and Resources Map for each tsunami risk zone. Two areas are distinguished: first, all tsunami inundation zone along the Arica coast. The second area, is defined by a security line that mark the whole non tsunami exposed zone.

Tsunami Emergency and Evacuation Plan of Arica, prepare and educate the population for alert, coordinate, evaluate, resolve and take plans decision integrated to government and local emergency agencies actions, so that the population knows what to make according to the area it lives. To assure the effectiveness of the plan, EOA has implemented a system of alarm of Tsunami with sirens of early alert, to guide the whole population in front of a possible tsunami event.

When the SNAM (National Tsunami Warning System of SHOA) issues a Distant Tsunami Watch, Arica Local Emergency Office and Local Committee of Civil Defense notify various government response agencies. Conference bridge discussions take place with these groups and Volunteer Tsunami Scientific Advisors to determine whether the Tsunami Watch should be upgraded to a Warning or cancelled. When SNAM issues a Tsunami Warning, the Committee of Civil Defense initiates evacuation of the coastlines. The EOA administrator and Fireman Department then activate sirens and the Tsunami Emergency Alert System of Arica announcing evacuation. When the SNAM issues an Urgent (local) Tsunami Warning, fireman designated immediately activate sirens system and EOA broadcasts a Tsunami Warning message to immediately evacuate the coastlines or evacuate vertically from the 3rd floor and above in steel/reinforced concrete structures. The sound of Arica sirens is the local Standard alert signal (a two minutes steady signal)

that prompts people to turn on their radio, which carries the evacuation notice and refers the public to the evacuation maps in the telephone book.

Several seminars have been carried out with the communities of the coastal communes of the central Chilean region in that the SNAM operation and the application of the flood maps has been explained.

D. FUTURE PLANS

Within the operative context, SNAM don't have the technical operability yet to estimate in real time the potential impact of tsunami waves arriving to the chilean coast. It is necessary to design a support methodology for the forecast of run-ups of near and far field events in real time.

The specific goals for the 2006 – 2010 period are: (1) to continue with the development of inundation maps (CITSU II), including far field simulation and wave propagation of coastal tsunami earthquakes toward insular areas of Easter and Juan Fernandez islands, for which it is necessary to improve the modelling technique, using better resolution grids, stability of numerical computation for extreme seismic parameters and border conditions in the grid boundary through Phase – II of TIME project, and (2) to design and implement an operative methodology for the SNAM, in order to estimate the potential impact of tsunami waves on the chilean coast, based on real time data of sea level obtained from stations located close to the source and from DART buoys (Humboldt II project).

VALPARAISO, August 2005