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Puerto Rico Tsunami Awareness

by Christa von Hillebrandt-Andrade, Director,
Puerto Rico Seismic Network (PRSN)

On the afternoon of 20 April 2008, the Puerto Rico Seismic Network had the official presentation of their new kids' book where tsunamis are explained in a simple and entertaining manner. The First Lady of Puerto Rico, Mrs. Luisa Gándara, was invited to read the book to the second graders of the Colegio Presbiteriano Pablo Casasús School in the city of Mayagüez. José Guillermo Rodríguez, the mayor of Mayagüez, accompanied the First Lady to the reading of the book. In the children's playground, Parque del Milenio, where the bay served as the perfect background for the official reading of *¡Alerta! ¡Tsunami! ¡Maremoto! En Puerto Rico*. Christa von Hillebrandt-Andrade, director of Puerto Rico Seismic Network, and other members of her team, hosted the activity assuring the success of the event. This book was initially written in English by the Intergovernmental Oceanographic Commission of UNESCO for the Pacific, and has been translated and adapted to Puerto Rico by the Network. Those interested may request a copy of the book by sending an email message to educa@midas.uprm.edu, or by downloading a copy directly from our website; <http://redsismica.uprm.edu/spanish/tsunami/edu.php>. This initiative is part of the Puerto Rico component of the US NOAA National Tsunami Hazard Mitigation Program.



Above. The First Lady of Puerto Rico, Mrs. Luisa Gándara, (far right) reading to second graders at the Colegio Presbiteriano Pablo Casasús School in the city of Mayagüez. José Guillermo Rodríguez, the mayor of Mayagüez is sitting next to her.

educa@midas.uprm.edu. This initiative is part of the Puerto Rico component of the US NOAA National Tsunami Hazard Mitigation Program.

SUMMARY OF EARTHQUAKES

1 JANUARY- 31 DECEMBER 2008

Reported by Tsunami Warning Centres

Compiled by The International Tsunami Information Centre, ITIC

Advisories issued by international tsunami warning centres. The Pacific Tsunami Warning Center (P) issues: Tsunami Information Bulletins (TIB), Fixed and Expanding Regional Warnings (FRW, ERW), and Ocean-wide Watch/Warnings (TWW) for the Pacific; Tsunami Information Bulletins (TIB), Local, Regional, and Ocean-wide Tsunami Watches (LTW, RTW, TW) for the Indian Ocean; Tsunami Information Statements (TIS), Local, Regional, and Ocean-wide Watches (LTW, RTW, TW) for the wider Caribbean. The Japan Meteorological Agency (J), issues: Tsunami Advisories (NWPTA) for the Northwestern Pacific; Tsunami Watch Information (TWI) for the Indian Ocean. The West Coast/Alaska Tsunami Warning Center (A) issues: Tsunami Information Statements (TIS), 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 (P) at action time. Wave height and period measurements from sea level gauges reported as amplitude, peak to trough, or greatest value for either inundation or runup as indicated.

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
05 Jan	11:01	Queen Charlotte Islands Region	51.260° N 130.752° W	12	6.6 (GCMT,P) 6.5 (G)	TIB (P)	11:11	NO	
05 Jan	11:45	Queen Charlotte Islands Region	51.163° N 130.542° W	12	6.5 (P) 6.4 (GCMT)	TIB (P)	11:53	NO	
08 Feb	09:38	Northern Mid-Atlantic Ridge	10.671° N 41.899° W	19	6.9 (A, GCMT, P) 6.8 (G)	TIS (A) TIB (P)	09:48 09:50	NO	
10 Feb	12:22	South Sandwich Islands Region	60.797° S 25.586° W	12	6.5 (G, GCMT, A, P)	TIS (A) TIB (P)	12:39 12:40	NO	
12 Feb	12:50	Oaxaca Mexico	16.357° N 94.304° W	85	6.5 (P) 6.4 (G, GCMT)	TIB (P)	13:00	NO	
20 Feb	08:09	Off West Coast of Sumatra, Indonesia	2.768° N 95.964° E	15	7.5 (G) 7.4 (GCMT) 7.2 (P)	(IO) LTWB 01 (P) TWI (J) LTWB 02 (P) LTWB 03 (P) (Cancellation)	08:22 08:29 09:26 09:47	NO	
23 Feb	15:57	South Sandwich Islands Region	57.326° S 23.421° W	12	6.9 (A, P) 6.7 (G, GCMT)	TIB (P) TIS (A)	16:12 16:12	NO	
25 Feb	08:37	Southern Sumatra, Indonesia	2.486° S 99.972° E	23	7.1 (P) 6.9 (G, GCMT)	LTWB 01 (IO-P) TWI (J) LTWB 01 (P) LTWB 02 (IO-P) (Cancellation)	08:50 08:59 08:50 10:09	YES NO	0.12 m Padang, Indonesia
25 Feb	18:06	Southern Sumatra, Indonesia	2.332° S 99.891° E	23	6.5 (P) 6.4 (GCMT) 6.3 (G)	(IO) TIS (P) TWI (J)	18:17 18:23	NO	
25 Feb	21:02	Southern Sumatra, Indonesia	2.245° S 99.808° E	23	6.6 (P) 6.5 (G, GCMT)	(IO) TIS (P) TIS TWI (J)	21:13 21:13 21:17	NO	

Earthquake summary, *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
03 Mar	14:11	Philippine Island Region	13.351° N 125.630° E	18	6.9 (P) 6.8 (G, GCMT)	TIB (P) TWI (J) TIS (A)	14:27 14:34 14:27	NO	
12 Mar	11:24	Vanuatu Islands	16.567° S 167.335° E	12	6.5 (P) 6.4 (G, GCMT)	TIB (P) TIS (A) TWI (J)	11:38 11:41 11:42	NO	
22 Mar	21:24	South of Aleutian Islands	52.176° N 178.716° W	134	6.5 (A*, P) 6.2 (GCMT) 6.1 (G, P002) *later revised to 6.1	TIS (A) TIB 001 (P) TIB 002 (P)	21:28 21:37 21:43	NO	
29 Mar	17:31	Off West Coast of Northern Sumatra	2.855° N 95.296° E	12	6.5 (P) 6.3 (G, GCMT)	TIB (P) TWI (J)	17:41 17:49	NO	
09 Apr	12:46	Loyalty Islands	20.071° S 168.892° E	36	7.3 (GCMT) 7.2 (A, G, P)	TIB (P) TIS (A)	13:00 13:01	NO	
12 Apr	00:30	Macquarie Island Region	55.664° S 158.453° E	21	7.2 (A, P) 7.1 (GCMT) 6.8 (G)	TIS (A) TIB (P)	00:42 00:44	NO	
15 Apr	23:00	Andreanof Islands, Aleutian Islands	51.854° N 179.358° W	12	6.9 (P) 6.5 (A) 6.4 (G, GCMT)	TIS (A) TIB (P)	23:04 23:08	NO	
16 Apr	05:54	Andreanof Islands, Aleutian Islands	51.878° N 179.165° W	12	6.6 (GCMT) 6.5 (A, G, P)	TIS (A) TIB (P)	6:01 6:08	NO	
28 Apr	18:34	Vanuatu Region	19.941° S 168.953° E	48	6.7 (A, P) 6.4 (GCMT) 6.3 (G)	TIB (P) TIS (A)	18:47 18:47	NO	
02 May	01:34	Andreanof Islands, Aleutian Islands	51.864° N 177.528° W	12	7.0 (A, P) 6.6 (GCMT) 6.5 (G)	TIS (A) TIB (P)	01:40 01:45	NO	
07 May	16:45	Near East Coast of Honshu, Japan	36.158° N 141.521° E	26	6.8 (GCMT) 6.7 (A, G, J, P)	NWPTA (J) TIS (A) TIB (P)	16:55 16:56 16:57	NO	
09 May	21:51	South of Mariana Islands	12.516° N 143.181° E	83	6.5 (A, J, P) 6.6 (G) 6.7 (GCMT) 6.9 (J 002, P 002)	TIB 001 (P) TIS (A) NWPTA (J) TIB 002 (P) NWPTA 002	22:05 22:05 22:10 22:19 22:39	NO	
13 Jun	23:44	Eastern Honshu, Japan	39.030° N 140.881° E	12	7.0 (P) 6.9 (GCMT) 6.8 (G)	NWPTA (J) TIB (P) TIS (A)	23:51 23:52 23:53	NO	
27 Jun	11:40	Andaman Islands, India	11.005° N 91.824° E	17	6.7 (P) 6.6 (GCMT) 6.4 (G)	(IO) TIB (P) TWI (J)	11:50 11:59	NO	
30 Jun	06:18	South Sandwich Islands Region	58.220° S 22.100° W	24	6.9 (G, GCMT) 6.7 (A, P)	TIS (A) TIS (P)	06:33 06:36	NO	

Earthquake summary, *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
05 Jul	02:12	Sea of Okhotsk	53.882° N 152.886° E	615	7.7 (G, GCMT) 7.6 (A, P)	TIB (P) TIS (A)	02:22 02:23	NO	
19 Jul	02:39	Off East Coast of Honshu, Japan	37.552° N 142.214° E	20	6.9 (GCMT) 6.8 (G) 6.6 (A, P)	NWPTA (J) TIB (P) TIS (A)	02:46 02:49 02:49	NO	
19 Jul	09:27	Santa Cruz Island Region	11.041° S 164.493° E	13	6.7 (A, P) 6.6 (G, GCMT)	TIB (P) TIS (A) NWPTA (J)	09:40 09:40 09:46	NO	
23 Jul	15:26	Eastern Honshu	39.802° N 141.464° E	102	6.8 (all)	NWPTA (J) TIB (P) TIS (A)	15:31 15:37 15:39	NO	
08 Sep	18:52	Vanuatu	13.501° S 166.967° E	125	7.1 (A, P, J) 6.9 (G) 6.8* revised to 7.1 (A, P, J)	TIB 001* (P) TIS 001* (A) NWPTA 001* TIB 002 (P) TIS 002 (A) NWPTA 002	19:05 19:06 19:11 19:35 19:41 19:47	NO	
10 Sep	13:08	Central Mid-Atlantic Range	8.092° N 38.718° W	17	6.6 (all)	TSN (P) TBN (A)	13:25 13:27	NO	
11 Sep	00:00	Halmahera, Indonesia	1.885° N 127.636° E	120	6.7 (A, P, J) 6.6 (G, GCMT)	TIS (A) TIB (P) NWPTA (J)	00:11 00:12 00:18	NO	
11 Sep	00:21	Hokkaido, Japan	41.892° N 143.754° E	24	7.0 (A, P, MJMA) 6.8 (G, GCMT)	TIS (A) NWPTA (J) TIB (P)	00:21 00:24 00:35	YES NO	0.2m Urakawa tide gauge (peak to trough)
24 Sep	02:33	Off Coast of Jalisco, Mexico	17.635° N 105.520° W	17	6.5 (A, P) 6.4 (G, GCMT)	TIB (P) TIS (A)	02:46 02:46	NO	
29 Sep	15:19	Kermadec Islands Region	29.860° S 177.653° W	50	7.0 (G, GCMT) 6.9 (A, P)	TIS (A) TIB (P)	15:32 15:34	NO	
11 Oct	10:40	Virgin Islands Region	19.161° N 64.833° W	29	6.1 (G, GCMT) 6.0 (A, P)	TIS (A) TIB (P)	10:43 10:51	NO	
16 Oct	19:41	Near Coast Chiapas, Mexico	14.423° N 92.364° W	32	6.7 (A, P) 6.6 (G, GCMT)	TIB (P) TIS (A)	19:51 19:51	NO	
19 Oct	05:11	Tonga Islands	21.863° S 173.819° W	44	7.0 (A, P) 6.9 (G, GCMT)	TIB (P) TIS (A)	05:21 05:23	NO	
07 Nov	07:20	Vanuatu Islands	14.829° S 168.032° E	12	6.5 (A, P) 6.4 (G, GCMT)	TIB (P) TIS (A)	07:32 07:32	NO	
16 Nov	17:03	Minahasa Peninsula Sulawesi, Indonesia	1.271° N 122.097° E	32	7.6 (A, P) 7.3 (G, GCMT)	(IO) TIB (P) TIS (A) TWI (J)	17:13 17:16 17:17	YES NO	0.255 m Toli-Toli tide gauge (peak to trough)

Earthquake summary, *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
22 Nov	16:01	Southern Sumatera	4.348° S 101.259° E	12	6.5 (A, P, J) 6.4 (G, GCMT)	(IO) TIB (P) TIS (A) TWI (J)	16:10 16:25 16:19	NO	
24 Nov	09:03	Sea of Okhotsk	54.203° N 154.322° E	505	7.3 (G, GCMT) 7.0 (A, P)	TIB (P) TIS (A)	09:12 09:11	NO	
09 Dec	06:24	Kermadec Islands Region	31.232° S 176.924° W	19	6.8 (A, P) 6.7 (G, GCMT)	TIB (P) TIS (A)	06:34 06:36	NO	
20 Dec	10:29	Off East Coast of Hokkaido, Japan	36.541° N 142.425° E	12	6.5 (A, P, J) 6.3 (G, GCMT)	NWPTA (J) TIB (P) TIS (A)	10:36 10:38 10:38	NO	

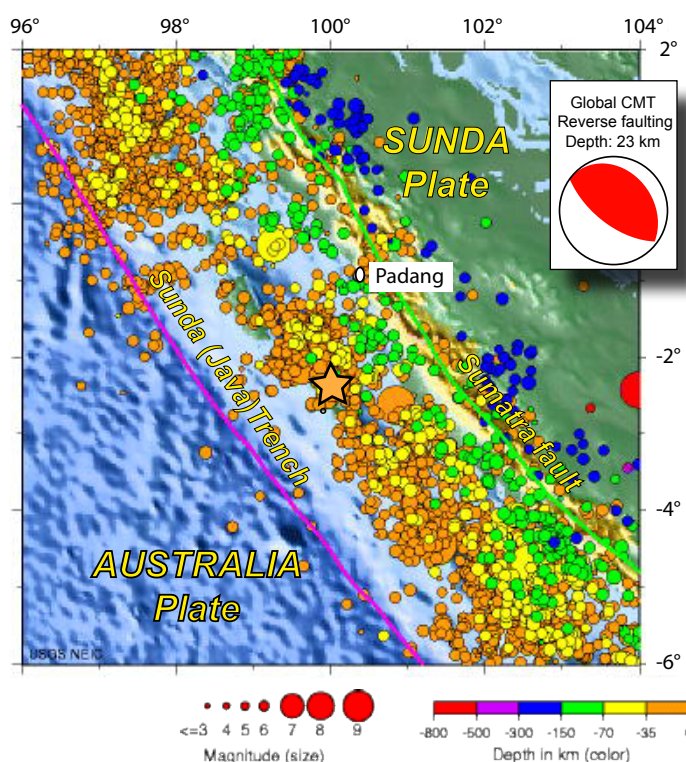
Southern Sumatra, Indonesia, 25 February 2008, 08:37 UTC, M_w=6.9

An earthquake occurred 160 km (100 miles) SSW of Padang, Sumatra, Indonesia and 855 km (530 miles) WNW of JAKARTA, Java, Indonesia at 08:36 UTC 25 February 2008 (3:36 PM local time in Indonesia). It was measured at 6.9 M_w by USGS.

The earthquake occurred as the result of thrust faulting on the boundary between the Australia and Sunda plates. At the location of this earthquake, the Australia plate moves north-northeast with respect to the Sunda plate at a velocity of about 60 mm/year. This earthquake continues the streak of unusually high earthquake activity that has impacted Sumatra and vicinity in recent years. Previous earthquakes in the series of shocks include the Sumatra-Andaman Islands earthquake of 26 December 2004 (M 9.1), the Nias earthquake of 28 March 2005 (M 8.6), and the southern Sumatra earthquakes of 12 September 2007 (M 8.4 and 7.9). The earthquake of 25 February 2008, occurred within the broad section of the Sumatra subduction zone that was spanned by aftershocks of the southern Sumatra earthquakes of 12 September 2007.

Details and analysis of this earthquake is summarized on a poster published by USGS and available at <http://earthquake.usgs.gov/earthquakes/eqarchives/poster/2008/20080225.php>.

The tsunami generated by this earthquake was recorded as 0.12 m at a tide gauge in Padang, too small to be damaging.



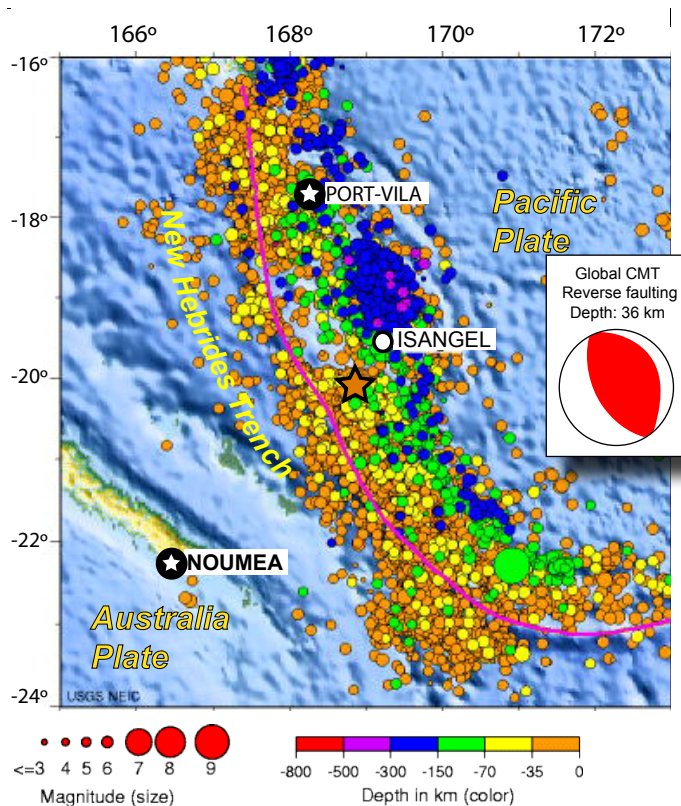
Above. Historical Seismic Activity in the region, 1990 to present, showing the recent earthquake epicenter and depth (orange star). Map courtesy of USGS National Earthquake Information Center.

Loyalty Islands (Vanuatu), 09 April 2008, 12:46 UTC, M_w=7.3

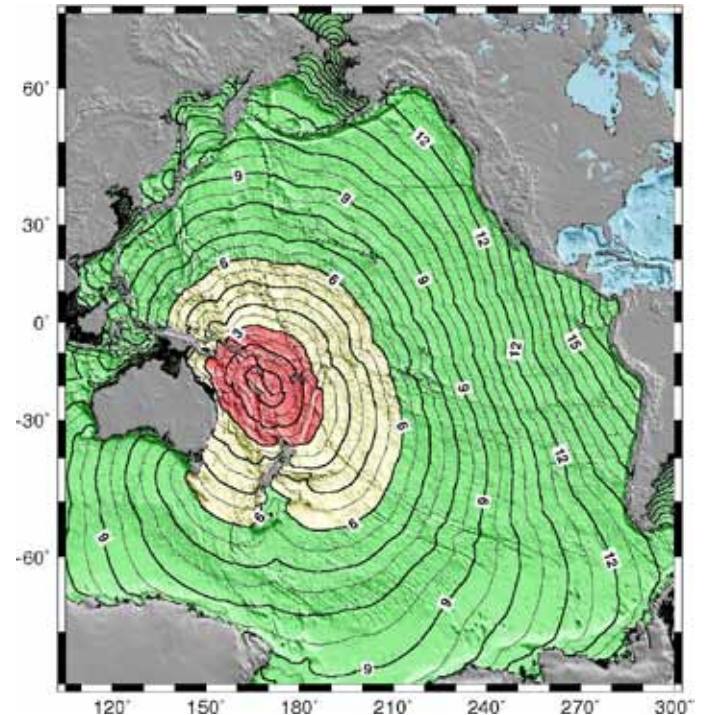
An earthquake measured with a Moment magnitude of 7.3 (USGS) occurred 09 April, 2008 at 12:46 UTC (11:46 PM local time). in Loyalty Islands.

The earthquake produced a tsunami that was recorded at the Port Vila, Vanuatu tide gage monitored at the Tsunami Warning Centers.

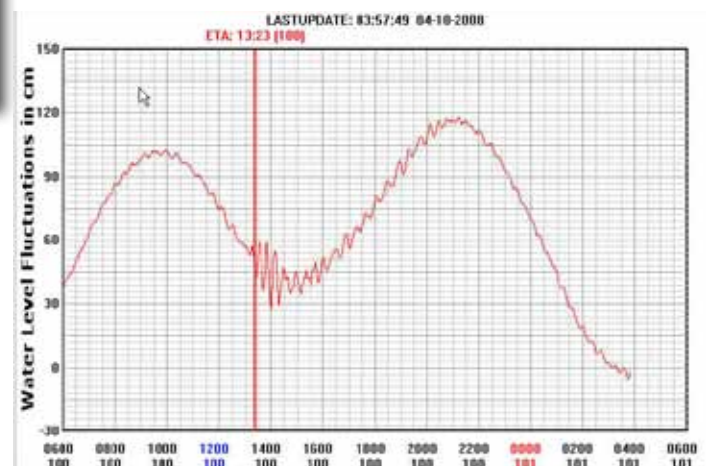
This Loyalty Islands (New Hebrides arc) earthquake occurred as the result of thrust-faulting on the boundary between the Australia plate and the New Hebrides plate. The New Hebrides arc region of the Australia/New Hebrides plate-boundary experiences numerous strong earthquakes.



Above. Map showing historical seismic activity in the region from 1990 to present, with the recent earthquake epicenter and depth (orange star). Map courtesy of USGS National Earthquake Information Center. Above small map of the area also from NEIC.



Above. Tsunami travel time map generated by the West Coast/Alaska Tsunami Warning Center, <http://wcatwc.arh.noaa.gov/previous.events/04-09-08-Vanuatu/04.09.08.html>.



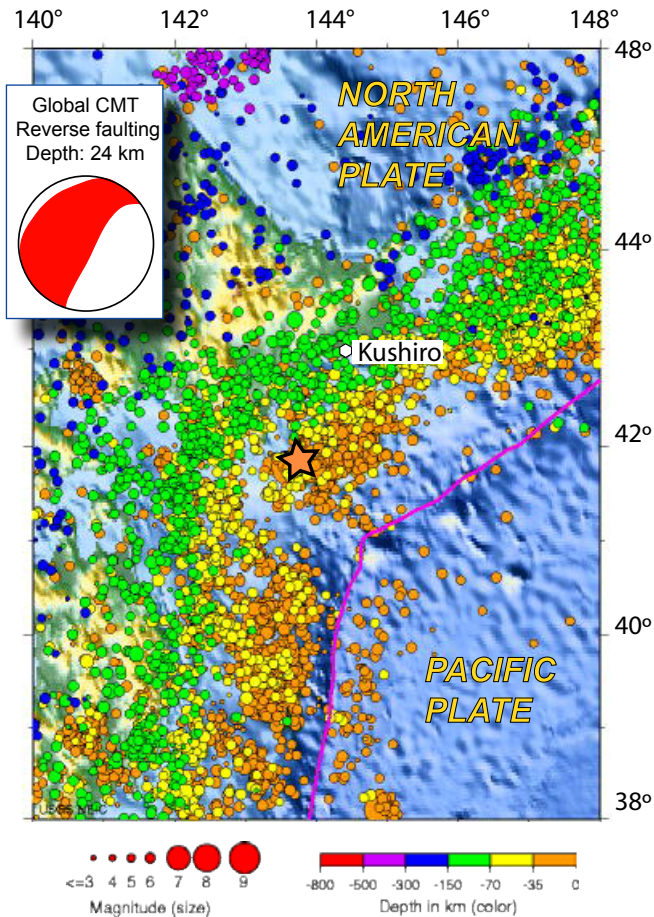
Above. Tide record showing tsunami indication at the Port Vila tide gauge in Vanuatu. From the ATWC website: <http://wcatwc.arh.noaa.gov/previous.events/04-09-08-Vanuatu/04.09.08.html>.

Hokkaido, Japan 11 September 2008, 00:21 UTC, $M_W=6.8$

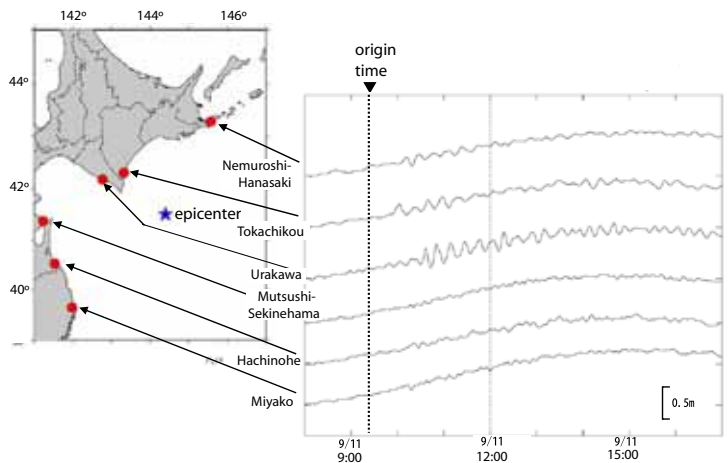
An earthquake occurred off shore of Hokkaido near the town of Tokachi (41.979N, 143.625 E) on 11 September 2008 at 00:21 UTC (09:21 am locally). The USGS measured the moment magnitude at 6.8 (USGS).

The earthquake generated a small non-destructive tsu-

nami wave indicated at several tide gauges along the coast of Hokkaido and Honshu (see below). The largest tide change was a 20 cm peak-to-trough reading at the tide station of Urakawa.



Left. Map showing historical seismicity of the region from 1990 to present event. Historical Moment Tensor Solutions with recent earthquake location marked by an orange star. Map courtesy of USGS National Earthquake Information Center.



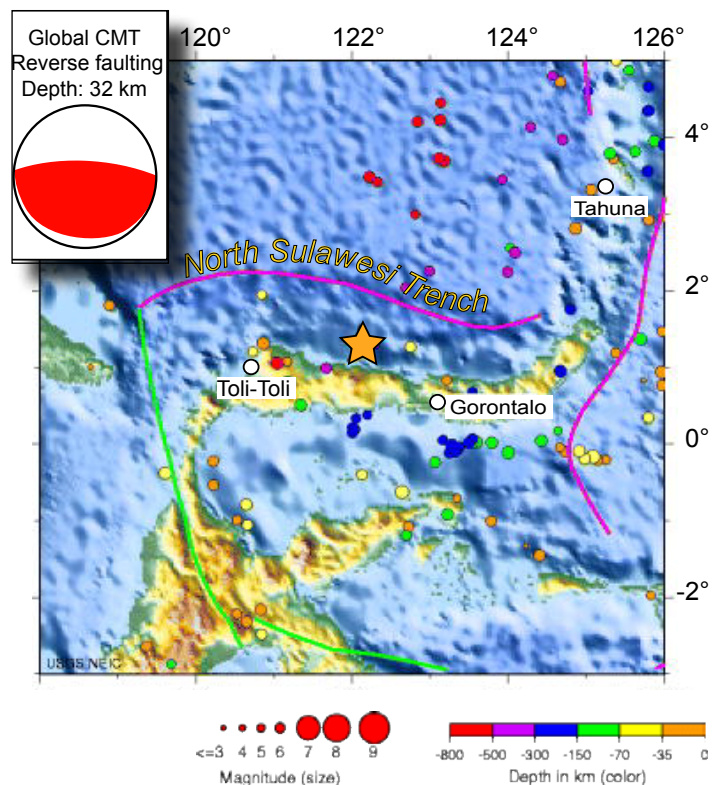
Above: a) Map with inset showing the stations in Japan reporting wave data following the 11 September 2008 (indicated by the blue star). b) A chart comparing wave records from Japanese stations, comparing records of the event, lined up to show the origin time. c) Individual tide records according to stations referred to on the map.

Minahasa Peninsula, Sulawesi, Indonesia, 16 November 2008, 17:03 UTC, $M_w=7.6$

The earthquake occurred 16 November 2008, at 17:03 UTC (01:03 local time) approximately 25 km off the northern coast of the Minahasa peninsula of the Island of Sulawesi. It was measured by the USGS with a moment magnitude of 7.6.

At least six people were killed, 77 injured, and approximately 10,000 people were displaced. Over 1,000 buildings were damaged and communications disrupted in the Buol area and in Gorontalo.

According to the USGS summary of this earthquake, the mechanisms involved thrust faulting on a plate-boundary marked by the North Sulawesi trench, separating the Celebes Sea basin and the Minahasa peninsula. Eastern Indonesia is characterized by complex tectonics in which motions of numerous small plates are accommodating large-scale convergence between the Australia and Eurasia plates. At the location of today's earthquake, the Celebes Sea basin (commonly considered part of the Sunda plate) moves south with respect



Right: Map shows 2008 seismicity for the region and the current earthquake as an orange star. Courtesy of USGS National Earthquake Information Center (NEIC).

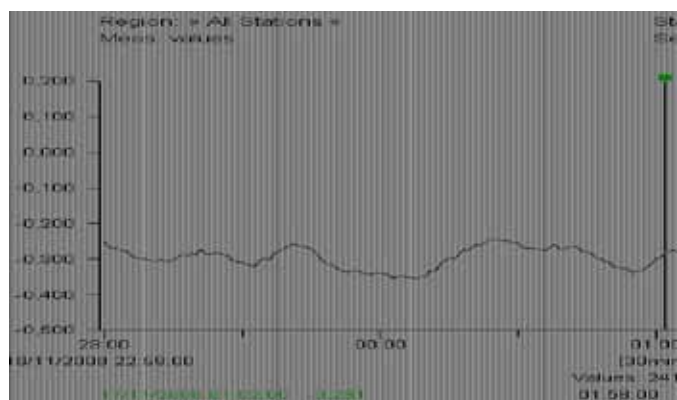
to the Minahassa peninsula (part of the Molucca Sea plate) at a velocity of about 30 mm/year. The lithosphere of the Celebes Sea basin is thrust beneath that of the Minahassa peninsula and is seismically active to a depth of about 250 km.

This area has experienced large earthquakes in the past. For example, the damaging magnitude 7.6 earthquake occurred on 18 April 1990 approximately 85 km east of today's earthquake. The magnitude 7.6 earthquake in 1990 was followed a year later by a magni-

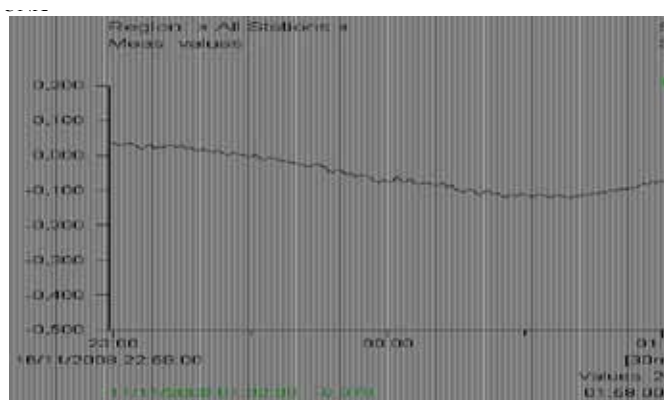
tude 7.5 earthquake in approximately the same place. More recently a magnitude 7.0 occurred within 45 km of today's earthquake on 25 November 1997. The 1997 earthquake caused damage to at least 90 building in the Gorontalo area of northern Sulawesi.

Numerical simulations of this tsunami were modelled by the USC Tsunami Research Center http://www.usc.edu/dept/tsunamis/2005/tsunamis/Sulawesi_Tsunami/index.html,

TOLI-TOLI



TAHURA



The tsunami was recorded on two tide gauges in Indonesia's tide station network. Courtesy of Bakosurtanal (Indonesia National Coordination of Survey and Mapping Agency)

IOC NEWS

Fifth Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS), ICG/IOTWS V, Putrajaya, Malaysia, 8–10 April 2008

1. The Fifth Session of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS-V) was held in Putrajaya, Malaysia, 8–10 April 2008. The session was attended by over 140 delegates from 16 countries in the Indian Ocean region, 5 observer States and 9 UN agencies and NGOs.

2. The ICG reviewed the progress made during the inter-session period, noted reports and recommendations from its Working Groups and adopted the RTWP Implementation Plan. The ICG received an update on the nomination of Tsunami Warning Focal Points (TWFP) and Tsunami National Contact (TNC): to date 25 out of

28 countries have already made either complete (13) or partial (12) formal nominations.

3. The ICG decided to establish an ad-hoc Task Team to consider and provide a detailed plan of the proposed Indian Ocean 2009 Exercise and to report back to the ICG Chairperson by written communication within three months. The ICG agreed that membership of the Task Team would be Kenya, Indonesia, Thailand, Australia, Malaysia, Sri Lanka, India and France and other interested Member States and agreed that Indonesia would be Chair, with Australia, Kenya and Thailand as Vice-Chairs.

4. The ICG recommended conducting an Indian Ocean tsunami modelling symposium at the end of 2009 or early 2010. Hosting offers have been received from Australia and India. Funding will be required for participants from IOTWS countries.

5. The ICG recognised the willingness of Australia, India, Indonesia, Iran, Malaysia, Thailand, and ADPC to

IO-TWS V, continued

commence the transition process for RTWPs, with India ready to commence in June, Australia in July, and Indonesia in November this year; and other potential RTWPs according to the RTWP Implementation Plan.

6. The ICG instructed Working Groups 1, 2, 3, 4 and 5 to address the outstanding technical issues to facilitate implementation according to the RTWP implementation schedule as a matter of priority.

7. It further instructed Working Group 5 to establish a RTWP Coordination Group (RCG), initially comprising current and potential RTWPs, the Interim Advisory Service providers, JMA and PTWC, and representatives of two NTWCs to report to and advise Working Group 5 on the operation of the System of Systems and the transition phases and to appoint a chair and vice chair, and to organize the collection and archive of performance statistics of the RTWPs.

8. The ICG decided to hold the Sixth session in March or April 2009 and accepted the kind offer from Thailand to host it. The ICG extended its deep appreciation to the Government of Malaysia, the Director and personnel of the Malaysian Meteorological Department for the excellent host arrangements for its Fifth Session.



A siren tower installed in Banda Aceh, Indonesia. Photo by Brian Yanagi, ITIC.



This electric power generation ship was washed inland in Banda Aceh, Indonesia and serves as a memorial to the 2004 Indian Ocean Tsunami. Photo by Brian Yanagi, ITIC.

Indian Ocean and SE Asia Regional SOP Training Kickoff, Bangkok, Thailand, 12-16 May 2008

by Charles McCreery, PTWC & Laura Kong and Brian Yanagi, ITIC

The following summarizes the mission trip taken to Bangkok, Thailand 12-16 May 2008. The trip was undertaken as part of the mission of UNESCO IOC ITIC to support tsunami capacity building in the Pacific and Indian Oceans. The ITIC carries out its international tsunami information resource and capacity building activities per NOAA-IOC arrangements. The PTWC is providing warning services for the Pacific Ocean, and interim services for the South China Sea Region and the Indian Ocean. The US is a Member State of the IOC and actively participates in various ICG organizations.

The Thailand trip consisted of conducting a regional training entitled, "Strengthening Tsunami Warning and Emergency Responses: Training Workshop on the Development of Standard Operating Procedures for Indian Ocean and Southeast Asian Countries". Additionally, on the last day, a coordination and planning meeting for the SOP strengthening project country missions was held between the IOC and experts, and country representatives from Myanmar, Pakistan, Philippines, and Vietnam.

Training topics, covered through plenary lectures and small group activities, were on tsunami warning and emergency response, especially:

- *Tsunami science, hazards, and warning centers, including PTWS and IOTWS services,*
- *Warning center operations, roles and responsibilities, and standard operating procedures for centers with and without active seismic monitoring capabilities,*

Bangkok Kickoff, *continued*

- *Tsunami Emergency Response by Disaster Management Organizations, including Roles and Responsibilities and Standard Operating Procedures for alerting and evacuation,*
- *Tsunami Information Dissemination, including technologies and the role of media*
- *Preparedness, Education and Awareness*
- *Lessons Learned from Past Tsunamis, and Tsunami Case Studies*
- *Exercises and Drills, including Table Top Exercise carried out on Day 5 followed by post-exercise evaluation.*

Outcomes of the Training included:

- *Sharing of best practices amongst international experts and countries*
- *Training of 35 participants from tsunami warning centers (TWC) and disaster management organizations (DMO) from 18 countries in the Indian Ocean and Southeast Asia on how to develop end-to-end standard operating procedures for tsunami early warning.*
- *Near real-time Table Top Exercise involving TWC and DMO participants practicing SOPs developed during the training, and post-exercise evaluation and discussion to identify gaps and weaknesses for improvement.*

A summary evaluation questionnaire was filled out by participants. Preliminary findings include:

- *The training and the topics covered were highly rated as useful and applicable to their jobs. The Course Notebook, containing SOP guidance, templates, case studies, and other reference materials was especially valuable.*
- *Because of the large amount of content covered, a longer training was needed. A follow-up workshop would be desirable, if funding can be identified. In general, more training on all topics was requested.*
- *Cross-country information sharing and learning on how other countries were handling end-to-end tsunami warning was valuable.*
- *Cross-learning and coordination between the TWC and DMO organizations needs to be continually emphasized, and opportunities to encourage this are useful*
- *Several gaps and topics identified for further elaboration include media interactions, structural mitigation and other hard/soft countermeasures, and more hands-on, interactive, small-group activities (such as through computer use on TWC operations,*

TWC/DMO coordination exercises, or other practical simulations).

Future actions based on the trip include the following:

- *Compile course evaluation results to identify gaps and provide to experts*
- *Investigate ways in which to meet the needs of western Indian Ocean and African nations that were no eligible for travel funding to this training workshop.*
- *In general, investigate ways in which to provide more similar training to wider audience.*
- *Follow-up especially with countries that will receive dedicated country missions under this project.*



Red Crescent personnel store tons of emergency relief supplies in a warehouse in Padang, Indonesia. Photo by Brian Yanagi, ITIC.

Indian Ocean and SE Asia Tsunami SOP Regional Training, Jakarta, Indonesia, 10-16 August 2008

by Laura Kong and Brian Yanagi, ITIC

The following summarizes the trip taken to Jakarta, Indonesia. The trip was undertaken as part of the mission of the United Nations Development Programme (UNDP) Regional Programme and the UNESCO IOC ITIC to support tsunami capacity building in the Pacific and Indian Oceans. The ITIC carries out its international tsunami information resource and capacity building activities per NOAA-IOC arrangements. Moreover, the Pacific Tsunami Warning Center (PTWC) is providing warning services for the Pacific Ocean, and interim services for the South China Sea Region and the Indian Ocean. The US is a Member State of the IOC and actively participates in various Intergovernmental Coordination Group (ICG) organizations.

The Indonesia trip consisted of conducting training entitled, "Strengthening Tsunami Warning and Emergency

Jakarta kickoff, continued

Participants of the Regional Tsunami Warning System SOP Workshop in Jakarta in August 2008.

Responses: Training Workshop on the Development of Standard Operating Procedures for Indian Ocean and Southeast Asian Countries” 11-15 August 2008 in Jakarta at the Nam Center. The Indonesia Bureau of Meteorology and Geophysics (BMG), which serves as the Indonesia National Tsunami Warning Center (TWC), provided in country coordination services. Participants came from four countries (Indonesia, Maldives Islands, Thailand, and Sri Lanka) representing National TWCs and disaster management organizations (DMOs).

Training topics, covered through plenary lectures and small group activities, were on tsunami warning and emergency response, especially:

- Tsunami science, hazards, and warning centers, including PTWS services



Dr. Fauzi of the Indonesia National Tsunami Warning Center explains seismology to the participants of the Regional Tsunami Warning System SOP Workshop in Jakarta in August 2008.

- Warning center operations, roles and responsibilities, and standard operating procedures for centers with and without active seismic monitoring capabilities
- Tsunami emergency response by disaster management organizations, including roles and responsibilities and standard operating procedures for alerting and evacuation,
- Tsunami information dissemination, including technologies and the role of media
- Preparedness, education and awareness
- Lessons learned from past tsunamis, and tsunami case studies.
- Exercises and drills, including table top exercise carried out on Day 5 followed by post-exercise evaluation

Outcomes of the training included:

- Sharing of best practices amongst international experts and Philippine participants,
- Training of four countries with over 35 participants from TWC and DMO agencies on how to develop end-to-end standard operating procedures for tsunami early warning.
- Near real-time table top exercise involving TWC and DMO participants practicing SOPs developed during the training, and post-exercise evaluation and discussion to identify gaps and weaknesses for improvement.

Future actions based on the trip include the following:

- Compile course evaluation results to identify gaps and provide to experts.
- Plan follow up missions with IOC and UNDP.
- In general, investigate ways in which to provide more similar training to wider audience.
- Follow-up especially with other countries (Vietnam, Pakistan) that will receive 2008/2009 dedicated IOC Country Missions under IOC arrangements.

SE Asia Regional Seismology and Tsunami Warning Training, Petaling Jaya, Malaysia, 24 August – 5 September 2008

by Laura Kong, Director, ITIC

The following summarizes the training mission taken to Malaysia (24 August – 5 September). The trip was undertaken as part of the mission of UNESCO IOC ITIC to support tsunami capacity building in the Pacific Ocean.

The Malaysia trip consisted of conducting a training for Malaysia and neighboring countries on Seismology and Tsunami Warning Standard Operating Procedures (SOP) 25-29 August, and consulting with the Malaysia

Malaysia, *continued*

Tsunami Warning Center (MTWC) on their SOPs 2-4 September. The activities were held at the Malaysia Meteorological Department (MMD) in Petaling Jaya, Malaysia. Trainer experts were from the IOC (Senior Tsunami Advisor, ITIC Director, ITIC Seismologist Staff).

Training topics, covered through plenary lectures and small group activities, were:

- *Earthquake source characterization, including hands-on analysis using Early Bird software*
- *Tsunami warning center operations, roles and responsibilities, and standard operating procedures for centers with active seismic monitoring capabilities*
- *Tsunami emergency response by disaster management organizations, including roles and responsibilities and standard operating procedures for alerting and evacuation,*
- *Tsunami information dissemination, including technologies and the role of media*
- *Lessons learned from past tsunamis, and tsunami case studies*
- *Exercises and drills, including a table top exercise carried out on Day 5 followed by post-exercise evaluation.*

Background materials, both in hard and soft copy, were distributed to participants as references and as materials used in the training and small group activities.

Outcomes of the Training included:

- *Sharing of best practices amongst international experts and participants*
- *Training of 37 participants from Malaysia (Meteorological Department, National Security Council, Astronautics Technology Sdn Bhd, Fire Rescue Department, Royal Malaysia Police, Putra University), Sri Lanka (Geological Survey and Mines Bureau), Thailand (National Disaster Warning Center, Meteorological Department), and Vietnam (Institute of Geophysics).*
- *Seismology sessions were held on days 1 and 2 covering earthquake location, magnitudes, and focal mechanism determination. Days 3-5 covered tsunami warning and emergency response centre operations. The trainers included many examples from their working experience in their lectures, which helped the trainees relate to their own operational experience. On Day 2, each country (Malaysia, Sri Lanka, Thailand, Vietnam) made a presentation on their present SOPs.*
- *Small group activities involved the creation of rou-*

tine and event response procedures for their operations involving information flow between responsible agencies as well as the media and the public.

- *A near real-time Table Top Exercise involving participants practicing SOPs for local and regional TWC response, and with the media/public was carried out on Day 5. The discussion and report-out exercise had the goal of identifying and correcting gaps and weaknesses in the procedures that were used during the exercise. The tabletop exercise tested the group's understanding of SOPs for both local (<1 hour) and regional (approx 3 hours) tsunamis.*

Puerto Rico Tide Gauge Network Installed

by Christa von Hillebrandt-Andrade, Director, Puerto Rico Seismic Network

The Puerto Rico Seismic Network (PRSN) of the Department of Geology of the University of Puerto Rico at Mayagüez successfully installed and is operating a network of 6 tsunami ready tide gauges and meteorological stations. The stations are located in Arecibo, Fajardo, Peñuelas, Mayagüez, Yabucoa and Isabel II in Vieques. A GOES receiver and central recording system was installed at the Puerto Rico Seismic Network



One of the tide stations now operational within the PRSN network.

Network, continued

to record and analyze the data from these and other tsunamis ready tide gauges that are operated by NOAA in Puerto Rico (San Juan, Parguera, Mona, Aguadilla, Esperanza in Vieques and Culebra) and the Virgin Islands (St. Thomas, St. Johns and two in St. Croix), as well as present and future stations in the Caribbean and Atlantic. The data gathered are being analyzed along with earthquake information to decide whether or not tsunami information, warnings, watches or advisories should be issued and when to upgrade or cancel them if they have been issued. An AHAB (All Hazards Broadcast System) was installed in Mayagüez. As part of the project the tsunami protocols were reviewed, updated and presented. A full scale tsunami exercise was also held in Mayagüez as part of the project to test the AHAB and protocol.

All the tide gauges fulfill the requirements of the National Oceanographic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Center for Operational Oceanographic Products and Services (CO-OPS) network and follow the guidelines of the National Tsunami Hazard Mitigation Program. The Geostationary Operational Environmental Satellite (GOES) system is being used to transmit all the data from the stations, not only to the PRSN, but the Pacific and the West Coast and Alaska Tsunami Warning Centers which are providing interim tsunami warning and guidance to the Caribbean and the US Caribbean (Puerto Rico and the Virgin Islands), respectively.

Given the heightened awareness of tsunamis, the PRSN was able to secure funding for the state through the Puerto Rico State Emergency Management Agency for 24/7 operations. Five hundred thousand dollars US per year has been promised, with the first \$250,000 assigned for the time period January-June, 2008. Also NOAA, through its National Tsunami Hazard Mitigation Program (NTHMP), Tsunami Ready and the Tsunami Law of 2006 is providing funding for the education and mitigation of tsunamis, as well as improved operations. At the Third (2008) Session of the UNESCO/IOC Intergovernmental Coordination Group for Tsunamis and other coastal hazards for the Caribbean and Adjacent Regions, member states proposed the PRSN host a Caribbean Tsunami Warning Center which is intended to be operational by 2010. By consensus the decision on where the CTWC should be located was postponed to 2009.

Note: This project was carried out between October 2005 and December 2007. FEMA provided \$565,000

for this project. The PRSN, through University and LAW 106 funding (\$155,276), the Puerto Rico State Emergency Management Agency (\$30,000) and the Municipality of Mayagüez (\$25,000) provided the required matching funds.

ICG Caribbean Working Group Meetings, Pointe-a-Pitre, Guadeloupe, Lesser Antilles, 6-8 December 2008

by Brian Yanagi, Disaster Management Specialist, ITIC

Working Group (WG) Meetings of the UNESCO Intergovernmental Oceanographic Commission (IOC) - Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG-CARIBE-EWS) were held from 6-8 December 2008 in Pointe-a-Pitre, Guadeloupe, Lesser Antilles. The ICG encompasses 29 Caribbean Member States, and other organizations.

A 2007 IOC Circular Letter established a Caribbean "end to end" tsunami early warning and mitigation system. ICG Vice Chairs provided general guidance to the four WGs to enable their existing work plans.

The four WGs included the following:

WG 1: Monitoring and Detection Systems, Warning Guidance

WG 2: Hazard Assessment

WG 3: Warning, Dissemination and Communication

WG 4: Preparedness, Readiness and Resilience

Expert presentations were made by working group participants. Each working group deliberated and produced various strategies and recommendations to move forward. The WG recommendations were forwarded for approval to the 2009 ICG-CARIBE-EWS General Session.



ICG/Caribbean Officers and Working Group Chairs share recommendations in Guadeloupe.

ITIC NEWS

Mauritius Tsunami Warning Center Support, 19-23 May 2008

by Laura Kong, Director, ITIC

The Mauritius mission consisted of tsunami warning center capacity building support to Mauritius Meteorological Services (MMS) and finalization of the arrangement for the 19-23 May 2008 ITIC mission for tsunami emergency response. The Mauritius trip was part of the Tsunami Capacity Building Project funded to the UNESCO IOC ITIC by the US Department of State, and hosted by the MMS. This support was carried out by Paul Whitmore, the Director of the West Coast/Alaska Tsunami Warning Center (WC/ATWC) and Laura Kong, the Director of ITIC.

Activities carried out included the following:

- *Two-day installation and training on the Early Bird Tsunami Warning Operations System used by the WC/ATWC, including configuration to access through the internet to 40+ Global Seismic Network stations for real-time earthquake characterization, and configuration of Early Bird TideView for viewing sea level records through Internet access, and pager alert for their internal notifications of events.*
- *Three-day seismology training on earthquake analysis using the Early Bird system.*
- *Continued work on the implementation of the PTWC Tide Tool application using data streams directly accessed from the GTS; data access through the internet is working already.*
- *Meetings with MMS Director and Deputies, Acting Police Commissioner and Police Special Forces Chief to finalize the Tsunami Emergency Response mission 19-23 May.*
- *Briefing with US Embassy Consular Officer on activities to be carried out and Press Release issued for activities.*

Outcomes of the trip include the following:

- *Successful installation of Early Bird and location of earthquakes in real-time for the Indian Ocean region; several events occurred which automatically gave reasonable solutions.*
- *15 MMS Staff trained in how to use Early Bird for earthquake analysis.*
- *Agreement on Goals and Agenda for Tsunami Emergency Response mission.*

Actions based on the trip include the following:

- *Compile installation, and how-to-run notes from Early Bird installation and training, including lessons learned from actual events tips on how to locate earthquakes for tsunami warning,*
- *Enable a user forum for Early Bird technical support; ITIC will enable a discussion group through the NWS List Serve,*
- *Compile Course Evaluation results to identify gaps and provide information and potential actions to MMS.*

This visit is the third mission conducted led by the ITIC to assist the government of Mauritius in building its national tsunami warning and mitigation system in the aftermath of the 2004 Indian Ocean Tsunami. The project is funded by the U.S. Government.

Previously, teams from the ITIC, IOC Tsunami Unit in Paris, and the U.S. Geological Survey visited Mauritius in October 2007, and January 2008. A team of experts in tsunami emergency management visited 19-23 May 2008 to work with the National Police on tsunami evacuations and other emergency responses to tsunami.

Mozambique Tsunami Capacity Building Mission, 9-14 September 2008

by Laura Kong, Director, ITIC

The trip was part of the Tsunami Capacity Building Project funded to the UNESCO IOC ITIC by the US Department of State and hosted by the Mozambique National Meteorological Institute (INAM) with logistics support from UNESCO Maputo and UNESCO National Commission. The mission was staffed by ITIC (Laura Kong, Yohko Igarashi) and IOC ICG/IOTWS Secretariat (Tony Elliott). The ITIC carries out its international tsunami information resource and capacity building activities per NOAA-IOC arrangements. The US is a Member State of the IOC and actively participates in various ICG organizations.

The schedule of the different activities is attached for reference, and summarized as follows:

- *1.5-day installation and training on tsunami warning decision support tools (Real-time Earthquake Display (RTED, aka USGS/NTHMP CISON), Tide Tool, Tsunami Travel Time Software), and summary briefings on other decision support tools, including the IOC Sea Level Monitoring Facility.*

Mozambique, *continued*

- 0.5-day briefing seminar on End-to-End Tsunami Warning.
- 0.5-day visit and discussion with DNG on potential upgrades to their seismic processing system (Seiscomp3) and installation/training of Real-time earthquake display.
- 0.5-day Tsunami Awareness Materials for Mozambique meeting attended by 11 participants from INAM, DNG, FOCO, IGNC, INAHINA, UNESCO National Commission, and UNESCO.
- 1-2 hr site visits each with INAM and INAHINA Directors to summarize mission activities and to demonstrate installed software.

Outcomes of the trip are the following:

- Successful installation of RTED, Tide Tool, and Tsunami Travel Time software on INAM tsunami warning center computer. Desktop PC with two displays provided by IOC through UNESCO for use in seismic and sea level monitoring, and tsunami travel time calculation as part of tsunami warning operations. Printer, backup power, and large-screen display on order by IOC through UNESCO. Hands-on computer training on software provided to four INAM staff. UNESCO staff trained and able to provide after-mission support.
- Successful installation of RTED, Tide Tool, and Tsunami Travel Time software on INAHINA computer (1 display) provided by IOC. Second display, as well as printer and backup power, on order by IOC through UNESCO. Hands-on computer training on software provided to six INAHINA staff.
- Information Briefing Seminar provided to 16 participants from INAM, INAHINA, DNG (National Agency responsible for seismic monitoring), FOCO (NGO), INGC/CENOE (National Disaster Management Agency), Ministerio de Adleau Estatab, EVRA, and MEC, and UNESCO,
- Installation of RTED at DNG, and confirmed interest in Seiscomp3 upgrade in 2008. Funding to be provided by IOC.
- Mozambique identification of tsunami materials for translation, and sign-up by different agencies to provide Portuguese translation. Materials selected are those developed by ITIC (Safety Flyers, Poster, Tsunami Warning!, Great Waves, Tsunami Glossary). ITIC will work with MZ to provide completed materials by end of January 2009 (end of Project).

Actions to be done based on the trip include the following:

- Follow up with INAM and INAHINA on software installation and use,
- Provide tsunami awareness materials for translation, and provide translated documents in cooperation with Mozambique national agencies,
- IOC to facilitate Seiscomp3 upgrade and training through a Germany company.

WORKSHOP AND MEETING SUMMARIES

NOAA TsunamiReady Hosts the 2008 North Pacific Tsunami Awareness Conference

by Timothy Hendricks, NOAA National Weather Service – Pacific Region

Pacific Island Countries (PIC) are located within some of the most geographically active parts of the world. On the whole, the PICs are amongst the most vulnerable countries in the world to multiple natural disasters, including local, regional, and teletsunamis.

Tsunami forecasters, emergency managers, researchers, and educators expressed a desire to re-group and assess progress being made towards the development of early warning systems in the Pacific Islands region. The inaugural North Pacific Tsunami Training Workshop



Dr. Peter Koltermann (podium), Tsunami Head, UNESCO Intergovernmental Oceanographic Commission in Paris, discussing the importance of early warning systems. Photo by Delores Clark, NOAA Public Affairs.

NWPAC meeting, *continued*

was held on Guam during August 2006. To meet the demand, NOAA TsunamiReady, in collaboration with the International Tsunami Information Center (ITIC), South Pacific Islands Applied Geosciences Commission (SOPAC), and Pacific Risk Management 'Ohana (PRiMO), hosted the 2008 North Pacific Tsunami Awareness Conference at the Ala Moana Hotel in Honolulu, 18–20 August. Over 90 participants represented PICs and territories of Guam, American Samoa, Commonwealth of Northern Mariana Islands, Federated States of Micronesia, Republic of Palau, and the Republic of Marshall Islands. Participants from UNESCO IOC Paris and USA also attended.

“Our goal is to review current efforts to manage tsunami risks and to enhance the effectiveness of the Pacific Tsunami Warning System” said Jeff LaDouce, Director of the National Weather Service Pacific Region. “To do this, we are assembling all the components of an effective tsunami early warning system — tsunami hazard and risk assessment, warning dissemination, and public education — to determine where we are and what more needs to be done.”

The conference kicked-off with a 1946 Hilo tsunami survivor story presented for the first time in public by Harriet Fukui Rompon of Ewa Beach, Hawaii.

Conference sessions included country progress reports and presentations about historic and recent tsunamis, new modeling and mapping research, building codes,



Jeff LaDouce (podium), Director, NOAA/NWS Pacific Region, delivers the opening remarks of the 2008 North Pacific Tsunami Awareness Conference. Seated from left to right, Tim Hendricks, NOAA/NWS Pacific Region WCM, and Carolyn Harshman, NOAA/NWS TsunamiReady Board and Emergency Planning Consultants (EPC) President. Photo by Delores Clark, NOAA Public Affairs.

the NOAA TsunamiReady program, tsunami mitigation projects, and new preparedness tools.

An afternoon working session was held for countries planning to participate in Exercise Pacific Wave 2008, the second Pacific-wide tsunami exercise set for late October.

The meeting concluded with field trips to the Pacific Tsunami Warning Center and the Hawaii State Civil Defense Emergency Operations Center.

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 30 Member States with official 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, Papua New Guinea, Peru, Philippines, Republic of Korea, Russian Federation, Samoa, Singapore, Thailand, Tonga, United States of America, and Vietnam.

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