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TSUNAMI NEWSLETTER

International Tsunami Information Centre

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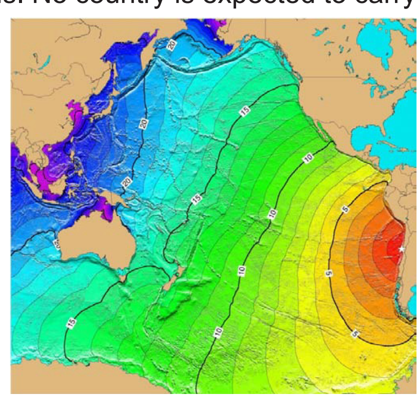
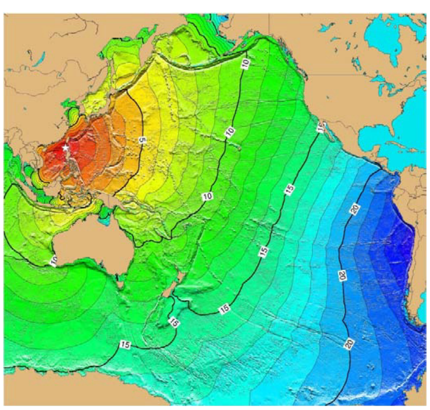
Duo-Scenario planned for Excercise Pacific Wave 06

The exercise, to be conducted in mid-May, will simulate Pacific countries being placed into a tsunami warning situation, and require Member State decision-making in all steps prior to public notification. These steps may be played during the exercise dates or the following days. The exercise scenario will use two originating earthquake source regions in the eastern and western Pacific Rim. A Tsunami Warning Cancellation will be issued as the wave nears the central Pacific. At least three tsunami warning centres will issue exercise bulletins in a compressed time schedule, including the U.S. Pacific and West Coast/Alaska Tsunami Warning Centers, and the Japan Meteorological Agency Northwest Pacific Tsunami Advisory Center.

A sessional Task Team of the ICG-ITSU-XX has developed the guiding principles for planning and conducting *Exercise Pacific Wave 06*, and will be overseeing the exercise. The aim is to exercise the operational lines of communication within the PTWS without disrupting or alarming individual citizens. No country is expected to carry out any level of drills with the general public. Member countries will, however, be encouraged to exercise, evaluate and report back on communication and decision making within a warning situation down to the level just prior to public notification. Each country will decide and design its own national exercise that begins upon receipt of the first test message from the warning centers. The exercise is not to be considered as a one-time event, but as the first of recurring exercises, that take place once each year, or once each intersessional period.





Participating Member States are expected to share information regarding the procedures applied and lessons learned during the exercise. Outcomes and performance measures will be collected using a standard instrument and at a minimum include:

a. How each Member State received the warning (e.g., GTS, fax, email),

b. Elapsed time between when the bulletin is issued and when it is received and recognized,

Exercise Pacific Wave 06, *continued*

c. *What assessment tools are applied for decision-making about evacuations,*
d. *How the public would be notified and instructed,*
e. *Elapsed time until public would be notified and instructed,*
f. *Summary of each Member State's National emergency plan for tsunamis including any chapters on exercises,*
g. *Feedback from stakeholders regarding their performance and that of information providers, and*
h. *Media response.*

PTWS National Contacts will be responsible for collecting results of their Member State and providing them to the Task Team. A report will be made by the ICG/PTWS Chair at the XX Session of the IOC Executive Council on June 24, 2006.

SUMMARY OF EARTHQUAKES

Occuring January–April 2006

With surface wave or moment magnitude (M_w) greater than or equal to 6.5 and a depth no greater than 100 km, or an event for which a Tsunami Information Bulletin (TIB) or Regional Watch Warning (RWW) was issued. Epicenter, and M_W from USGS National Earthquake Information Center (NEIC, G); M_W, and centroid depth from Harvard (H); M_W from PTWC (P) at action time.

DATE	TIME (UTC)	LOCATION	EPICENTER	DEPTH (km)	M_w	PTWC ACTION	ACTION TIME	TSUNAMI? DAMAGING?	Maximum height and place
Jan 2	6:11	Southwestern Atlantic Ocean (East of the Sandwich Islands)	60.934° S 21.575° W	10	7.4 (H) 7.3 (P) 7.1 (G)	TIB	6:48	No	
Jan 2	22:14	Fiji Islands Region	19.926° S 178.178° W	583	7.2 (H) 7.1 (G) 7.0 (P)	TIB	22:28	No	
Jan 4	8:33	Gulf of California	28.164° N 112.096° W	14	7.0 (P) 6.6 (H) 6.5 (G)	TIB	8:33	No	
Jan 23	6:03	Vanuatu Islands	17.423° S 167.708° E	32	6.6 (P) 6.4 (G) 6.3 (H)	TIB	6:23	No	
Jan 27	16:49	Banda Sea Indonesia	5.482° S 128.093° E	397	7.7 (P) 7.6 (G,H)	TIB	17:13	No	
Feb 22	22:19	Mozambique	21.259° S 33.480° E	11	7.2 (P) 7.0 (G,H)	TIB	22:35	No	
Mar 14	6:58	Seram Indonesia	3.596° S 127.211° E	30	6.8 (P) 6.7 (G, H)	TIB	7:10	Slight, No	40 cm, Buruk Island
April 20	23:25	Eastern Siberia (Koryakia), Russia	61.075° N 167.085° E	22	7.7 (P) 7.6 (H) 7.3 (G)	TIB	23:40	No	
April 29	16:58	Eastern Siberia (Koryakia), Russia	60.479° N 167.519° E	12	6.8 (P) 6.6 (H) 6.6 (G)	TIB	17:08	No	

SERAM INDONESIA M_W=6.7, 14 March 2006, 6:58 UTC

An earthquake of magnitude M_w 6.7 (Hrv) occurred on March 14, 2006 at 3:58 local time, 105 km from Ambon, Moluccas, Indonesia, just offshore of Buru Island, Molucca-Indonesia.

Post-tsunami surveyor measuring indication of wave along the side of a building in a coastal village on Buru Island. (Photo courtesy of Yudicara)

News sources reported one person killed on Buru, with another two people killed, one injured and one missing due to a local tsunami. The observed wave height was given as 5 meters (peak-to-trough), with maximum runup approximately 100 meters from the shore.

In a post-tsunami assessment, Yudhicara, Directorate of the Center for Volcanology and Hazard Mitigation in Bandung, Indonesia, noted that houses were destroyed, but none appeared to be washed away. Wave traces could be seen on buildings up to 40 cm from the ground in a village less than 1 meter above sea level. Some liquefaction was 1 m in diameter and 40 cm deep. Concurrently, Indonesian agencies with tide data found that none of three stations in the area recorded signs of a tsunami, but that a GLOSS station in Ambon showed a small disturbance that was difficult to identify as a tsunami wave.

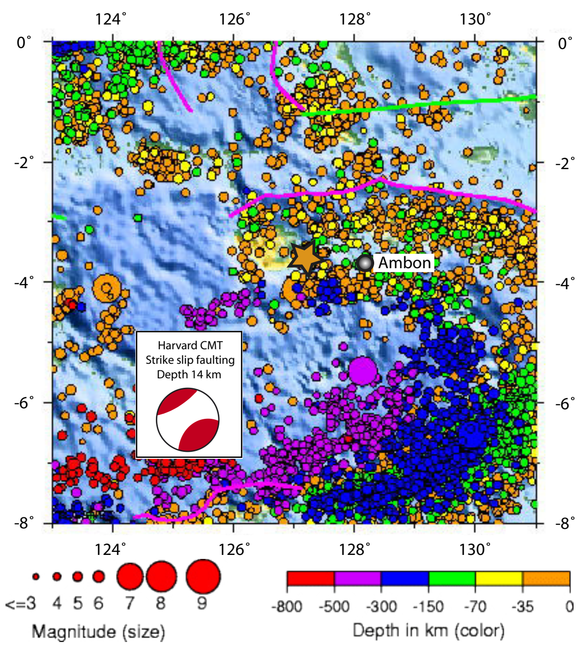


Figure 1. Historical Seismicity (from 1990-present) of the region from National Earthquake Information Center (NEIC). The orange star indicates the 14 March earthquake epicenter.

Political map showing the area of Indonesia affected by the recent earthquake.

IOC NEWS

First Session of the IOC Intergovernmental Co-ordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean Sea and Adjacent Regions (ICG/CARIBE–EWS)

Bridgetown, Barbados, 10-12 January 2006

The First Session of the IOC Intergovernmental Co ordination Group for Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions was attended by nearly 70 participants from 26 countries in the Caribbean Region, six organizations, and five observers. The Meeting ensured that Caribbean Member States are fully informed, at the technical level, on tsunami and coastal inundation warning and mitigation programmes at the national, regional and global levels. The Meeting adopted a series of conclusions and recommendations that provide guidance to all partners regarding the required actions that will lead towards the establishment and consolidation of the Tsunami and Other Coastal Hazards Warning System for the Caribbean Sea and Adjacent Regions.

In order to meet these objectives, the group elected a Chair and two Vice-Chairs of the ICG. Acting in the

Barbados, *continued*

capacity of Chair will be Mr. Paul Saunders, of Trinidad & Tobago (Office of Disaster Preparedness and MGMT). The two Vice-Chairs will be Mr. Israel Matos of the USA (National Weather Service, San Juan) and Mr. Gustavo Malave of Venezuela (Funcación Venezolana de Ivestigaciones de Sismología or FUNVIS).

Similarly, by the end of the meeting, four intersessional working groups were established; Group 1–Tsunami and Coastal Inundation Hazard Risk Assessment and Research): Chair: Mr. Aurelio Mercado (University of Puerto Rico, USA), with Vice-Chairs: Mr. Hernan Perez-Nieto (Comision Nacional de Oceanologìa, Venezuela) and Mr. Jeffrey Simmons (Bahamas Department of Meteorology, Bahamas); Group 2–Monitoring and Detection Systems, Warning Guidance: Chair: Mr. Carlos Fuller (National Meteorological Service, Belize), with Vice-Chairs: Mr. Douglas Wilson (IOCARIBE- GOOS, USA), and Ms. Christa Von Hillebrandt (Puerto Rico Seismic Network, USA); Group 3–Warning, Dissemination & Communication, Chair: Mr. Roy Watlington (UN Environment Programme–University of the Virgin Islands), Vice-chair: Mr. Richard Robertson (University of the West Indies, Trinidad & Tobago); and Group 4–Preparedness, Readiness, and Resilience, Chair: Mr. Paul Saunders (ODPM, Trinidad and Tobago), with Vice-Chair, Mr. George A. Maul (IOCARIBE GOOS, USA).

Discussing mitigation are (left to right) Paul Saunders (Chair, ICG/CARIBE–EWS), Roy Watlington (Chair, Working Group 3) and George Maul (Vice–Chair, Working Group 4).

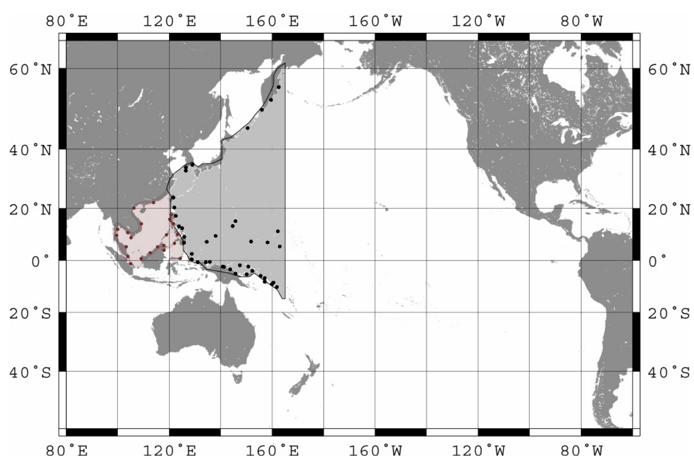
One of the sessions covering an aspect of the agenda at the first session of the ICG/CARIBE–EWS in Barbados.

The complete meeting and other documents related to the meeting, can be found at ***http://ioc3.unesco.org/cartws***.

ICG/PTWS NEWS

Northwest Pacific Tsunami Advisory Center Inaugurated and Service Expands

On 1 February 2006, the Northwest Pacific Tsunami Advisory Center (NWPTAC), was formally inaugurated. Under the auspices of the Japan Meteorological Agency (JMA) the NWPTAC began operations on an interim basis on 28 March 2005. The NWPTAC advisory is the product offered, which provides earthquake and possible tsunami information to recipient countries. Issued in conjunction with PTWC bulletins, (sent by the Pacific Tsunami Warning Center in Ewa Beach, Hawaii), each advisory contains earthquake information, including analysis of tsunamigenic potential, estimated wave heights, estimated arrival times, and notes any observed tsunami information.



NWPTAC advisory coverage area is now expanded from the light grey shaded area to include the South China Sea area indicated by the red shaded area. The NWPTAC, which has been operational since March 2005 was officially inaugurated on 1 February 2006. On 1 April 2006, the area of coverage expanded from 13 coast blocks to 23 coast blocks and from 41 forecast blocks to 63 forecast blocks.

The advisory is available to nations in the region who have designated a 7/24 Tsunami Focal Point for its receipt. A handbook describing the details of the tsunami advisory issued by the NWPTAC, was prepared by JMA. The handbook explains the type of earthquake data obtained in the advisories and will be used in training courses. A meeting took place on 14 March in Ewa Beach, to coordinate messaging between the new JMA advisory and PTWC bulletins.

To encourage a fuller dialogue on the tsunami and earthquake risks of the South China Sea Region and the requirements for a permanent tsunami early warning and mitigation system for this region, the IOC was pleased to announce a regional symposium planned for 27-28 April 2006 in Kuala Lumpur, Malaysia. The Round–Table Dialogue on Earthquakes and Tsunamis was organized and hosted by the Malaysia Ministry of Science, Technology & Innovation, and took place just prior to the meeting of the ICG/PTWS-XXI in Melbourne, Australia 1-5 May 2006 (*see article on*

NWPTAC, *continued*

page 9).

A communication test of the new messaging service was conducted on 22 March 2006. Firstly, at 2:00 UTC a test message went out via FAX, or GTS. Ten minutes later, at 2:10 UTC, dissemination of the test message was made via e-mail. Each of the organizations listed by country below participated and returned a test evaluation form. The chart summarizies the outcome of the test through the channels used. The results are those reported on the evaluation form returned to JMA from the various organizations. An entry of 'not received' is a failure to receive the message, whereas 'No reply' indicates a place where the evaluation form was left blank.

Results of the first NWPTAC Advisory Communications Test

Country	Organization	Communication Methods	3/22/2006 TEST o=okay, X='failed to receive'	Received Time (UTC)
People's Republic of China	National Marine Environmental Forecasting Center	FAX	o	No reply
	Hong Kong Observatory	GTS FAX E-mail	o o o	2:00 2:04 2:12
Republic of Indonesia	Meteorology & Geophysical Agency	GTS FAX1 FAX2 E-mail1 E-mail2 E-mail3 E-mail4	o o o - - - -	No reply No reply No reply No reply No reply No reply No reply
Republic of Korea	Earthquake Division, Climate Bureau, Korea Meteorological Service	GTS FAX E-mail	o o o	2:00 2:03 2:13
Malaysia	Malaysian Meteorological Service	GTS FAX1 FAX2 FAX3 E-mail1 E-mail2	o x o o o o	2:00 Not received 3:01 3:01 2:13 2:13
Independent State of Papua New Guinea	Port Moresby Geophysical Observatory	FAX E-mail	o o	1:03 2:19
Republic of the Philippines	Seismologic Observations and Earthquake Prediction Division, Philippine Institute of Volcanology and Seismology	FAX E-mail	o -	2:05 No reply
Russian Federation	Yuzhno-Sakalinsk Tsunami Warning Center	GTS FAX E-mail	o o o	2:01 2:06 3:33
Singapore	Meteorological Services, National Environment Agency	GTS FAX E-mail	o o o	1:59 2:02 6:12
Thailand	Thai Meteorological Department	GTS FAX1 FAX2 FAX3 E-mail1 E-mail2 E-mail3	o o o o - - -	2:01 2:03 2:03 2:03 No reply No reply No reply
	National Disaster Warning Center	FAX1 FAX2 E-mail1 E-mail2	x o - -	Not received 5:10 No reply No reply
Socialist Republic of Viet Nam	Institute of Oceanography	FAX E-mail1 E-mail2	o o o	2:05 4:00 4:00

ICG/PTWS Seismic Working Group Meeting, Honolulu, Hawaii, USA, 15-16 March 2006

The Seismic Measurements, Data Collection and Exchange Working Group One (WG1), met on 15-16 March 2006 in Honolulu, Hawaii, USA to build upon the recommendations made in Chile and to evaluate the strengths, weaknesses, and improvements to the seismic monitoring and evaluation capabilities of the Pacific Tsunami Warning and Mitigation System (PTWS). Through the course of several presentations and much discussion, the Working Group (WG) made thirteen recommendations for PTWS. Many, if not most, of the recommendations have application for the tsunami warning centres of other ocean basins. The WG also identified promising new technologies that should be incorporated into the warning system as these data become available.

The WG was chaired by Dr. Stuart Weinstein of the Pacific Tsunami Warning Center (PTWC). Throughout the meeting, the 14 participants vigorously deliberated on the information presented, asking questions and discussing the merits and limitations of the many standards, techniques, and processing methodologies available for real-time earthquake source characterization to support tsunami warnings.

Through collective discussion and agreement on the afternoon of the 16th, in which all of the WG participants made valuable comments and suggestions, the WG concluded with the following recommendations:

1. *The WG highly recommended that regular scientific symposia are convened to focus on improving tsunami warning systems and their operational procedures. The WG noted that the IUGG Tsunami Commission has convened such meetings on tsunami research, but not on operational systems, and further noted the need and high value for such symposia on real-time seismology.*
2. *The WG recognized that the international tsunami warning system depends largely upon the real-time seismic waveforms made available by the Global Seismographic Network (GSN), and noted that this scientific network is funded largely by the US National Science Foundation (NSF) and the US Geological Survey (USGS). The WG also recognized the important contributions made by international and Member State organizations toward GSN. However, the WG noted that the function of these organizations is primarily for earthquake monitoring and research, and not tsunami warning. The WG, thus, strongly stated that it is essential that the GSN and other contributing networks should be sustained at high levels of operational reliability for tsunami warning.*
3. *The WG stated that open and unrestricted access to real-time data is essential for both research and operations. These data include seismic and sea level time series.*
4. *The Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) presently provides its primary station and hydro-acoustic data to tsunami warning centres. The WG noted its high value as presented by the Japan Meteorological Agency (JMA) and PTWC, and recommended that this data flow be continued. The WG also recognized the importance of auxiliary station data for tsunami warning, and recommended that these be also made available in real time.*
5. *The CTBTO shares its Global Communications Infrastructure (GCI) with the GSN, and this telemetry is vital for tsunami warning systems. The WG recommended that the IOC recognize and encourage that this important cooperation with CTBTO continue.*
6. *The WG recognized and recommended that the GSN constitute the basis for the Pacific Core Network, and agreed that additional stations will add density to the network. Added density, such as in the Southwest Pacific, South China Sea, and seaward of major seismogenic zones, will be very valuable.*
7. *The WG recognized that the best seismometers for determining the tsunamigenic potential of an earthquake are Streckeisen STS-1. Therefore, the WG stated that it is imperative for Member States with STS-1 sensors to share the data in real time.*
8. *The WG was concerned that STS-1 sensors are no longer being manufactured, and that no adequate replacement is in sight. Furthermore, existing deployed sensors are aging. The WG finds it is necessary for the continued integrity of the tsunami warning system that a successor be developed as soon as possible.*
9. *The WG recognized that research plays a fundamental role in developing better ways of characterizing earthquakes and their potential for tsunamigenesis, and that it is critical that this research be developed into operational tools. The WG recommended that these tools should be openly shared with earthquake monitoring centres and tsunami warning centres.*
10. *The Pacific Tsunami Warning Center provides timely international tsunami warnings for tele- and regional tsunamis. However, the WG recognized the limitations of the PTWC to provide local tsunami warnings, and recommended each Member State consider*

WG1 meeting, *continued*

national or coordinated sub-regional tsunami warning centres to address local tsunami hazards. The WG encourages Member States with local capabilities to share their know-how and experience.

11. *The WG recognized the high value of providing guidance on the establishment of local warning capabilities, and recommended this issue be addressed by the Working Group on the Medium-Term Strategy for the Pacific Tsunami Warning and Mitigation System.*
12. *The WG recognized that all seismic coverage is from land-based seismic stations, and that almost no coverage is available seaward from the major seismogenic zones around the Pacific. The WG noted that this is a fundamental gap in the PTWS' ability and speed to characterize the earthquake source in near real-time. It was recognized that extensive deep-ocean tsunami infrastructure is being developed and deployed to monitor sea levels in real time. The WG recommended that enhancing these systems with seafloor seismic and acoustic sensors should be explored and developed.*
13. *Areas of the southwest Pacific face a significant threat from locally-generated tsunamis that needs to be addressed. The WG reaffirmed the Action Plan developed by eight SOPAC Member States during the South Pacific Tsunami Awareness Workshop in July 2004.*

The full report is available at ***http://ioc3.unesco.org/ptws/working_groups_other_tsunami_meetings.htm.***

Thailand Tsunami Curriculum Development and Disaster Preparedness in Primary Schools

It is widely recognized that primary school education is one of the key elements in long term disaster risk reduction strategies. School children can play an important role in real life situations if disaster risk reduction is integrated as part of the school curriculum. To address this vital need, the IOC provided $160,000 of IOTWS Flash Appeal funds to the Asian Disaster Reduction Center (ADRC) to undertake and complete a Thailand tsunami curriculum and disaster preparedness project by the spring of 2006.

Five Thailand schools were destroyed by the December 2004 Indian Ocean Tsunami. Fortunately, no students were killed because the event occurred when no school was in session. However, Thailand's Ministry

Thai students learn about plate tectonics from newly developed tsunami curriculum for Thailand.

Students at the Tab Lamu School in Phang Nga Province practice vertical evacuation into the school's reinforced concrete building.

Thai schools, *continued*

of Education acknowledged that their school system is not prepared for future tsunami events because 1) no curriculum exists to teach students about tsunami hazards and safety procedures, and 2) no coastal schools have emergency evacuation plans in the event of an approaching tsunami.

To contribute to the development of tsunami educational materials, ADRC, in collaboration with experts from UNESCO/IOC, UNICEF, UN/ISDR, Kyoto University and Hyogo Prefecture Education Board (Japan), teamed with concerned government agencies, such as the Thailand Ministry of Education and Ministry of Interior, to compile and review existing materials on tsunami and other natural hazards. The ADRC drafted pilot materials in English, which were subsequently translated into Thai languages. Initially, a committee of experts met in Bangkok on 19 January 2006 to provide consultation on the contents of the tsunami disaster education materials. A second, 3-day Phuket workshop was convened from 1-3 March to target two primary schools (4th to 6th grades) in the coastal provinces of Phuket and Phang Nga. The purposes of the seminars were to:

(1) impart scientific information about tsunami and disaster preparedness to teachers,

(2) disseminate the developed materials and teaching know-how, and,

(3) introduce the tsunami evacuation drill in schools.

The main activities of the seminar were to:

(1) provide expert lecture knowledge about tsunami and preparedness,

(2) explain the contents of tsunami education materials and teacher guide,

(3) explain to the pilot classes the concept of tsunami evacuation drills, and,

(4) draft an example evacuation drill exercise.

Unprecedented emergency tsunami evacuation drill plans were formulated with the pilot school principals and teachers. The evacuation plans were explained to the school children by their teachers, and then drills were successfully executed.

Both schools were encouraged to write tsunami evacuation plans that included both vertical and horizontal evacuation options that could be implemented based on review of (a) how much notification time they have to react to an approaching tsunami, and (b) how much time it takes for a school's safe evacuation. Horizontal, inland evacuation was recommended when there is ample time to execute such an evacuation to completely exit a coastal impact zone. However, if there is little time for evacuation before a tsunami wave arrival, vertical evacuation to the highest floors is recommended in reinforced concrete structures.

Tab Lamu School in Phang Nga Province, with over 100 students, conducted a simple vertical evacuation drill into a newly built, reinforced concrete school building. The campus is located along a flat coastal area surrounded by dense jungle, with no high ground nearby. It took 15-20 minutes to complete the evacuation.

Kalim School in Phuket Province conducted a horizontal, inland evacuation starting from the coastline. About 30 students climbed up a hill to a designated safe area on higher ground. Because the school is in a low-lying area, some distance from the hill, the evacuation took approximately 30-45 minutes to complete.

The concept of school evacuation drills was new to the two Thai pilot schools because fire drills are not routinely conducted.

Finally, on 7 April, a one-day Phuket workshop was held to introduce tsunami classroom materials and the tsunami evacuation drill concept to about 100 Thai educators from the coastal provinces impacted by the 26 December 2004 tsunami. During the workshop, discussion focused on the two pilot schools evacuation drills. Other teachers showed great interest in conducting drills at their schools. The Thai curriculum materials introduced will be included as part of the IOC's TsunamiTeacher project. It comprises both a student course manual and a teacher's guide.

Students at Kalim School in Phuket Provice participate in an evacuation drill from the school's coastal location to a safer area on higher ground.

International Round–Table Dialogue on Earthquake and Tsunami Risks in Southeast Asia and the South China Sea Region, Kuala Lumpur, Malaysia, 27-28 April 2006

By Prof. Dr. Ho Sinn Chye, Director, National Oceanography Directorate (NOD) Ministry of Science, Technology and Innovation, Ground Floor, Block C5, Parcel C Federal Government Administrative Center, 62662 Putrajaya. 03-88858883, scho@mosti.gov.my

The Ministry of Science, Technology and Innovation (MOSTI), Malaysia organized and sponsored the International Round–table Dialogue on Earthquake and Tsunami Risks In Southeast Asia and The South China Sea Region, held in Kuala Lumpur on 27–28 April 2006. Co-sponsors included the UNESCO-IOC International Tsunami Information Centre (ITIC) and the Organization of Islamic Conferences (OIC). The international conference was organized by a local organizing committee comprising representatives from the National Oceanography Directorate, MOSTI and the Malaysian Meteorological Department (MMD).

The Round–table was officiated by the Honorable Dato' Sri Dr. Jamaludin Mohd. Jarjis, Minister of MOSTI. Thirty-one participants came from 21 countries including Australia, Bangladesh, Cambodia, China, India, Indonesia, Pakistan, Malaysia, Maldives, Myanmar, Philippines, Singapore, Thailand and Vietnam. In addition, 40 representatives from local Malaysian agencies and institutes of higher education were present.

Altogether 27 papers were delivered; 5 were on seismic and tsunami risk, 11 on preparedness and mitigation, 3 on the subject of modeling and eight national reports were also presented from Malaysia, Cambodia, Indonesia, Myanmar, Philippines, Singapore, Thailand and Vietnam.

A joint statement was prepared and endorsed by the round–table delegates, and a report made to the ICG/PTWS-XXI. It follows in its entirety.

JOINT STATEMENT

Objectives of the Meeting:

1. *To assess earthquake and tsunami and vulnerability in Southeast Asia and the South China Sea region,*
2. *To review the level of preparedness and mitigation measures in place and identify gaps/weaknesses,*
3. *To identify opportunities to strengthen regional and international partnerships, networking and capacity building.*

Attendees to this International Round-Table Dialogue on Earthquake and Tsunami Risks in Southeast Asia and the South China Sea Region represented the countries of the region, including Australia, Bangladesh, Cambodia, China, India, Indonesia, Pakistan, Malaysia, Maldives, Myanmar, Pakistan, Philippines, Singapore, Thailand, Vietnam, tsunami warning centre and disaster preparedness organizations of the Asian Disaster Preparedness Center (ADPC), Japan Meteorological Agency (JMA), University of Hawaii Sea Level Center (UHSLC), and USA Pacific Tsunami Warning Center (PTWC), seismological and tsunami experts from Canada, Northern Ireland, Russian Federation, Turkey, and the USA, the IOC of UNESCO and its Tsunami Unit, the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS), the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS), the GLOSS Group of Experts, and the International Tsunami Information Centre, and the private sector.

Over a period of one and a half days, Round–Table attendees shared information on the earthquake and tsunami hazards of Southeast Asia and the South China Sea, and the Indian Ocean, discussed the implications of the tsunami hazard on coastal communities and the ways in which to mitigate the earthquake and tsunami hazard in order to save lives and reduce property damage.

Background

In developing an action plan, the attendees recognize that arrangements for operation and establishment of international and regional tsunami warning systems are under the leadership of the IOC of UNESCO. IOC coordinates activities globally through tsunami warning and mitigation systems in the Indian Ocean (ICG/IOTWS), the Caribbean and vicinity (ICG/CARIBE-EWS), and the northeastern Atlantic, Mediterranean, and connected seas (ICG/NEAMTWS), and the Pacific (ICG/PTWS).

Earthquake and tsunami hazards exist in the Indian Ocean, Andaman Sea, the Philippine Sea, Bohai Sea, East China Sea, South China Sea, Java Sea, Sulawesi [Celebes] Sea, Mindanao Sea, and Sulu Sea. The tsunami travel times across these seas are, in many cases, on the order of only an hour or two and consequently require a dense network of instrumentation and real or near real time data.

In particular, the Twentieth Session of ICG/ITSU [now ICG/PTWS] in October 2005, recognized that the South China Sea region is vulnerable to destructive tsunamis and requested both the PTWC and the JMA provide interim tsunami advisory services for the South China Sea and develop a communication plan for the South China Sea.

Malaysia Round–table, *continued*

Also, the ASEAN Task Force for Tsunami Early Warning identified seismic data (July 2005) and sea level data (April 2006) to be shared amongst Member States to enable the earliest of tsunami warnings.

In addition strong common links exist between the ICG/PTWS and other operational programmes of the IOC and WMO, including the Global Sea Level Observing System (GLOSS), the Global Telecommunication System (GTS), and the global Geostationary Meteorology Satellite System, operated by European Space Agency, the Japan Meteorological Agency, and the US National Oceanic and Atmospheric Administration.

Action Plan As a result of the round-table dialogue, the following Action Plan was agreed upon:

1. *Continue the significant progress on assessing earthquake and tsunami and vulnerability in Southeast Asia and the South China Sea region through the support of national and international research initiatives including historical and paleotsunami assessments.*
2. *Although substantial progress has been made in some countries with regard to tsunami preparedness and mitigation, there are still some gaps and weaknesses, and the countries within the region should continue efforts to address these shortcomings and to raise the general level of preparedness.*
3. *Build on the regional partnerships that have been developed and strengthen international partnerships through membership and active participation in ICG/PTWS and/or ICG/IOTWS.*
4. *Ensure long term sustainability by implementing an end-to-end framework in a multi-hazard context.*
5. *Urge ICG/PTWS to continue to focus on establishing regional TWS capabilities to cover the South China Sea region.*
6. *Countries in the region to improve sea level coverage in the South China Sea.*
7. *Promote the free and open exchange of real time seismic and sea level data and information to be used for national tsunami warning and event monitoring.*
8. *Southeast Asia and the South China Sea region should utilize or build on the PTWS, IOTWS and other existing organizations and institutions in order to achieve durability.*
9. *Request each country in the region to provide a 7x24 Tsunami Warning Focal Point to the ICG/PTWS Secretariat, ITIC, to receive tsunami warnings issued by the JMA and PTWC.*
10. *Countries in the Southeast Asia and the South China Sea region should continue to improve their instrumentation and provide the resulting data and information in real time to PTWC and the JMA.*
11. *Request the ITIC continue to provide advice on the establishment of National Warning Systems, including especially public awareness and education.*
12. *Request the WMO and its Member National Meteorological Services continue to support the IOC through warning products and data exchange through its Global Telecommunications System (GTS), and to ensure that the GTS links are adequate for such purposes.*
13. *Urge capacity building organizations, such as ADPC, to continue their efforts in the region to reduce risk from all disasters, including tsunami.*
14. *Encourage participation in the PTWS Tsunami Exercise on 17 May 2006.*
15. *Recommend a follow-up meeting be held in a year's time to report on progress of this Action Plan.*

Some of the 80 participants pose for a group photograph on the steps of the Sheraton Imperial in Kuala Lumpur, Malaysia. They gathered for a 2-day round-table discussion of the earthquake and tsunami risk to the Southeast Asia and South China Sea Region. During the meeting, the group decided on an Action Plan.

The attendees expressed their appreciation to the Government of Malaysia through the Ministry of Science, Technology and Innovation and UNESCO-IOC for convening and co-hosting the round–table dialogue, and the Organization of Islamic Conference –Commission on Science and Technology, and the International Tsunami Information Centre for co-sponsoring the dialogue.

The attendees also requested that the Malaysian National Contact to ICG/PTWS report on this meeting at the ICG/PTWS-XXI in Melbourne on 3–5 May, 2006.

ITIC-PTWC NEWS

Training Session Held for Visiting Scientists

For two weeks in January, ITIC hosted a team of visiting scientists working together to improve tsunami warning in the Indian Ocean. The team was composed of scientists from Germany and Indonesia, who are working together in the INA TWS, an early warning system mitigation effort that is encorporated in the Indian Ocean Tsunami Warning System (IOTWS). The group was composed of three Indonesians; Drs. Fauzi, Masturyono, and Abdul Gafur, all from the Meteorology and Geophsycial Agency (BMG); and three Germans; Petra Köhler and Matthias Müller from GeoForschungsZentrum Potsdam (GFZ), and Torsten Riedlinger from the German Remote Sensing Data Center in Munich. The group was interested in learning about tsunami mitigation efforts in Hawaii, particularly technical aspects of the Pacific Tsunami Warning Center (PTWC) operations, and the Hawaii State and Honolulu County civil defense structure. In addition to tours and discussions at those facilities, the scientists also met with University of Hawaii affiliates to discuss the Global Seismic Network (GSN) and sea level networks and data processing with other organizations, including the University of Hawaii Sea Level Center (UHSLC).

Training group with certificates of programme completion, from left to right, Matthias Müller (GFZ Potsdam), Stuart Weinstein (group instructor, PTWC), Dr. Laura Kong (ITIC), Masturyono (BMG), Abdul Gafur, (BMG), Petra Köhler (GFZ Potsdam), Torsten Riedlinger (German Remote Sensing Data Center) and Fauzi (BMG).

WORKSHOP AND MEETING SUMMARIES

Report: Development of Design Guidelines for Structures that Serve as Tsunami Vertical Evacuation Sites (2005), National Tsunami Hazard Mitigation Program (NTHMP) Seattle Washington, USA, January 2006

By Harry Yeh, Oregon State University, Ian Robertson, University of Hawaii, Jane Preuss, Planwest Partners, and Timothy Walsh, Washington Division of Geology and Earth Resources (geology@wadnr.gov)

The U.S. National Tsunami Hazard Mitigation Program (NTHMP) strategic implementation plan for tsunami mitigation projects identified construction guidelines and coastal land use guidance in areas of both strong ground shaking and tsunami hazard as a primary need. In November 2002, a workshop was held in Seattle, Washington, with attendees having expertise in structural, marine, and civil engineering, seismology, geology, and emergency management to assess the feasibility of such guidance and to formulate a plan for its development.

A two-phase program was recommended. The purpose of Phase I was to extract data from unpublished tsunami surveys to estimate forces from tsunami waves on buildings, to analyze buildings that survived tsunami wave attack, and to test those forces against building code designs. This report is an account of work on Phase I performed under contracts to the Washington State Military Department, Emergency Management Division, on behalf of the NTHMP.

Phase II will build on Phase I results to develop design

Vertical evacuation study, *continued*

and siting specifications, a manual for field data collections, and an outreach program consisting of the creation of databases and a series of workshops to disseminate and train design professionals in the application of the guidelines. The Phase II contract has been let to the Applied Technology Council of Redwood City, California, under contract to the U.S. Federal Emergency Management Agency, and is anticipated to be completed in 2006 or 2007. [*note:* A final NTHMP Phase III project develops a companion planning document on how tsunami shelter design guidance can be implemented at the local level].

The Phase I report is an exploratory study for the development of standards and guidelines for building safely against combined seismic-tsunami loads. Unlike seismic ground shaking, tsunami effects are limited to its inundation zone, and the closer to the shore the more severe the destruction. The present wet-or-dry presentation of the tsunami hazard maps must be improved to identify the multiple influence zones: e.g. high, medium, and low tsunami force zones in terms of both human survival and structural safety. Another issue associated with buildings within the tsunami inundation zone is to evaluate the design requirements for a structure to survive strong seismic ground shaking as well as subsequent tsunami forces. The design requirements for seismic response generally depend on structural flexibility, ductility and redundancy, while design for tsunami effects requires considerable strength and rigidity, particularly at the lower levels.These requirements need not be contradictory, but both must be considered.

These issues are particularly critical for buildings that may be used as evacuation shelters. In contrast to no notice seismic ground shaking, there is usually a short lead-time prior to tsunami attack, which makes effective forewarning and evacuation possible. The lead-time can range from a few minutes for a local source to several hours for a distant source. Tsunami lead-times are generally shorter than those of many other natural hazards, e.g. volcanic eruptions, hurricanes, and floods. Hence, in some situations, vertical evacuation to upper floors or evacuation to tsunami resistant buildings, i.e. tsunami shelters, within tsunami inundation zones is the only choice for human survival.

Past field observations, also supported by the numerical simulations, show that there is much variability over, not only cross-shore but also short alongshore distances in tsunami energy and resulting damage to coastal structures. Local amplification of tsunami energy along the shore results from the influence of three-dimensional bathymetry and coastal topography. The bathymetry leads to wave refraction, diffraction, reflection, and resulting interference phenomena that cause both focusing and de-focusing of tsunami energy. These factors account for the observed alongshore variability of wave energy. Building destruction is often exacerbated by the impacts of water-born missiles (floating automobiles, lumber and other debris). Hence final evaluation of tsunami effects on an individual structure should be made using case-by-case analysis.

Guidelines and standards should be used for the initial and preliminary evaluation only. Because of the substantial uncertainties with respect to the tsunami phenomena, the design tsunami itself cannot be

Type of forces	Comments for tsunami considerations
Hydrostatic Forces	Not used for the evaluation of building as a whole, but need to be considered for the strength of each structural wall panel of the building.
Buoyant Forces	Controlled by the inundation depth and the rate of water-level increase.
Hydrodynamic Forces	Controlled by the maximum value product of the inundation depth, the square of the flow velocity, and the shape of the structural element.
Surge Forces	Controlled by the flow velocity of the leading tongue of the runup.
Impact Forces	Controlled by the maximum flow velocity and depth, object mass, and elasticity associated with the impact.
Breaking Wave Forces	May not be relevant to the tsunami forces on onshore buildings: Tsunami waves tend to break offshore and approach the shore as a broken bore.
Scour	Controlled by flow velocity (shear stress), and pore-pressure gradient that can be estimated by the change in inundation depth and its duration.

Considerations for tsunami forces as found in Table 7 of the Washington [State] Division of Geology and Earth Resources, Open File Report 2005-4, *Development of Design Guidelines for Structures that Serve as Tsunami Vertical Evacuation Sites*, (Yeh, Robertson and Preuss), November 2005, p. 14. (Available online at: ***http://www.dnr.wa.gov/geology/pdf/ofr05-4.pdf***).

Vertical evacuation study, *continued*

estimated systematically even if the designearthquake were to be identified. No rational stochastic approach is possible due to insufficient data to support its probability.

Very little guidance is provided by current structural design codes for loads specifically induced by tsunami effects on coastal structures; the established design codes focus mainly on loadings due to riverine floods and storm waves. There are significant differences in physical conditions between tsunami and other floods. For a typical tsunami, the water surface fluctuates near the shore with amplitude of several meters during a period of a few to tens of minutes. This timescale is intermediate between the hours to days typical of riverine floods, and the tens of seconds or less associated with cyclic loading of storm waves. This intermediate timescale makes tsunami behaviors and characteristics quite distinct from other coastal hazards, and the effects cannot be inferred from common knowledge or intuition. The time scale is long enough to allow tsunami to penetrate a great distance inland, while it is still short enough to make the tsunami flow highly transient. Rapid rise and fall of tsunami inundation appears to enhance scour around a building. A relatively short lead-time for warning and evacuation likely leaves unsecured potentially hazardous objects behind, e.g., propane gas cylinders, automobiles, and boats. These objects can cause devastating effects once they become water-borne missiles. With sufficient lead-time such as is the case with hurricane, the damage potential can be reduced by securing floatable (and/or flammable) objects, as well as by moving motor vehicles inland. For tsunami events, extended runup durations introduce the potential to transport floating bodies (e.g. automobiles and driftwood) far inland, impacting buildings in their path.

In comparison to the case of riverine flooding, tsunami inundation fluctuates faster, hence there is a higher potential to cause greater buoyant forces to be exerted on buildings; i.e. the water level outside may increase rapidly while the inside is still dry and empty. Rapid water-level fluctuations induce pore-pressure gradients in the soil, which may loosen the foundation – in some cases the soil can be liquefied.

In summary, the following factors must be considered for tsunami shelter design. First, the shelter must be able to withstand seismic ground shaking that often precedes the tsunami attack: seismic ground shaking and tsunami attack are seldom concurrent. Tsunami shelters located near the shore must be evaluated both for resistance to structural and foundation failure. Second, the shelter must provide sufficient floor space for evacuees above the base flood elevation. No matter how strong the shelter is, evacuees may drown if the shelter is submerged by the inundation. Third, the shelter must withstand tsunami-induced forces, including impact of water-borne missiles. Tsunamis often trigger fires; hence the shelter must be fire resistant. Lastly, careful attention must be paid to evaluation of tsunami-induced scour around the shelter's foundation.

Based on the existing building codes together with recent literature review, we have identified potential forces that should be considered in establishing guidelines for tsunami-shelter design. All of the forces are relevant for tsunamis, although some are more important than others. Assuming that the tsunami shelters being constructed will be reinforced concrete or steel structures, and will be located in the tsunami inundation zone but inshore from the shoreline, the most probable forces will be the hydrodynamic force and the impact force. Once the flow depth and velocity at the shelter site are established, both forces can be computed in a rational manner. Note that the present estimations of the impact force are not well established and need to be improved. To predict the flow velocities and depths for a given design tsunami at a site of interest, the best practice available is to run a detailed numerical simulation model with a very fine grid size in the runup zone.

The full report is available at ***http://www.dnr.wa.gov/geology/pdf/ofr05-4.pdf.***

Malaysia National Workshop: Seismic and Tsunami Hazards and Risks Kuala Lumpur, Malaysia, 24-25 April 2006

By P. Loganathan, Project Coordinator, Seismic and Tsunami Hazards and Risks Study in Malaysia, The Academy of Sciences Malaysia, logan@akademisains.gov.my

As part of a two-year study, beginning 2006, entitled "Seismic and Tsunami Hazards and Risks in Malaysia," to determine the level of seismic and tsunami risks in Malaysia and to consider seismic factors in planning and design decisions, the Government of Malaysia, through the Ministry of Science, Technology and Innovation Malaysia, the Academy of Sciences Malaysia and the Malaysian Meteorological Department jointly organized a two-day National Workshop on 24–25 April 2006 at the Manhattan II Ball Room, 14th Level, Berjaya Times Square Hotel and Convention Centre, Kuala Lumpur. The Minister of Science, Technology and Innovation Malaysia, the Honorable Dr. Jamaludin bin Dato' Mohd Jarjis officiated the workshop.

A total of 170 participants representing state govern-

Malaysia Workshop, *continued*

ments (including local government representatives and members from the Village Security Committees, or JKKKs), federal government departments, research institutes, local universities and relevant NGOs attended the Workshop.

The objectives of the National Workshop were:

To create awareness on the phenomena and effects of seismic and tsunami hazards among federal and state government and local council officials as well as selected JKKKs and NGOs;

To disseminate information and knowledge on the phenomena and effects;

To obtain feedback from the participants on their expectations of the Government's role in facing the hazards; and

To give input which assists the government in formulating policies and strategies in facing seismic and tsunami hazards and risks.

Seventeen speakers from federal agencies, local universities, research institutions, and MERCY Malaysia presented papers covering five subject areas as follows:

Scientific understanding (6 papers) – touching on origin of earthquakes and tsunamis, the 26 December 2004 Tsunami, and effects of earthquakes on public and residential buildings, impact of tsunami on the coastline and on marine bio-resources;

Managerial aspects (4 papers) – touching on the National Early Warning System, mitigation measures and hazard risk management;

Public awareness (2 papers) – touching on the role of public agencies and the community in facing such hazards;

Capacity building (2 papers) – touching on international networking and the local tertiary educational curriculum on earthquake engineering; and

Socio-economic recovery (3 papers) – touching on the socio-economic and psychological impact of the last tsunami.

A panel discussion was held after the presentations to deliberate on "Policy Responses" towards handling the twin hazards. The Panel found that there should be wider distribution of public awareness materials in the print and electronic media to inform and educate the populace. The Panel recommended that public drills be conducted regularly on a nation-wide basis.

The deliverable of this workshop was a paper providing information on Malaysia's status in early warning systems and mitigation measures presented at the International Round–Table held on 27–28 April 2006. The findings will also be input into the final report of the study.

At the official opening, the Minister launched a book entitled "Tsunami Hazard 26.12.04 in Malaysia," published jointly by the Academy of Sciences Malaysia and LESTARI (National University of Malaysia). The publication provides information on the 26 December 2004 Tsunami, its environmental and socio-economic impacts, as well as on socio-psychological well-being impacts resulting from the tsunami.

In conjunction with the workshop, an exhibition was held in the same venue, displaying cause and effect of earthquakes and tsunamis, the early warning system, mitigative measures planned by the government, and the management of such hazards.

Located in Honolulu, the International Tsunami Information Centre (ITIC) was established on November 12, 1965, by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). In 1968, the IOC convened the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/PTWS).

The present 28 Member States are:
Australia, Canada, Chile, China, Colombia, Cook Islands, Costa Rica, Democratic People's Republic of Korea, Ecuador, El Salvador, Fiji, France, Guatemala, Indonesia, Japan, Malaysia, Mexico, New Zealand, Nicaragua, Peru, Philippines, Republic of Korea, Samoa, Singapore, Thailand, Russian Federation, United States of America, and Vietnam.

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