January - June 2012 VOLUME XLIV, NUMBER 1

Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System

TSUNAMI NEWSLETTER

International Tsunami Information Center

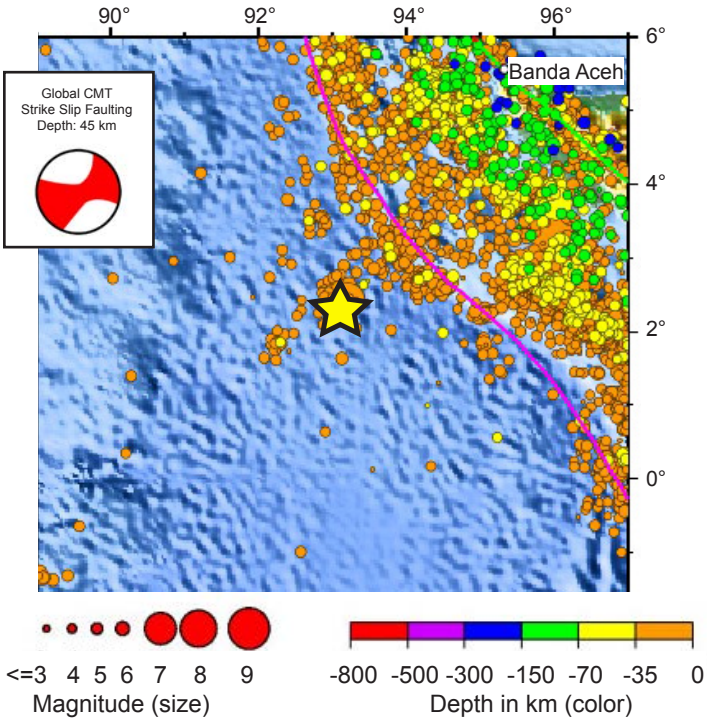
TABLE OF CONTENTS

Off West Coast of Northern Sumatra, Indonesia, 11 April 2012, UTC 08:38, M_w = 8.6

A M8.6 shallow strike-slip earthquake occurred at 08:38 UTC, 11 April 2012 off the coast of northern Sumatra, Indonesia, and was followed by a second shallow M8.2 strike-slip aftershock at 10:43 UTC (USGS). Both generated small local tsunamis with a maximum of 1.06 m measured at 1007 UTC in Meulaboh, Indonesia located about 395 km west southwest of the epicenter. Waves heights up to 0.4 m were recorded throughout the region and as far away as Rodrigues Island, Mauritius in the western Indian Ocean (0.22 m wave amplitude). Amateur video of the tsunami arriving in Indonesia was captured.

At least eight countries issued tsunami alerts for the M8.6 event. Coastal evacuation orders were promulgated for Indonesia, Thailand, Sri Lanka, India, and Myanmar. Two hours later, a M8.2 aftershock at 10:43 UTC triggered a second round of tsunami alerts across the region. There were no reports of significant tsunami damage from the two events.

Since October 2011, Regional Tsunami Service Providers (RTSP) of Australia, India and Indonesia have been serving as the primary sources for tsunami advisories for the Indian Ocean, with the PTWC and Japan Meteorological Agency (JMA) continuing to



Historic regional seismicity with Sumatra earthquake location marked by a yellow star. Map courtesy of USGS National Earthquake Information Center (NEIC).

Continued p. 4

SUMMARY OF EARTHQUAKES

1 JANUARY - 30 JUNE 2012

Reported by: International Tsunami Warning Centres

Compiled by: International Tsunami Information Center, ITIC

Advisories issued by international tsunami warning centers. The Pacific Tsunami Warning Center (P) issues: Tsunami Information Bulletins (TIB), Fixed and Expanding Regional Warnings (FRW, ERW), and Ocean-wide or Widespread Watch/ Warnings (TWW) for the Pacific; Tsunami Information Bulletins (TIB), Local, Regional, and Ocean-wide Tsunami Watches (LTW, RTW, TW) for the Indian Ocean (IO) until 31 March 2013; Tsunami Information Statements (TIS), Local, Regional, and Ocean-wide Watches (LTW, RTW, TW) for the wider Caribbean (C). The Japan Meteorological Agency (J), issues: Tsunami Advisories (NWPTA) for the Northwestern Pacific; Tsunami Watch Information (TWI) for the Indian Ocean until 31 March 2013. The West Coast/Alaska Tsunami Warning Center (A) issues: Tsunami Information Statements (TIS), Tsunami Advisories (TA), Tsunami Watch/Warnings (TWW) for Canada, the US (including Puerto Rico, excluding Hawaii and US-affiliated Pacific Island countries), and the US/British Virgin Islands. Depth (from GCMT solution), epicenter and Mw from the USGS (G), and Mw from PTWC, WC/ATWC, and JMA at action time. Other earthquakes with Mw greater than or equal to 6.5 and a depth no greater than 100 km, as recorded by USGS, have also been included. Wave height and period measurements from sea level gauges (g) reported as amplitude (amp), peak to trough, or greatest value for either flow depth (fd) or runup (r) as indicated. Event location (e.g. name) is derived from PTWC message(s).

DATE	TIME (UTC)	LOCATION	EPICENTER	DEPTH (km)	M_w	PTWC (P), JMA (J) or WC/ATWC (A) ACTION	ACTION TIME (UTC)	TSUNAMI? DAMAGING?	MAXIMUM MEASUREMENT and LOCATION
1-Jan	05:28	Southeast of Honshu, Japan	31.416° N 138.155° E	354	7.0 (A, J, P) 6.8 (G)	(P) 01 TIB (A) 01 TIS	05:36 05:39	NO NO	
8-Jan	04:07	Santa Cruz Islands	10.557° S 165.160° E	42	6.6 (A, G, P)	(P) 01 TIB (A) 01 TIS	04:14 04:16	NO NO	
10-Jan	18:37	Off W Coast of Northern Sumatra	2.396° N 93.175° E	14	7.3 (G, J, P)	(P) 01 TIB (J) 01 NWPTA	18:45 19:01	NO NO	
15-Jan	13:40	South Shetland Islands	60.765° S 55.858° W	12	6.7 (A, P) 6.6 (G)	(P) 01 TIB (A) 01 TIS	13:50 13:52	NO NO	
2-Feb	13:35	Vanuatu Islands	17.810° S 167.149° E	19	6.9 (A, G, P)	(P) 01 TIB (A) 01 TIS	13:41 13:48	YES NO	8 cm (amp) (g) Port Villa, Vanuatu (A)
6-Feb	03:49	Cebu, Philippines	9.964° N 123.246° E	12	6.8 (A, J, P) 6.7 (G)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	03:55 03:57 04:04	NO NO	
14-Feb	08:20	Solomon Islands	10.387° S 161.262° E	60	6.5 (A, J, P) 6.4 (G)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	08:27 08:29 08:39	NO NO	
3-Mar	12:20	Southeast of Loyalty Islands	22.157° S 170.317° E	21	6.9 (A, P) 6.6 (G)	(P) 01 TIB (A) 01 TIS	12:25 12:27	NO NO	
9-Mar	07:10	Vanuatu Islands	19.115° S 169.643 °E	12	7.1 (A, P) 6.7 (G)	(P) 01 TIB (A) 01 TIS	07:16 07:18	NO NO	
14-Mar	09:08	Off East Coast of Honshu, Japan	40.899° N 144.923° E	12	6.8 (A, J, P) 6.9 (G)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	09:17 09:20 09:24	YES NO	6 cm (amp) (g) Hanasaki, Japan (A)
20-Mar	18:03	Guerrero, Mexico	16.662° N 98.188° W	20	7.8 (A, P) 7.4 (G)	(P) 01 TIB (A) 01 TIS	18:13 18:16	YES NO	20 cm (amp) (g) Acapulco, Mexico (A)
21-Mar	22:15	New Guinea, Papua New Guinea	6.244° S 145.959° E	127	6.7 (A, J, P) 6.6 (G)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	22:21 22:24 22:40	NO NO	

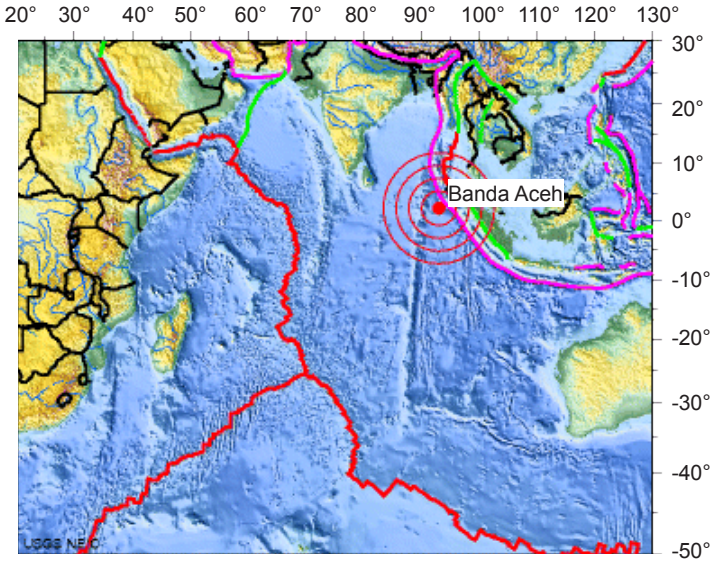
Earthquakes, *continued*

DATE	TIME (UTC)	LOCATION	EPICENTER	DEPTH (km)	M_w	PTWC (P), JMA (J) or WC/ATWC (A) ACTION	ACTION TIME (UTC)	TSUNAMI? DAMAGING?	MAXIMUM MEASUREMENT and LOCATION
25-Mar	22:37	Near Coast of Central Chile	35.183° S 71.792° W	27	7.2 (A, P) 7.1 (G)	(P) 01 TIB (A) 01 TIS	22:44 22:45	NO NO	
11-Apr	08:38	Off W Coast of Northern Sumatra	2.311° N 93.063° E	45	8.7 (A, J, P) 8.6 (G)	(P) 01 TW (IO) (A) 01 TIS (J) 01 TWI (P) 02 TW (IO) (P) 03 TW (IO) (J) 02 TWI (P) 04 TW (IO) (P) 05 TW (IO) (P) 06 TW (IO) (P) 07 TW (IO)	08:45 08:49 08:55 09:45 10:14 10:40 10:54 11:51 12:36 13:18	YES NO	1.1 m (amp) (g) Meulaboh, Indonesia (A, P)
11-Apr	10:43	Off W Coast of Northern Sumatra	0.773° N 92.452° E	54	8.3 (P) 8.2 (G)	(P) 04 TW (IO) (P) 05 TW (IO) (P) 06 TW (IO) (P) 07 TW (IO)	10:54 11:51 12:36 13:18	YES NO	4 cm (amp) (g) 1,111 km west-northwest of Phuket, Thailand (A)
11-Apr	22:55	Michoacan, Mexico	18.390° N 102.652° W	21	7.0 (A, G, P)	(P) 01 TIB (A) 01 TIS	23:02 23:04	NO NO	
12-Apr	07:16	Baja California	28.790° N 113.142° W	14	7.1 (A, P) 6.9 (G)	(P) 01 TIB (A) 01 TIS	07:30 07:32	NO NO	
14-Apr	22:05	Vanuatu Islands	18.998° S 168.771° E	12	6.6 (A, P) 6.5 (G)	(P) 01 TIB (A) 01 TIS	22:11 22:13	NO NO	
17-Apr	03:50	Near Coast of Central Chile	32.701° S 71.484° W	41	6.5 (A, P) 6.7 (G)	(P) 01 TIB (A) 01 TIS	03:57 04:00	NO NO	
17-Apr	07:14	Eastern New Guinea Reg. P.N.G.	5.474° S 147.097° E	206	7.0 (A, J, P) 6.8 (G)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	07:21 07:22 07:28	NO NO	
21-Apr	01:17	Iran Jaya Region, Indonesia	1.603° S 134.274 °E	14	6.9 (J, P, A) 6.6 (G)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	01:23 01:24 01:32	NO NO	
28-Apr	10:08	Tonga Islands	18.643° S 174.725° W	143	6.7 (A, G, P)	(P) 01 TIB (A) 01 TIS	10:15 10:16	NO NO	
18-May	02:01	Off Coast of Southern Chile	44.594° S 80.073° W	16	6.7 (P) 6.5 (A) 6.2 (G)	(A) 01 TIS (P) 01 TIB	02:07 02:09	NO NO	
24-May	22:48	Norwegian Sea	72.994° N 5.651° E	12	6.5 (A, P) 6.2 (G)	(A) 01 TIS (P) 01 TIS	22:54 22:57	NO NO	
4-Jun	00:45	South of Panama	5.287° N 82.580° W	21	6.6 (A, P) 6.2 (G)	(P) 01 TIB (A) 01 TIS	00:51 00:52	NO NO	
4-Jun	03:15	South of Panama	5.507° N 82.457°W	15	6.6 (A, P) 6.4 (G)	(P) 01 TIB (A) 01 TIS	03:22 03:24	NO NO	

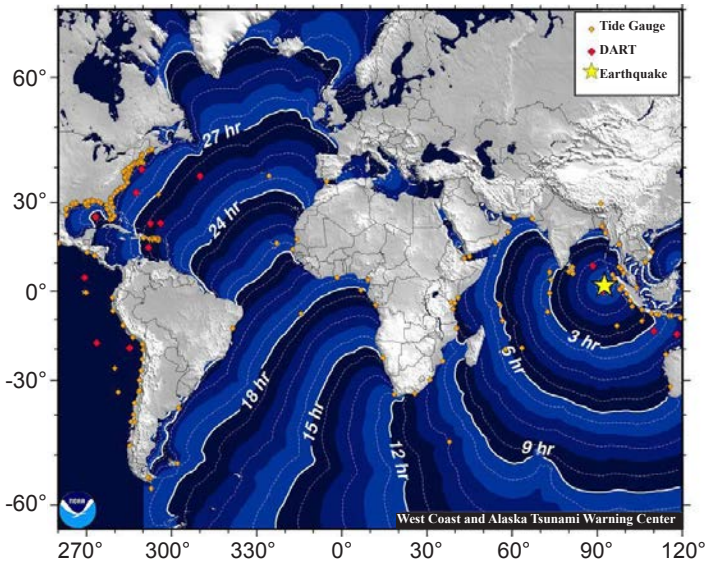
Sumatra, *continued*

operate a parallel service until the end of 2012. The RTSP provide tsunami alerts directly to national tsunami warning centers in each country, and the countries use the advice to assess and issue warnings and advisories to their populations. The PTWC issued an Indian-Ocean wide Tsunami Watch at 08:45 UTC, and JMA issued Tsunami Watch Information at 08:55 UTC. PTWC cancelled its tsunami watch at 1318 UTC. Public bulletins are available from the Australia, India, and Indonesia RTSPs, and from the PTWC.

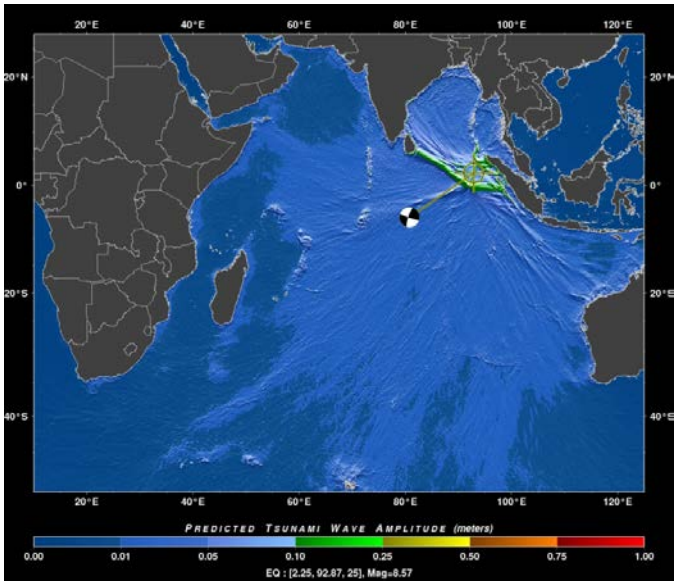
This region of the Indo-Australian plate has been seismically very active throughout history, and includes the great M9.1 earthquake of 26 December 2004 that generated the deadliest tsunami ever killing 226,898 (as reported by the National Geophysical Data Center (NGDC), February 2014) in Indonesia and across the Indian Ocean. Immediately following the disaster, the IOC of UNESCO took the lead in coordinating activities and immediate action to establish an Indian Ocean Tsunami Warning and Mitigation System (IOTWS). The response included the start of an interim Advisory Service in 2005 through the PTWC in Hawaii and the JMA in Tokyo, and in 2011 the start of the permanent RTSPs for the Indian Ocean.



Magnitude 8.6 off West Coast of Northern Sumatra, 11 April 2012, depth 45 km. Map courtesy of USGS National Earthquake Information Center (NEIC).

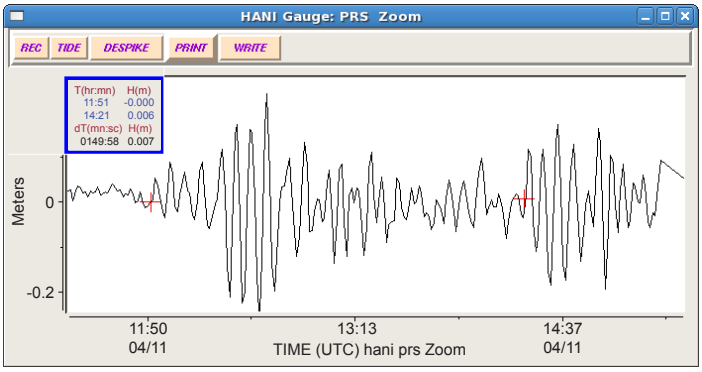


Sumatra tsunami travel times. Map courtesy of WC/ATWC.

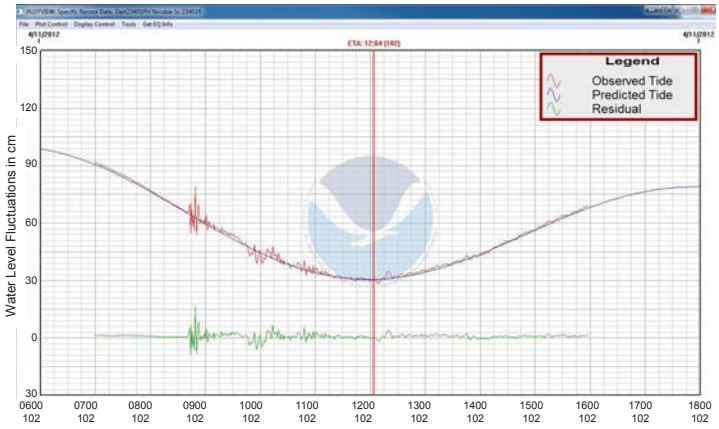


PTWC Real-Time International Forecasting Tsunami (RIFT) model simulation showing the predicted maximum off-shore tsunami wave amplitudes from the M8.6 0838 UTC 11 April 2012 strike-slip earthquake. Courtesy of PTWC.

Sumatra, *continued*



Tsunamis recorded on the Hanimaadhoo, Maldives coastal sea level gauge. The 1st tsunami (0.23 m amplitude) was generated by the M8.6 08:38 UTC earthquake and the 2nd tsunami (0.18 m amplitude) was generated by the M8.2 1043 UTC earthquake. Courtesy of PTWC.



DART 23401 deep-ocean instrument in the Bay of Bengal clearly shows the 2 tsunamis (WC/ATWC). Courtesy of WC/ATWC.

Tide gage/ Measurement Location	Observed Arrival time (UTC)	Peak amplitude (above sea level in cm)	Time of Peak Amplitude Measurement (UTC)	Initial motion	Sample Interval (min)
Sabang, Indonesia	0943	40	1009	up	1
Meulaboh, Indonesia	0959	107	1031	up	1
Talukdalam, Indonesia	0946	31	1213	up	1
Hillary Harbor, Australia	1458	8	0226	down	1
Cocos Islands, Australia	1043	7	1102	down	1
Enggano, Indonesia	1033	13	1253	down	1
Trinconmalee, Sri Lanka	1115	9	1125	up	1
Ko Taphao, Thailand	1132	11	1402	down	1
Hanimaadhoo, Maldives	1210	4	1404	down	1
Rodrigues, Mauritus	1351	20	1444	up	1
Prigi, Indonesia	1431	9	1800	down	1
Gan, Maldives	1119	3	1235	up	1
Port Louis, Mauritus	1454	17	1605	down	1
Pointe La Rue, Seychelles	1544	12	0024	down	1
Pointe des Galets, Reunion Is.	1537	6	1805	down	1
Sainte Marie, Reunion Is.	1439	20	0507	up	1

Sea Level Measurements of the Mag 8.6 Northern Sumatra Tsunami. Courtesy WC/ATWC.

Tide gage/ Measurement Location	Observed Arrival time (UTC)	Peak amplitude (above sea level in cm)	Time of Peak Amplitude Measurement (UTC)	Initial motion	Sample Interval (min)
Dart 23401	1213	4	1219	?	15 sec

Sea Level Measurements of the Mag 8.2 Northern Sumatra Tsunami. Courtesy WC/ATWC.

IOC News

PTWS Steering Committee Meeting, 24-25 May 2012, Honolulu, Hawaii

The meeting of the Steering Committee of the Intergovernmental Coordination for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS) was held in Honolulu, Hawaii USA, from 24-25 May 2012 and convened by Dr. Kenneth Gledhill, Chair of the ICG/PTWS. It was attended by 9 official Steering Committee participants from 8 PTWS member States, and other IOC officials and observers. The Chair reminded the Steering Committee of its Terms of Reference, noting in particular the coordination role of the committee during the intersessional period between bi-annual ICG/PTWS sessions. The main outcomes of the Steering Committee meeting were 1) follow up on recommendations arising from ICG/PTWS-XXIV session held in Beijing, China in May 2011, 2) receiving reports from PTWS Regional Working Groups, Technical Working Groups (WG) and their associated Task Teams (TT), and 3) review and adoption of Steering Committee Summary Report.

The Steering Committee adopted the following summary of recommendations and actions:

Outstanding Actions from ICG/PTWS-XXIV Beijing Session

Secretariat:

- Survey the PTWS Member State Tsunami Warning Focal Points (TWFP) regarding their need to receive PTWC message products by fax
- Inform Member States about the website for Tsunami National Contacts (TNC) and TWFP contact details, provide them with passwords and advise them of the procedures for updating contact details.

IOC/ITIC Website accessibility during tsunami events.

- The Steering Committee noted the current deficiencies and possible solutions and requested the Secretariat to investigate and resolve.

Post Tsunami Survey Field Guide

- The Steering Committee requested that the language and intent of ICG/PTWS XXIV.2 as well as appropriate protocols are included in the Post Tsunami Field Survey guide.

Decisions, Recommendations and Actions Arising from Steering Committee Meeting

South China Sea (SCS) - WG

- The Steering Committee noted that the WG's discussion on the options with regards to the nature and role of a sub-regional Warning Centre capability, or of an information exchange platform, will continue and that a proposal will be made to the next meeting of the ICG/PTWS.
- The Steering Committee noted Association of Southeast Asia Nations Sub-committee on Meteorology and Geophysics (ASEAN SCMG) decision that the development of a SCS Tsunami Warning System (TWS) should be implemented under the framework of the ICG/PTWS and agreed to invite ASEAN SCMG to be a permanent observer of the SCS-WG.

Action: Secretariat to invite ASEAN SCMG as a permanent observer of the SCS-WG.

Southeast Pacific (SEP) - WG

- The Steering Committee noted Ecuador's intention to install 2 tsunameter buoys and requested PTWS WG2 to investigate and advise on the protocol and required specifications to ensure sharing of data on international networks.

Tsunami Awareness and Response - WG3

- The Steering Committee requested WG3 to follow up on TsunamiReady through Tsunami and Other Coastal Hazards (TOWS) WG TT2.
- The Steering Committee requested WG3 to look into the feasibility of developing guidelines for evacuation zone mapping.

Emergency Management Representation in the ICG

- The Steering Committee recalled the recommendation on the inclusion of emergency managers in delegations to the next ICG.

Action: The ICG Chair and the Chair of WG3 to explore ways and means of reaching out to the international EM community to register the requirement and seek assistance.

PTWS, *continued*

PTWS Planning assignments:

- Finances Strategy: Takeshi Koizumi and Filomena Nelson
- Medium Term Strategy: Ken Gledhill and Patricio Carrasco
- Implementation Plan: Filomena Nelson, Ken Gledhill and WG Chairs

Action: Full review before the next ICG/PTWS-XXV Session in Russia

Task Team on PacWave Exercises

- The Steering Committee requested the PacWave11 Task Team to continue until the 25th Session of the ICG/PTWS to plan and conduct a PacWave Exercise in 2013 under its existing Terms of Reference, noting that the exercise will not be end-to-end and will focus on validation of the enhanced products.

Task Team on Enhancing Products

- The Steering Committee noted the progress reported by the Task Team and requested that PTWC should continue with the development of its new products taking into consideration the information presented, discussions, issues raised, and advice of the Task Team during this meeting. PTWC should finalize procedures and software for an initial version of the products, including a Users Guide, and begin issuing the new products in an experimental mode in parallel with current products by February 1, 2013. Unresolved or new issues regarding the products during this development period can be addressed remotely by the Task Team and/or PTWS Steering Committee before the experimental period begins. In addition, the Task Team agreed that before full implementation there will need to be a comprehensive training program on the new products for PTWS Member States to ensure that the products are understood and that Member State SOPs are modified accordingly.

Timetable for Implementation of PTWC Enhanced Products

- Announcement of PacWave13: Oct 1, 2012

Participants of the PTWS Steering Committee and Task Team Meetings in Honolulu, Hawaii, 21-25 May 2012. *(*) Sterring Committee members, IOC officials and PTWS Task Team participants included:* ***Front Row*** *(Left to Right). (*) Dr. Charles McCreery, Director PTWC and Chair of WG Tsunami Detection,Warning and Dissemination, Chair Enhanced Tsunami Products Task Team; (*) Capt. Patricio Carrasco, Vice-Chair PTWS; (*) Dr. Kenneth Gledhill, Chair PTWS and Chair SW Pacific Seismic Data Sharing Task Team; (*) Takeshi Koizumi, Vice-Chair PTWS; (*) Dr. Laura Kong, Director ITIC and Co-Chair PacWave11 Task Team;* ***Middle Row*** *(Left to Right). Brian Yanagi, PacWave11 Task Team; Lt. Cmdr Miguel Vasquez, Associate Director ITIC; Angelica Munoz, Acting Chair WG Central American Pacific Coast Region; (*) Filomena Nelson, Chair WG SW Pacific Region; (*) Dr. Mahd Rosaidi bin Che Abas, Chair WG South China Sea Region; Jo Guard, Co-Chair PacWave 11 Task Team; CPNV EMC Jaime Davalos Suarez, WG SE Pacific Region; Rajendra Prasad, IOC Secretariat.* ***Back Row*** *(Left to Right). Tony Elliott, IOC Secretariat; Dr. Dominique Reymond, Director CPPT; Lt. Willington Renteria Agurto, WG SE Pacific Region. Photo courtesy of ITIC.*

PTWS, *continued*

- Start trial of Enhanced Products: Feb 1, 2013
- Conduct PacWave13: April 2013
- Evaluation forms back: by 30 April
- Evaluate PacWave13, validate PTWC new products and procedures: 31 May
- VC/teleconf for TT: as required
- Review/approved by Steering Committee just prior to ICG

Training on Enhanced Products

- The Steering Committee requested the Secretariat to work with ITIC and the Working Group chairs to document the record of training conducted and planned, leading up to and beyond the implementation date of the enhanced products.

The Great East Japan Tsunami and Tsunami Warning Systems: Policy Perspectives, Summary Statement, Tokyo Japan, 16-17 February 2012,

The Symposium

Coming from 25 countries, 290 physical and social scientists, warning system operators, emergency and response managers, planners, journalists, policy– and decision makers attended the Japan – UNESCO – UNU Symposium on The Great East Japan Tsunami on 11 March 2011 and Tsunami Warning Systems: Policy Perspectives from 16 – 17 February 2012 in Tokyo. The symposium was organized by the Intergovernmental Oceanographic Commission of UNESCO and the United Nations University, in collaboration with the Government of Japan.

The Opening Session was moderated by Dr Wendy Watson-Wright, Executive Secretary of IOC and Assistant Director-General of UNESCO. Welcoming remarks were provided by His Imperial Highness Crown Prince Naruhito. The symposium was officially opened by Ms Irina Bokova (Director General of UNESCO) and Dr Konrad Osterwalder (Rector of the United Nations University). Closing remarks were provided by Mr Kōichirō Matsuura, Former Director General of UNESCO.

The Background

The Great East Japan Earthquake and Tsunami on 11 March 2011 resulted in the loss of 18,537 lives (as reported by the National Geophysical Data Center (NGDC), February 2014). Major damage and destruction occurred to buildings and infrastructure in the flooded areas, with large societal impacts and social and economic consequences. The Japan Cabinet Office has estimated the losses to 16,9 Trillion Yen (approximately 220 Billion US $).

Since the event many national and international post-tsunami field surveys have been carried out. Performance analyses of tsunami early warning systems in place at the time of this event have also been done.

The Facts (as of 29 February 2012)

- 18,537 were killed (as reported by the National Geophysical Data Center (NGDC), February 2014).
- 128,753 houses were completely destroyed and 245,376 houses were partially destroyed.
- 92.4% of the deaths were caused by drowning (1.1% were burned, 4.4% crushed, and 2% unspecified).
- 65% of the dead were over 60 years old.
- The magnitude 9.0 earthquake and the associated gigantic tsunami were unforeseen.
- Maximum run-up heights greater than 10 m are distributed along 530 km of coast and maximum run-up heights greater than 20 m are distributed along 200 km of coast measured directly. The highest run up height was 40 m.
- 535km2 of land area was inundated over a coast line of about 2400 km.
- Many coastal tsunami protecting structures were destroyed; 190 km of coastal dikes and sea walls (out of a total of 300 km of such structures) in the Tohoku region were fully or partly destroyed.
- Much of the critical infrastructure such as disaster management centers, city-government halls, fire stations, railways, ports, airports, hospitals, and schools was destroyed by the tsunami.
- Power outages occurred in wide geographic areas and over long time periods.
- A major tsunami warning was issued by the Japan Meteorological Agency (JMA) within 3 minutes, but the initial warning underestimated the size of the tsunami. JMA subsequently updated the warnings, however in some locations public communication systems were damaged by the earthquake hindering dissemination.

Policy Perspectives, *continued*

- According to the report by the Japan Central Disaster Management Council (28 September 2011) the underestimated tsunami warning delayed immediate evacuation in some cases. In other cases communities assumed they were safe due to the existence of tsunami sea walls and didn't evacuate.

Based on the information provided by the surveys and performance analyses, the symposium provided a number of high level perspectives that addressed:

- Event facts and analysis.
- Tsunami Warning Systems, tsunami preparedness and event experiences.
- Lessons learned from this event that have policy implications for improving tsunami detection, warning, community education, planning and response.

Tsunami monument at Unosumai-chou near Kamaishi (Iwate Prefecture) commemorating the Great East Japan Earthquake and Tsunami of 11 March 2011. The inscription at the bottom of the monument reads: "Memorial Stone of the Tsunami! Just run. Run Uphill! Don't worry about the others. Save yourself first. And tell the future generations that a Tsunami once reached this point. And that those who survived were those who ran. Uphill. So run! Run uphill!". Photo courtesy of the Japan-UNESCO-UNU Symposium on the Great East Japan Tsunami on 11 March 2011 and Tsunami Warning Systems: Policy Perspectives 16-17 February 2012. UNESCO/IOC 2012.

The Symposium: Lessons Learned and Policy Implications

The symposium was organized in five sessions, each including presentations and a subsequent panel discussion among presenters and invited panelists. For each of the sessions the main synthesis of the lessons learned and policy implications are provided below. Details about the programme, presenters and panelists are available in Ref 2.

Session 1:

What happened during the Tsunami of 11 March 2011? What was unexpected? What is a new strategy to prepare for the unexpected?

- Early self-evacuation is of major importance, particularly if a strong earthquake is felt or if the earthquake is weak but with slow tremors that continue for a long time. It is not necessary to wait for an official evacuation order.
- Tsunami drills and exercises should include worst-case scenarios; with due consideration of seasonal meteorological conditions and that primary evacuation routes may be blocked.
- Reliable and back-up communication systems for dissemination of tsunami warnings are essential for providing information to the public and the media.
- Breakwaters and seawalls can not always protect lives and property.
- Coastal structures and coastal planning should be implemented in a holistic manner that takes into consideration the capacity and capability of the warning system, land use planning and coastal mitigation measures in order to optimize protection of life and property from earthquakes and tsunamis.
- Tsunami "monuments" can be helpful in passing on the tsunami experience to coming generations.

Session 2:

Run away from the Tsunami! Education in schools and communities. Why do some people not evacuate?

- Awareness of the risk of tsunami disaster can reduce impacts and loss of lives. Psychological and sociological aspects should be taken into consideration in developing education and awareness materials.
- Continual tsunami disaster education in schools and at the community level is essential to facilitate effective community response.

Policy Perspectives, *continued*

- Underestimated tsunami warnings do have an impact on people's reaction; the content of the national tsunami warnings must be examined from recipients' point of view.
- Local tsunami hazard maps with detailed explanations should be developed in order to enhance the residents' tsunami disaster awareness and response during an event.
- Evacuation by car may be the only option possible for people with limited mobility. In an evacuation situation clear prioritization of car usage is critical to avoid traffic congestion and this should be taken into consideration when developing evacuation route maps.
- There is an ongoing need to better educate communities about the tsunami threat and the associated risk to help manage expectations about what warning systems can do and what the communities themselves must take responsibility for.

Session 3:
Towards the improvement of standard operational procedure (SOP) of Tsunami warning centers. What is an understandable and effective Tsunami warning?

- All tsunami warnings need to be timely, as accurate as possible in the time available, brief and comprehendible to ensure appropriate community response.
- Every tsunami is different in character, with local tsunamis such as occurred on 11 March 2011 creating the greatest challenges due to the extremely short time available to detect and warn coastal communities.
- Enabling research and collaboration between the research and operational tsunami communities should continue to reduce the time for determining reliable earthquake magnitudes, as well as increase the accuracy and space resolution for forecasts of possible tsunami wave impacts, from local and distant earthquake sources.
- Broadband, high-dynamic range seismometer measurements are necessary for rapid and precise analysis of strong local tsunamigenic earthquakes (magnitude greater than 8.0).
- Analysis of real-time continuous GPS measurements is useful for determining earthquake dynamics; there is a need to develop this processing technique from research mode to operational mode.
- Offshore and coastal real-time sea level observations help to verify and modify warnings.

Session 4:
What is the role of mass media:
Global media collaboration in response to natural hazards and preparedness?

- The essential role that mass media play during a disaster event is the broadcasting of reliable information for the safety of the public.
- Information can save lives. Therefore cooperation among media and between media and tsunami warning and emergency authorities for broadcasting timely, reliable and accurate information is essential.
- Social media have a role in the collection and distribution of information to/from the public, but the information requires the same verification as any other source of information used by journalists in order to be credible and reliable.
- For disaster related information two essential keywords are reliability and accuracy. All journalists are looking for reliable sources and for authoritative information provided by experts. The cooperation established over the years between JMA and Japan Broadcasting Cooperation (NHK) on tsunami warning dissemination and response is exemplary and is a model for others to follow.

Session 5:
Strengthening international cooperation:
What is the role of international organizations?
IOC/UNESCO with partner organizations must continue to lead the coordination of global tsunami warning systems, based on its experience and responsibility over more than five decades. This includes:

- Ensuring the robust, efficient and effective performance, and global coverage of end-to-end, interoperable warning systems for coastal hazards, operated by mandated national agencies, requires intergovernmental coordination in norm- and standard setting.
- Continuing to raise awareness about the tsunami threat and to advocate why nations need to invest in early warning systems.
- Facilitating the exchange and sharing of information on all facets of end-to-end tsunami warning systems, from tsunami detection to community education response.
- Continuing to provide for networking and

Policy Perspectives, *continued*

stimulation of education and multi-disciplinary science and enabling research in support of tsunami warning systems and mitigation efforts.

- Facilitating the provision of data and information to all countries.

ITIC News

Trapped Communities in the Great East Japan Tsunami of March 2011

ITIC participated in a field trip to the damaged Tohoku coastline in late June 2012. Fifteen months after the March 2011 Great East Japan tsunami, the region was mostly cleared of structures and cleaned up. What remained were vast empty areas strewn with thousands of concrete foundations of houses and buildings, where previously, there were dense cities, sprawling residential communities, and thriving fishing ports. Formerly bountiful rice agricultural fields lay barren due to salt water and debris contamination of the soil. Fishing boats still lay washed up on land. There was little visible reconstruction activity. The only sounds of the day were heavy machinery continuing to clear debris from the few remaining vacated buildings. Piles of rubble and automobiles several stories high were stacked throughout the region. Also, vast areas of the coastline sank or subsided due to the earthquake. About 19,000 persons were killed and missing, mostly elderly and children. The overwhelming tsunami waves were generated by a great earthquake magnitude 9.0 off the Tohoku coastline, the largest earthquake recorded in Japan history. This earthquake size for the region was unexpected. Waves traveled up to 5 kilometers (over 3 miles) through inland waterways. Maximum flooding runup wave heights ranged through 25 meters (over 80 feet), with a few measurements over 35 meters (over 110 feet) in narrow inlets.

The day was filled with somber emotions, eye witnessing where entire communities had been washed off the face of the earth.

There were frequent stories about how communities became trapped by tsunami waves. Many communities were surprised and never expected to see how far inland the waves surged from the ocean. Many communities were surrounded by rivers and canals connected to the sea. These waterways provided the transport mechanism for tsunami waves to penetrate further inland and overtop its banks. Other communities were “outflanked” and engulfed by flooding waves approaching different directions from surrounding waterways. Moreover, communities with flat terrains or backed up against steep mountains also became trapped with limited escape options. Roadways quickly became snarled in stagnant traffic jams. With only minutes to react to the oncoming waves, many residents escaped by climbing up steel pedestrian overpasses, running to nearby hilltops, and climbing tall multi-story reinforced concrete structures.

ITIC learned the following lessons:

- There is a need for countries to conduct tsunami modeling of maximum credible earthquake scenarios (e.g. magnitude 8 and 9 range earthquakes), which may occur perhaps once every 500 – 1000 year return periods that could generate huge tsunamis. Historic paleotsunami sand deposits on shore or event runup measurements may or may not have been recorded for such events in the tsunami historic database at the NOAA National Geophysical Data Center.
- These models should include precision forecasts particularly along rivers, canals and waterways connected to the ocean where the tsunami can penetrate further inland and overtop its banks.

Tsunami waves overtopped and flattened a densely wooded forest during the 11 March 2011 Great East Japan Tsunami near Sendai Airport. Most of the trees were more than 9 meters in height. Photo courtesy of B. Yanagi, June 2012.

Great East Japan, *continued*

Thousands of house cement foundations remained in June 2012 after the 11 March 2011 Great East Japan Tsunami in Ishinomaki city. The tsunami waves overtopped the background coastal forest where trees heights exceeded 9 meters. Residents living in this flat terrain region, surrounded by waterways, were engulfed and trapped by the oncoming waves from the ocean and rivers. Many people were flooded while trying to evacuate by vehicle in snarled traffic jams. Photo courtesy of B. Yanagi.

- These models should be made available to the public and policy decision makers for viewing with appropriate caveats on the return periods. Communities must then diligently plan, designate, and publicize vertical evacuation facilities.

Amazingly, however, over 95% of the population in inundated areas survived the devastating waves due to Japan Meteorological Agency's rapid tsunami early detection and warning system and strong community preparedness (e.g. NHK media announcements, disaster management agencies sounding siren alerts, evacuation maps designating coastal escape routes and designation of safe assembly areas on high ground and tops of buildings, and evacuation drills). Moreover, only two known persons were killed outside of Japan, in Oregon, USA and Indonesia due to timely alerts issued by other international Tsunami Warning Centers (e.g. US Pacific Tsunami Warning Center and West Coast/ Alaska Tsunami Warning Center) and National Tsunami Warning Centers. This was in stark contrast to the 2004 Indian Ocean tsunami where there were almost 230,000 casualties caused by the lack of a Tsunami Early Warning System and public preparedness.

In summary, a community should not be surprised that they can become trapped by a tsunami.

If a community views the forecast tsunami models and becomes aware that it could become trapped, long term efforts must be undertaken to designate existing structures and/or build new structures and berms as vertical evacuation options. Every resident must know to self evacuate to these these designated vertical evacuation sites near places like their home, work, school, church, shopping malls, and how they can access them on a 24 hour basis, day or night after the occurrence of "strong or prolonged earthquake ground shaking."

Located in Honolulu, the International Tsunami Information Centre (ITIC) was established on 12 November 1965 by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). In 1968, the IOC first convened the International Coordination Group for the Tsunami Warning System in the Pacific (ITSU). In 2005, ITSU became the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS) so as to better convey the comprehensive approach required to reduce tsunami risks.

The 35 Member States with Tsunami National Contacts and Tsunami Warning Focal Points 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, Niue, Panama, Papua New Guinea, Peru, Republic of the Philippines, Republic of Korea, Russian Federation, Samoa, Singapore, Solomons, Thailand, Tonga, Tuvalu, U.S.A., Vanuatu and Vietnam.

International Tsunami Information Center
A UNESCO/IOC - NOAA Partnership
737 Bishop Street, Suite 2200
Honolulu, Hawai'i 96813 USA
Phone: 1-808-532-6422
Fax: 1-808-532-5576
E-mail: itic.tsunami@noaa.gov
Web: www.tsunamiwave.info