July–September 2007 VOLUME XXXIX, NUMBER 3

Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System

TSUNAMI NEWSLETTER

International Tsunami Information Centre

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Summary of the Chairman's Opening Remarks to ICG/PTWS-XXII

by Fred Stephenson, Manager, Geomatics Engineering, Canadian Hydrographic Service, Fisheries & Oceans, Canada, Institute of Ocean Science (IOS) and past PTWS Chair, e-mail: fredstephenson03@shaw.ca

The Twenty-Second Session of the ICG/PTWS was held 17–20 September 2007 in Guayaquil, Ecuador, hosted by the Instituto Oceanográfico de la Armada (INOCAR). I was unable to attend the meeting and I am indebted to Dr. François Schindelé, who chaired the meeting in my absence. I also want to thank Ecuador for hosting the meeting, and Samoa for agreeing to host the next ICG/PTWS meeting in 2009.

The sixteen months since the Group's previous meeting in Australia have been very productive, with Member States and their agencies making significant contributions in the Pacific and in support of the other IOC TWS initiatives.

Exercise Pacific Wave '06, the first basin-wide test of the warning capability of the Pacific Tsunami Warning System, was conducted 16–17 May 2006. It involved 44 countries, including 29 of the 30 ICG/PTWS Member States. Five countries also carried out public evacuations, thus exercising procedures down to the "last mile." Evaluation forms completed following the exercise provided useful feedback to the organizers and indicated that Member States would like to see these exercises continued.

Fred Stephenson, PTWS Chairman during the PTWS Officers' meeting in Hawaii, April 2007.

The JMA Northwest Pacific Tsunami Advisory Center (NWPTAC) and Pacific Tsunami Warning Center (PTWC) continue to serve as interim service providers for the South China Sea region and for the Indian Ocean. In addition, the PTWC continues to provide interim services for the Caribbean, and the regional WC/ATWC now provides warning services for the US Gulf Coast and for the east coasts of the United States and Canada.

On 3 May 2006, a large earthquake occurred near Tonga. This earthquake generated a (*continued p. 24*)

SUMMARY OF EARTHQUAKES

Occuring July-September 2007

With surface wave or moment magnitude (Mw) greater than or equal to 6.5 and a depth no greater than 100 km, or an event for which an international warning centre issues a message. Pacific Tsunami Warning Center (P) issues; Tsunami Information Bulletins (TIB), Expanding Regional Warnings (ERW), Regional Watch/Warnings (RWW) or Indian Ocean Watch Bulletins (IO), or Local Tsunami Watch Bulletins (LTWB) or Tsunami Information Statements (TIS). Japan Meteorological Agency (J), issues the Northwest Pacific Tsunami Bulletins (NWPTA), or Indian Ocean Tsunami Watch Information Bulletins (TWI). When the West Coast/Alaska Tsunami Warning Center (A) issues a message it is also included. Epicenter depth from GCMT solutions, and M_W from USGS (G), and M_W from PTWC (P) at action time. Height measurements from tide gauges peak to trough or half peak to trough as indicated, otherwise measurement is the greatest value for either inundation or runup depending on the event.

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
16 Jul	01:13	Near West Coast of Honshu, Japan	37.535° N 138.446° E	12	6.7 (P) 6.6 (GCMT) 6.5 (G)	TIB	01:33	YES NO	<0.5m (half peak to trough) Sado Island
16 Jul	14:18	Sea of Japan	36.808° N 134.850° E	373	6.8 (G, GCMT) 6.6 (J, P)	NWPTA TIB	14:23 14:29	NO	
26 Jul	05:40	Northern Molucca Sea	2.872° N 127.464° E	42	7.0 (P) 6.9 (G, GCMT)	TIB NWPTA	05:55 05:57	NO	
01 Aug	17:09	Vanuatu	15.595° S 167.680° E	127	7.3 (P) 7.2 (G, GCMT)	TIB	17:24	NO	
02 Aug	02:38	Tatar Strait	47.116° N 141.798° E	12	6.2 (G, GCMT)			YES NO	30 cm (peak to trough) Wakkanai, Hokkaido, Japan
02 Aug	03:22	Andreanof Islands, Aleutian Is.	51.307° N 179.971° W	32	6.9 (P) 6.7 (GCMT) 6.6 (G)	TIB	03:32	YES No	slight, Amchitka, AK tide gauge
08 Aug	17:05	Java, Indonesia	5.859° S 107.419° E	304	7.7 (J) 7.5 (GCMT, P) 7.4 (G)	TIB TWI	17:22 17:32	NO	
15 Aug	20:22	Andreanof Islands, Aleutian Is.	50.322° N 177.548° W	12	6.8 (P) 6.4 (GCMT)	TIB	20:31	NO	
15 Aug	23:41	Near Coast of Peru	13.386° S 76.603° W	33	8.0 (GCMT) 7.9 (P) 7.5 (P 001)	TIB 001 FRW 001 FRW 002 FRW 003- (Cancellation)	23:53 00:19 (16 Aug) 01:26 02:09	YES NO	5.6 m (runup) Caleta Lagunillas Ica, Peru
16 Aug	08:39	Solomon Islands	9.830° S 159.467° E	14	6.5 (P) 6.4 (GCMT)	TIB NWPTA	09:00 09:04	NO	
2 Sep	01:05	Santa Cruz Islands	11.610° S 165.762° E	18	7.4 (P001, J001) 7.3 (P002-3, J002) 7.2 (G, GCMT)	TIB 001 NWPTA 001 TIB 002 NWPTA 002 TIB 003	01:21 01:32 01:59 02:13 04:26	YES NO	0.5 m Port Vila, Vanuatu

Earthquake summary, *continued*

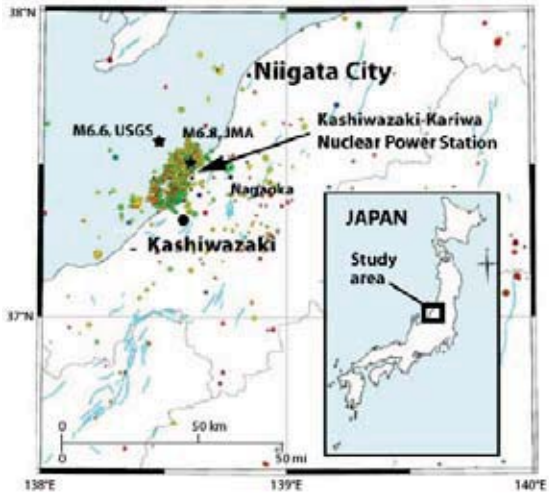
DATE	TIME (UTC)	LOCATION	EPICENTER	DEPTH (km)	M_w	PTWC (P) JMA (J), or WC/ATWC (A) ACTION	ACTION TIME (UTC)	TSUNAMI? DAMAGING?	MAXIMUM MEASUREMENT and LOCATION
06 Sep	17:51	Taiwan Region	24.340° N 122.219° E	60	6.5 (J) 6.2 (GCMT) 6.1 (G)	NWPTA	17:58	NO	
10 Sep	01:49	West Coast of Colombia	2.982° N 77.967° W	17	6.8 (G,P) 6.7 GCMT)	TIB	01:58	NO	
12 Sep	11:10	Southern Sumatra Island, Indonesia	4.438° S 101.367° E	23	8.5 (GCMT) 8.4 (G) 8.3 (IO 002,P002) 8.2 (J 002-6) 7.9 (J, P001)	(IO) RW 001 TIB 001 TWI 001 (IO) RW 002 TWI 002 (IO) RW 003 TWI 003 (IO) RW 004 TWI 004 TWI 005 (IO) RW 005 TIB 005 TWI 006 TWI 007	11:24 11:35 11:36 11:53 12:08 12:30 12:51 13:21 13:35 14:25 14:40 15:05 17:26 21:10	YES	3.60 m (runup) Pantai Pasir Indah (beach in Mukomuko Sumatra)
12 Sep	23:49	Kepulauan Mentawai Region, Indonesia	2.625° S 100.841° E	44	7.9 (G, GCMT) 7.8 (P)	(IO) 001 TIB 001 TIB 002 TIB 003	00:01 (13 Sept) 00:04 (13 Sept) 00:28 03:02	NO	
13 Sep	03:35	Southern Sumatra Island	2.130° S 99.627° E	17	7.1 (P) 7.0 (G, GCMT)	TIB TWI	03:48 03:59	NO	
13 Sep	09:49	Talaud Island, Indonesia	3.801° N 126.335° E	22	6.6 (P) 6.3 (G, GCMT)	TIB TWI	10:00 10:03	NO	
14 Sep	06:02	Southern Sumatra	4.075° S 101.169° E	15	6.5 (P) 6.4 GCMT) 6.2 (G)	TIB TWI	06:17 06:28	NO	
20 Sep	08:31	Southern Sumatra	1.999° S 100.141° E	32	6.7 (G, GCMT) 6.6 (P)	TIB TIB TWI	08:44 08:46 08:50	NO	
26 Sep	12:36	New Ireland Region, P.N.G.	4.990° S 153.500° E	47	6.9 (P) 6.7 (G, GCMT)	TIB NWPTA	12:52 12:55	NO	
28 Sep	01:36	S.E. of the Loyalty Islands	21.133° S 169.373° E	20	6.7 (P) 6.5 (G) 6.3 (GCMT)	TIB	01:51	NO	
28 Sep	13:39	Mariana Islands Region	22.004° N 142.651° E	276	7.4 (G, GCMT, P)	TIB NWPTA	13:52 14:01	NO	
30 Sep	02:09	South of Mariana Islands	10.454° N 145.718° E	12	7.1 (P) 6.9 (G,GCMT)	TIB NWPTA	02:23 02:27	NO	
30 Sep	05:24	Auckland Islands, New Zealand	49.271° S 164.115° E	13	7.4 (GCMT, P) 6.9 (G)	TIB 001 TIB 002	05:38 09:14	YES	0.45 m (half peak to trough) Dog Island NZ gauge
30 Sep	09:48	Auckland Islands, New Zealand	49.138° S 164.110° E	30	6.8 (P) 6.6 (GCMT) 6.5 (G)	TIB	10:01	NO	

West Coast of Honshu, Japan, 16 July 2007, 01:13 UTC, M_W 6.6

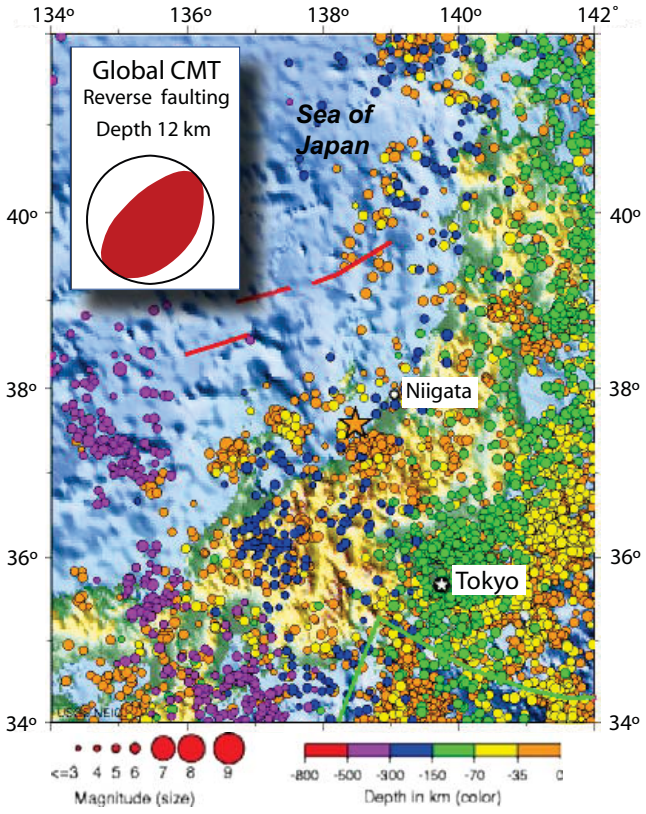
The Niigata Chuetsu Oki earthquake occurred 16 July 2007 01:13 UTC (10:13 a.m. local time).The mainshock had an estimated focal depth of 10 km and struck in the Japan Sea offshore Kariwa, Niigata Prefecture. The earthquake resulted in eleven fatalities and nearly two thousand injuries. Over 1,000 residences collapsed, many of them older homes with wood and clay walls and heavy *kawara*, clay-tile roofs. The earthquake affected an area approximately 100-km-wide along the coast of southwestern Niigata and triggered ground failures as far as the Unouma Hills in central Niigata, approximately 50 km inland, the source area of the 2004 Niigata Chuetsu earthquake. Damage occurred in lifeline utilties of gas, water, and electricty. The world's largest nuclear power plant is located in Kariwa where 33 records of the mainshock were recovered from within the grounds of the power plant, which was heavily instrumented with strong motion seismometers.

A post-earthquake survey has been published by USGS entitled, *Investigation of the M6.6 Niigata-Chuetsu Oki, Japan, Earthquake of July 16, 2007; Open File Report 2007-1365*. As a joint effort between the Earthquake Engineering Research Institute (EERI) and Geo-Engineering Earthquake Reconnaissance (GEER) work of the National Science Foundation (NSF), with support and funding from a multiple other organizations, the team was led by Robert Kayen (USGS). The online report is available at *http://pubs.usgs.gov/of/2007/1365/of2007-1365.pdf.*

The primary event produced tsunami run-ups that reached maximum runup heights of 32 centimeters along the shoreline of Niigata Prefecture and was recorded on water level gauges in the area.



Map showing the mainshock and the immediate aftershocks clustered offshore. From the USGS Open File Report 2007-1365 at: http://pubs.usgs.gov/of/2007/1365/of2007-1365.pdf.



Above. Historical seismicity in the area (1990-present) with recent earthquake location and depth marked by a star. Map courtesy of USGS National Earthquake Information Center (NEIC).

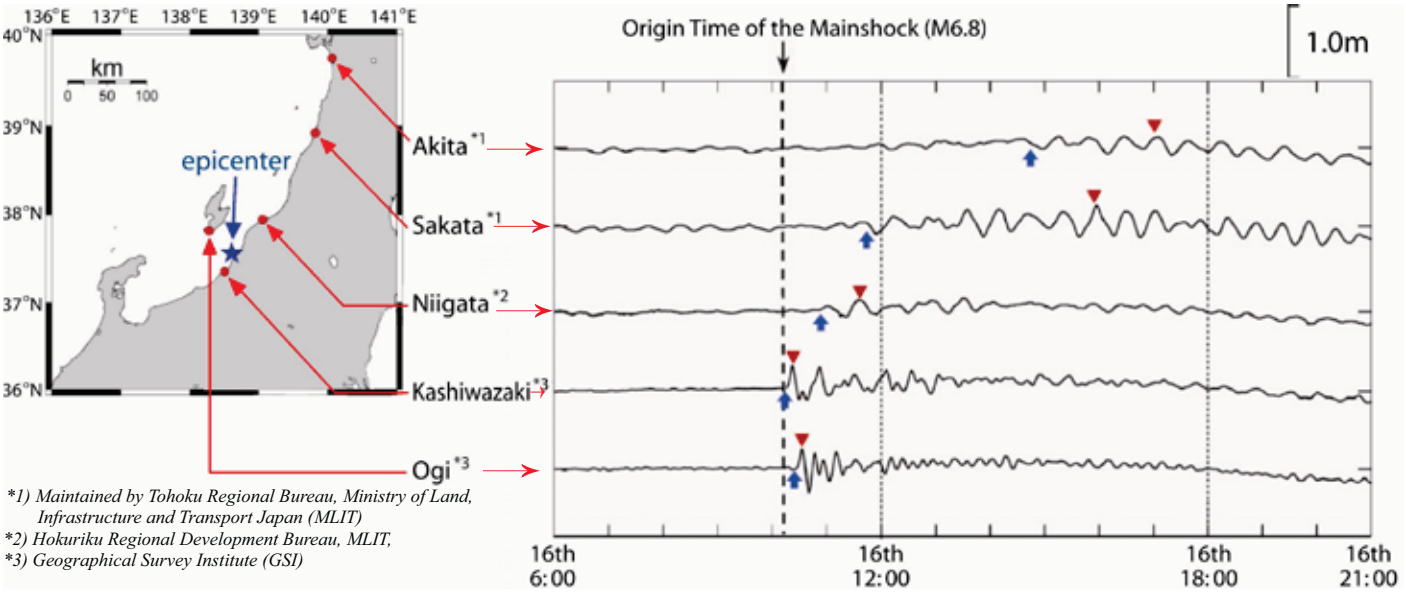
Observed sea level data 16 July 2007, Japan

	initial wave			Max. height	
Tide Station	Arrival time	rise/fall	wave height (cm)	time of maximum wave height (JST)	wave height (cm)
Akita*1	14:43	fall	10	17:05	12
Skata*1	11:47	fall	13	15:58	24
Niigata*2	10:53	rise	6	11:35	14
Ogi*3	10:27	rise	27	10:33	27
Kashiwazaki*3	10:16	rise	32	10:22	32
Nezumigaseki*3	11:54	rise	3	14:22	9
Sadoshi Washizaki	10:39	rise	4	12:33	7
Wajima*3	—	—	—	17:36	6
Suzushi Nagahashi	—	—	—	12:41	5
Toyama	10:44	rise	4	12:03	5

**1) Tohoku Regional Bureau, Ministry of Land, Infrastructure and Transport Japan (MLIT)*
**2) belong to the Hokuriku Regional Development Bureau, MLIT,*
**3) belong to Geographical Survey Institute (GSI)*

Above. Graph of sea level data observed by tide gauges in Japan. Stations with no designation belong to Japan Meteorological Agency (JMA), otherwise agency names are listed below chart. When blank ("-"), first wave arrival could not be determined. Courtesy of JMA.

Honshu, *continued*



*1) Maintained by Tohoku Regional Bureau, Ministry of Land, Infrastructure and Transport Japan (MLIT)
*2) Hokuriku Regional Development Bureau, MLIT,
*3) Geographical Survey Institute (GSI)

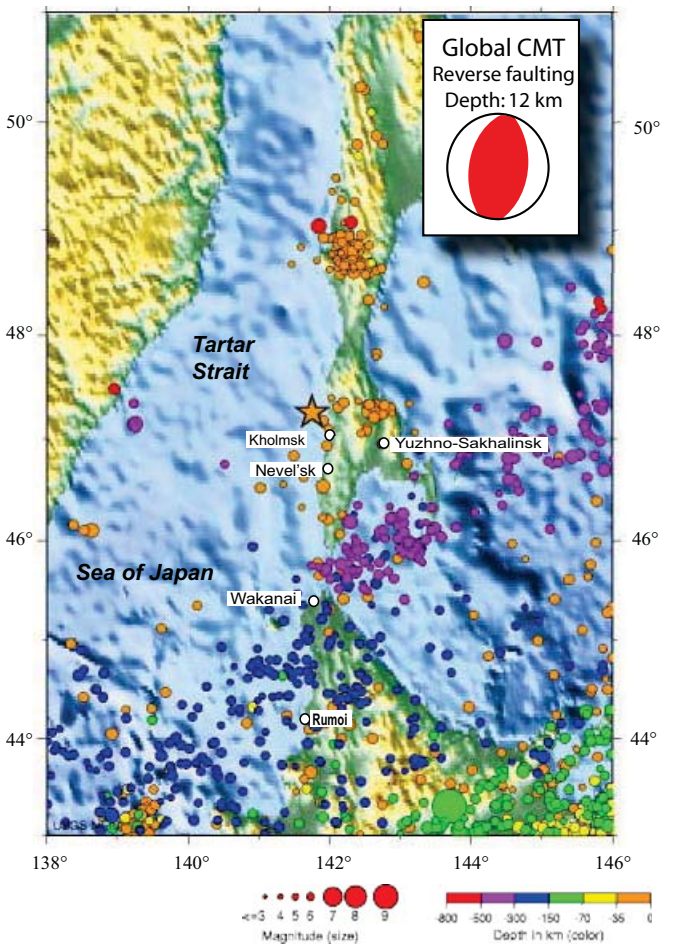
The map shows the epicenter (blue star) and station locations (red circles). These stations had waveforms observed with amplitudes of 5 cm or greater. The dotted line on the graph is the earthquake origin time in Japan Standard Time (JST). The blue arrows indicate initial wave arrival times and the red triangles mark when maximum amplitudes were recorded. Courtesy of JMA

Tatar Strait, 2 August 2007, 02:38 UTC, M_W 6.2

An earthquake with a magnitude of 6.2 occurred at 02:38 (UTC) 2 August 2007 in the Tatar Strait, the northernmost part of the Sea of Japan. The epicenter of the earthquake was located near Nevel'sk, Southern Sakhalin, about 60 km from Yuzhno-Sakhalinsk. The earthquake tremor was felt over the entire southern part of Sakhalin Island. Significant damage was observed around Nevel'sk. At least two people were killed and several were injured. Property damage was extensive and included destruction of eleven buildings.

The earthquake generated a weak tsunami that was recorded on the southwestern coast of Sakhalin (~ 20 cm in Nevel'sk and Kholmsk) and on the northern coast of

Earthquake destruction and damage as photographed following the Sakhalin Earthquake of 02 August 2007. Photographs courtesy of Tatiana Ivelskaya, Sahkalin Tsunami Warning Center.



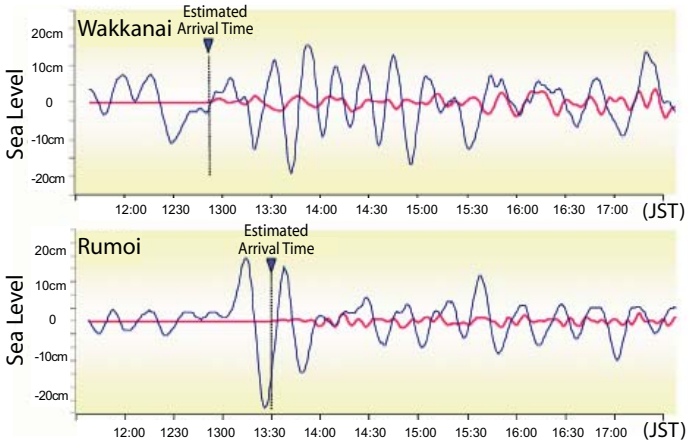
Above. Historical seismicity (1990-present) with this earthquake location and depth marked by star. Map courtesy of USGS National Earthquake Information Center (NEIC).

Tatar Strait, *continued*

Hokkaido Island, Japan; ~ 30 cm at Wakkanai (arrival at 09:52 UTC) and ~ 20 cm at Rumoi (arrival time at about 10:30 UTC).

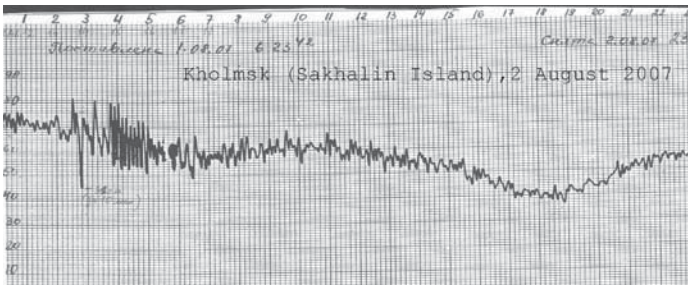
An aftershock (M=5.9) occurred at 03:22 UTC.

Japan sea level records, 2 August 2007



Above. Sea level records from Wakkanai and Rumoi stations in Hokkaido Japan, provided by Japan Meteorological Agency (JMA). Each graph shows the observed (blue line) and simulated (red line) sea levels for 02 August 2007, with wave arrival estimations indicated by vertically labelled line. Japan Standard Time (JST) is UTC+9 hrs. Courtesy of JMA.

Kholmsk sea level record, 2 August 2007



Tide record for 2 August 2007 from the Port of Kholmsk. Maximum wave height was determined to be 31 cm at 02:50 UTC. Courtesy of Tatiana Ivelskaya,

Observers looking for evidence of tsunami inundation along the shore of Southern Sahkalin near Nevel'sk, where wave height was reported at 20 cm. Courtesy of Tatiana Ivelskaya.

Information on Sakhalin Event 02:37 UTC, 2 August 2007

UTC	To:	From:	Event	Comments
02:38	Sakhalin Tsunami Warning Center (STWC)	Yuzhno-Sakhalinsk Seismic Station	Yuzhno-Sakhalinsk Seismic Station	Trigger registration P-wave, P023852 Z
02:40	WEPA 40 distribution	STWC	p-time	
02:40	Domestic	Sakhalin Emergencies Department (SED)	Strong shaking in Nevel'sk	
02:49	STWC	Nevel'sk Marine Station (NMS)	Nevel'sk	MSK-64 instensity value was 6
02:55	STWC	Kholmsk Marine Station (KMS)	Kholmsk	MSK-64 instensity value was 5
02:57	STWC	YSS	Coordination	M_S 6.6 epicenter coodinates 46.7° N, 142.1° E
02:59	NMS and KMS	STWC	Coordination	Max wave (by instrumental observation) is 31 cm 02:50 UTC 02 August
03:11	STWC	SED	Nevel'sk Port	Visual observation max wave 20 cm height
03:16	STWC	YSS	YSS updated EQ parameter to 02:38 UTC	Time 02:37 UTC, M_S 6.8, coordinates 46.6° N, 142.1° E
04:10	STWC	KMS	Kholmsk Port	Max wave (by instrumental observation) is 31 cm 02:50 UTC 02 August
07:05	STWC	YSS	YSS updated EQ parameter to 02:37 UTC	M_S 6.1
11:21	STWC	YSS	YSS updated EQ parameter to 02:37 UTC	M_S 6.0, coordinates 46.6° N, 141.6° E

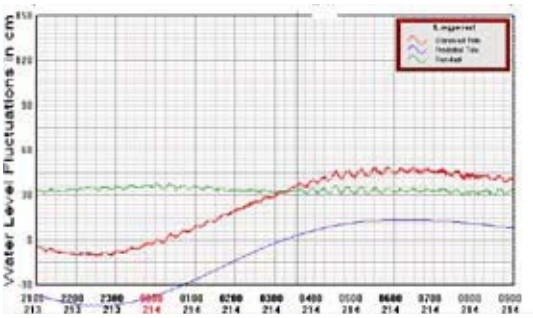
Courtesy of Tatiana Ivelskaya, Chief, Sakhalin Tsunami Warning Center, e-mail T_Ivelskaya@SakhUGMS.ru

Andreanof Islands, Aleutian Islands, 2 August 2007, 03:22 UTC, M_W 6.7

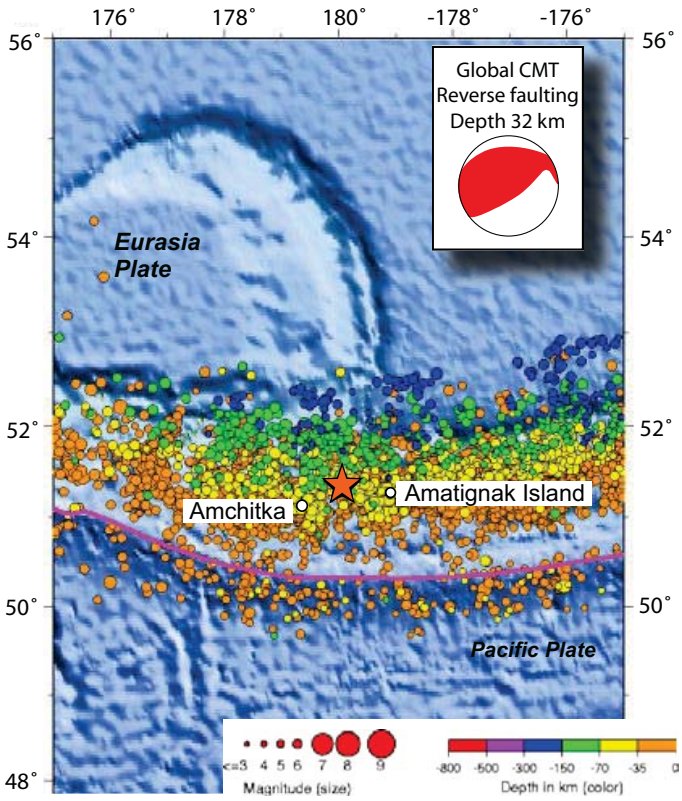
An earthquake measuring a magnitude of 6.7 (Mw) occurred 2 August 2007 at 03:22 UTC. The earthquake was located 239 km (148 miles) WSW of Adak, Alaska and approximately 200 km (120 miles) east of the tide station at Amchitka, Alaska. The estimated depth was 32 km.

The earthquake produced a very small tsunami that was recorded on the tide gage at Amchitka, Alaska operated by the West Coast/Alaska Tsunami Warning Center (WC/ATWC) and the USGS Alaska Volcano Observatory. The estimated time of arrival computed at the West Coast/Alaska Tsunami Warning Center is based on the origin time and location and estimated to be 03:30 UTC Julian Day 214, or 2 August 2007.

Amchitka Alaska tide record 1-2 August 2007



The tide record for Amchitka Alaska indicates a very minor tsunami was recorded there after the Aleutian Islands earthquake. The graph indicates observed water level in red. Courtesy of WC/ATWC.



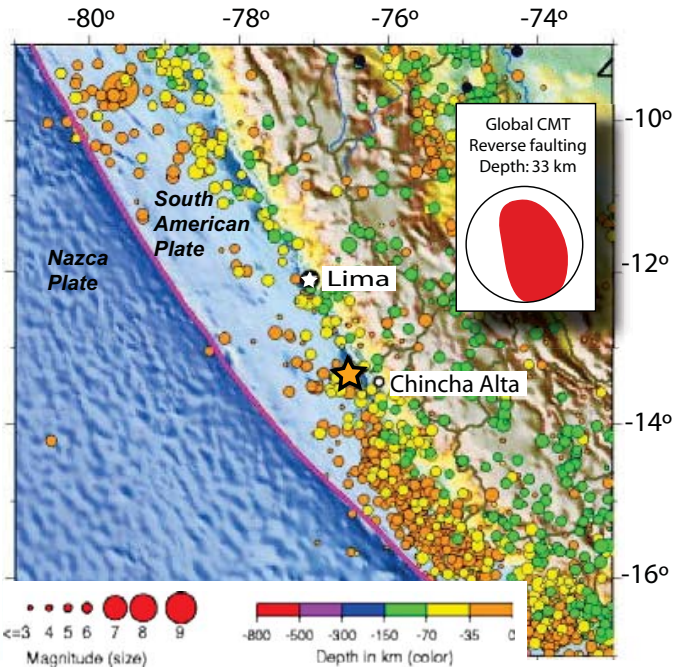
Above. Historical seismicity for the area from 1990-present, with recent earthquake location and depth marked by a star. Map courtesy of USGS National Earthquake Information Center.

Coast of Peru, 15 August 2007, 23:41 UTC, M_W 8.0

An earthquake occurred off the coast of Peru 15 August 2007, 23:41 UTC, (18:41 local time). The epicenter is calculated to be 13.322°S, 76.508°W at a depth of 23 km with a magnitude of 8.0 (Mw), approximately 45 km (25 miles) from Chincha Alta, Peru and 145 km (90 miles) south of Lima.

At least 514 people were killed and 1090 injured. More than 35,500 buildings were destroyed and more than 4200 buildings damaged. The majority of the damage and casualties occurred in Chincha Alta, Ica and Pisco. Widespread communications and power outages occurred in the area. The Panamerican Highway, the Carretera Central and other main transport routes suffered heavy damage due to landslides and cracks. Felt reports from around Lima and into Ecuador, Colombia, Bolivia, Brazil, and Chile.

Tide stations from around the Pacific recorded tsunami wave heights, including the following: 16 cm at Antofagasta, 36 cm at Arica (*see next page*), 19 cm at Caldera, 27 cm at Coquimbo, 20 cm in Archipielago Juan Fernandez, 17 cm at San Antonio, 27 cm at San Felix,



Historical seismicity (1990-present) with recent earthquake depth and location marked by a star. Map courtesy of USGS National Earthquake Information Center (NEIC).

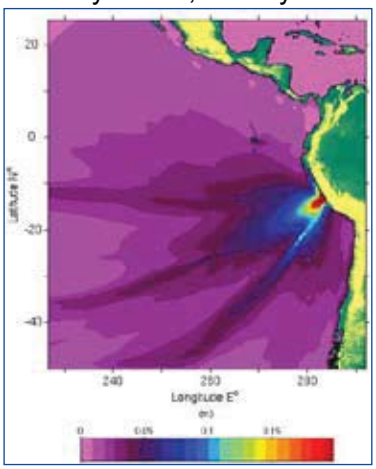
Peru, *continued*

35 cm at Talcahuano and 18 cm at Valparaiso, Chile; 12 cm at Hanasaki and 13 cm at Tosa-Shimizu, Japan; 30 cm at Chatham Island, 13 cm at Green Island, 25 cm at Kaikoura, 17 cm at Lyttelton, 22 cm at Sumner Head and 26 cm at Tinaru, New Zealand; 100 cm at Callao and La Punta, Peru; 13 cm at Apia, Samoa; 10 cm at Dutch Harbor, Alaska; 16 cm at Crescent City, California; 37 cm at Hilo, 28 cm at Kahului, 11 cm at Kawaihae, Hawaii, USA and 14 cm at Port Vila, Vanuatu.

Unfortunately the closest tide station (55 km south of the epicentre in Puerto General San Martin) was unable to record the tsunami, when the shock of the earthquake knocked the pressure sensor unoperational.

Within eight minutes of the earthquake, the Geophysical Institute of Peru (IGP) was able to communicate initial details of the earthquakes size and location. Seven minutes later a fax was received from PTWC that there was no teletsunami generated, but the possibility existed of a local tsunami being generated. Most of the people interviewed were aware of the tsunami danger. A tsunami evacuation of Callao was initiated, then cancelled at 23:02 local time.

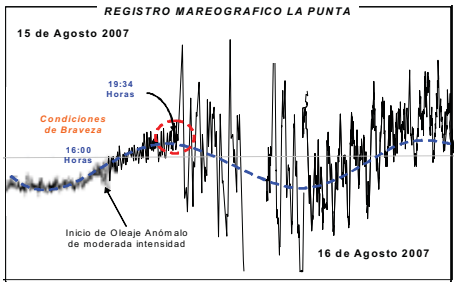
An International Tsunami Survey Team, led by Hermann Fritz, made an investigation on 4-7 Sept, traveling over 1,000 km and surveying 248 km of coastline. Quoting inpart from the preprint article,



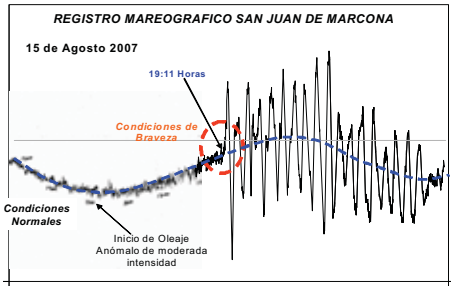
Above. Maximum wave height distribution 10 hours after the earthquake in the vicinity of Peru. Modelled by the Tsunami Research Group, University of Southern California, http://www.usc.edu/dept/tsunamis/2005/tsunamis/Peru_2007/index.html.

Sea Level Records 15-17 August 2007

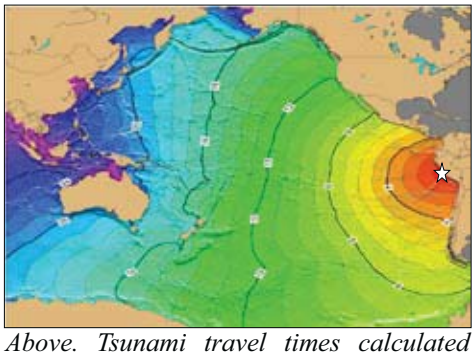
La Punta, Peru 15 August



San Juan de Marcona 15 August

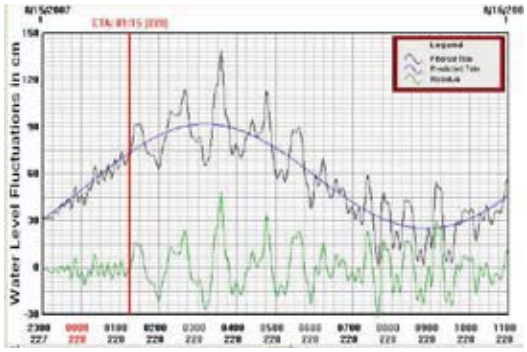


The tide gauge nearest the epicenter was knocked out of commission from the earthtquake These Peruvian tide gauge recordings were included in the HIDRONAV tsunami survey results.



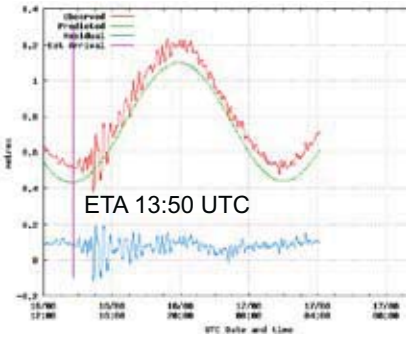
Above. Tsunami travel times calculated using the epicenter as a point source for the tsunami.

Arica Chile 16 August 2007

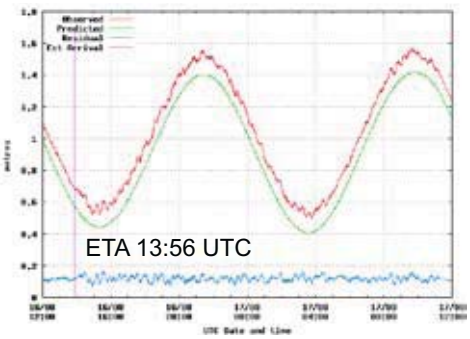


Left. Tide record for Arica Chile shows a tsunami was recorded there after the Peruvian earthquake. The estimated time of arrival was 01:15 UTC 16 August, or Julian Day 228. Courtesy of WC/ATWC. One of many tide records found for this event at http://wcatwc.arh.noaa.gov/previous.events/08-15-07-Peru/08.15.07.html

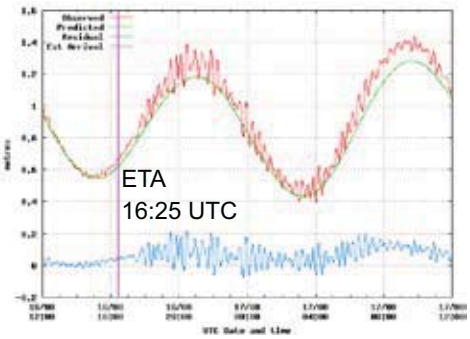
Sea Level Record Apia, Samoa 16–17 August



Sea Level Record Nuku'alofa, Tonga 16–17 August



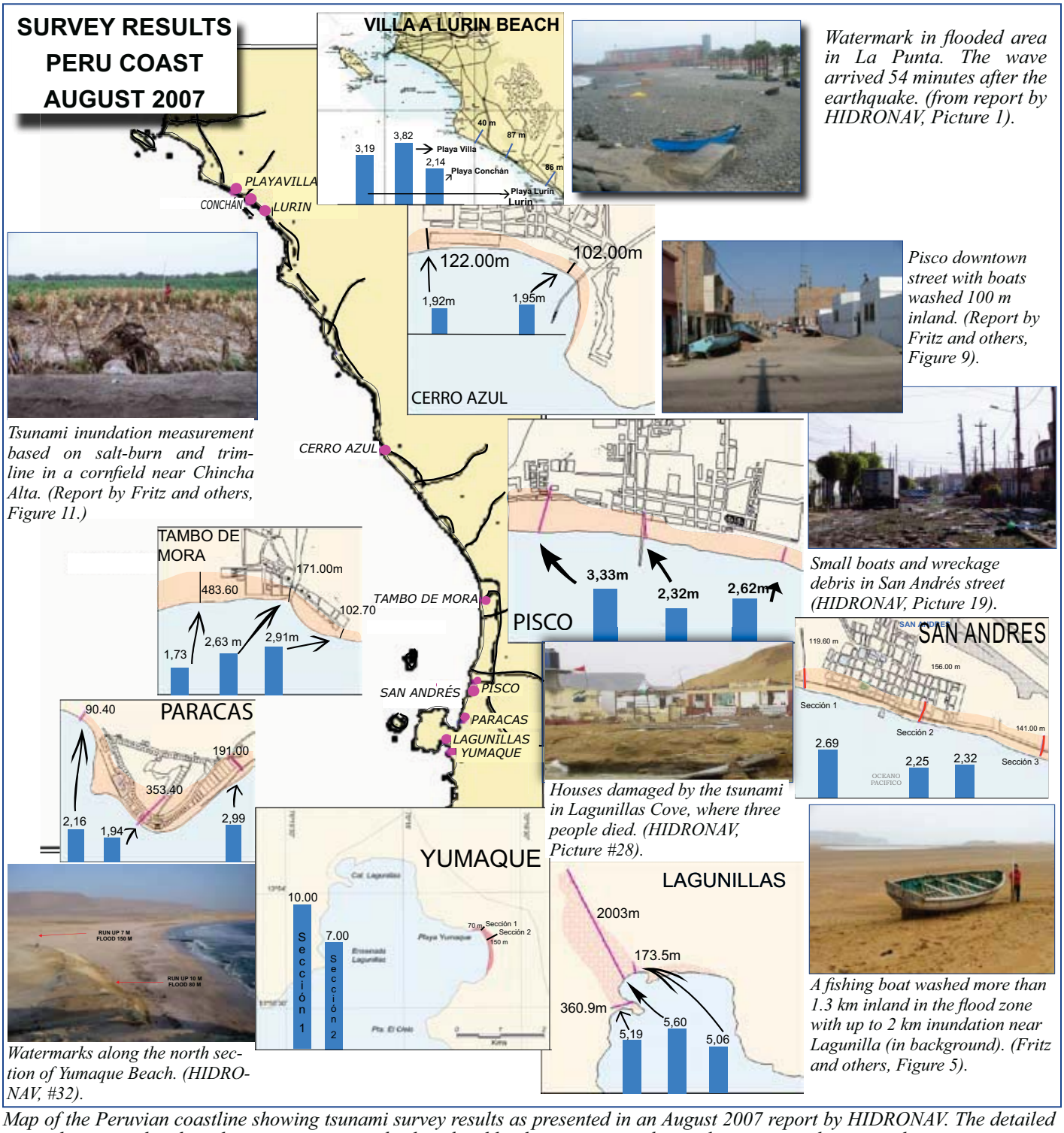
Sea Level Record Port Vila, Vanuatu 16–17 Aug



Sea level records show water level fluctuations following the Peru earthquake of 15 August 2007 across the Pacific in Samoa, Tonga and Vanuatu, where the height was recorded on sea level instruments. Lower three compliments of BOM's National Tide Centre.

Peru, *continued*

15 August 2007 Peru tsunami and runup and inundation, by Hermann M. Fritz, Niko Kalligeris, Erick Ortega and Pablo Broncano, over 50 transects were recorded from the waterline to the inundation limit and adjusted for tide levels at estimated time of wave arrival. The largest tsunami height and inundation was measured south of the Paracas peninsula at Play Yumaque where 10 m heights and inundation of over 7 m was sustained for a 5 km section of coastline. North of Paracas there was less inundation but still boats were washed into streets in the town of Pisco as they were in Lagunailla, where impact was measured at twice the level. It was in Laguanilla that seven inhabitants were swept up in the



Watermark in flooded area in La Punta. The wave arrived 54 minutes after the earthquake. (from report by HIDRONAV, Picture 1).

Pisco downtown street with boats washed 100 m inland. (Report by Fritz and others, Figure 9).

Tsunami inundation measurement based on salt-burn and trim-line in a cornfield near Chincha Alta. (Report by Fritz and others, Figure 11.)

Small boats and wreckage debris in San Andrés street (HIDRONAV, Picture 19).

Houses damaged by the tsunami in Lagunillas Cove, where three people died. (HIDRONAV, Picture #28).

A fishing boat washed more than 1.3 km inland in the flood zone with up to 2 km inundation near Lagunilla (in background). (Fritz and others, Figure 5).

Watermarks along the north section of Yumaque Beach. (HIDRONAV, #32).

Map of the Peruvian coastline showing tsunami survey results as presented in an August 2007 report by HIDRONAV. The detailed maps show wave height at locations in meters displayed as blue bars corresponding to locations on the maps where measurements were also made of inundation (distance water moved inland). The complete report is available through HIDRONAV, in Spanish or English, at their website, http://www.dhn.mil.pe/docs/tsunami/Informe_Post_Tsunami_Pisco%202007.pdf.

Peru, *continued*

tsunami, three of them died, their bodies recovered 1.8 km inland. In Chincha Alta, the Tambo de Mora prison was flooded, but no one was killed as prison walls had already collapsed from the earthquake and 600 prisoners escaped.

In addition a formal survey was made by the Peruvian Navy's Directorate of Hydrography and Navigation (HIDRONAV), which also gathered survey information from local branches of naval and emergency relief agencies. One of the conclusions of the report was that many people along the coast are aware of tsunami hazards through varous public awareness campaigns of the last ten years, but that efforts need to continue. The report makes several other recommendations toward improving mitigation and response.

Meteorological Tsunami Adriatic Sea, 22 August 2007, 05:24 UTC

Ivica Vilibic, Institut za oceanografiju i ribarstvo (Institute of Oceanography and Fisheries) Setaliste I. Mestrovica 63, 21000 Split, Hrvatska/Croatia tel. +385 21 408048 fax. +385 21 358650, email: vilibic@izor.hr, URL: http://www.izor.hr/~vilibic

Quite strong sea level oscillations, estimated to reach 4 m in range and having a period of 5-10 minutes, struck a cone-line bay located at the southeast coast of the island of Ist, Adriatic Sea, on 22 August around 15:30 UTC. The oscillations resulted in one injured person, flooding of tens of houses close to the shore and caused electrical outages. No seismic activity has been reported, but just at that time a large atmospheric convective cell passed over the area.

Photos show the waterline marked on the houses instead of a tide gauge record.

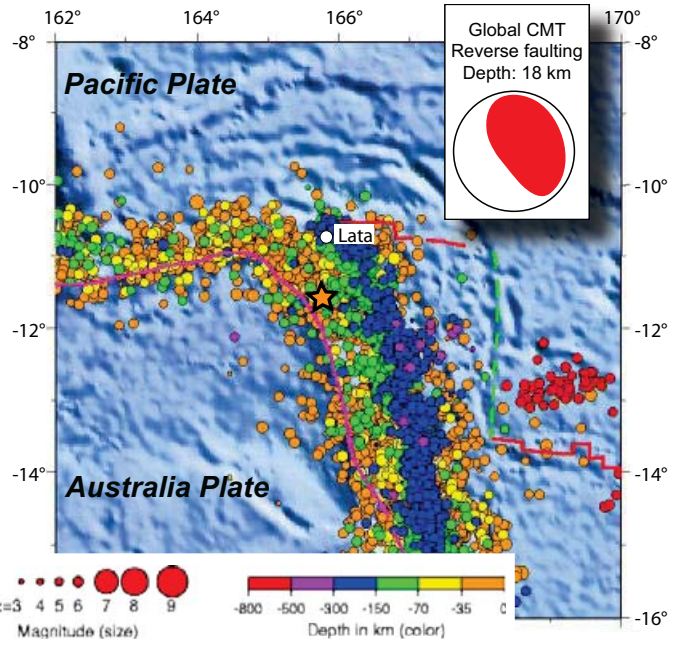
Therefore, it is suspected that these tsunami-like oscillations were generated by the convective cell, producing a destructive meteotsunami in the bay. By investigating analogous barograms at the nearest stations, a sharp oscillation in air pressure with the period of about 30 min and range of 4 hPa is found just at the time when meteotsunami occurred. The convective system and associated high-frequency air pressure oscillations passed the area towards the ENE-NE as visible at the satellite images. However, a more precise estimate of disturbance propagation direction will be done when digitising all available data. Also, disturbance velocity should be estimated, as it is known that such convective systems may excite the ocean waves at certain depths (so called *Proudman Resonance*). A broad shelf (approx. 150 km wide and 50-70 deep) is placed SW from the Ist, being favourable for the generation of Proudman resonance when a disturbance is coming from W to S with velocities of 22-26 m/s.

More on meteotsunamis can be found in: Monserrat, S., Vilibic, I., Rabinovich, A.B., 2006. Meteotsunamis: atmospherically induced destructive ocean waves in the tsunami frequency band. Natural Hazards and Earth System Sciences, 6, 1035-1051

Santa Cruz Islands, 2 September 2007, 01:05 UTC, M_W 7.2

An earthquake occurred on 2 September at 01:05 UTC (02 Sep 12:05 PM local time in Santa Cruz Islands and 7:05 PM MDT, 01 Septempber 2007) with a magnitude of 7.2. It was located 95 km (60 miles) S of Lata, Santa Cruz Islands, Solomon Isl., or approximately 680 km (425 miles) ESE of Honiara, Guadalcanal, Solomon Islands

The Santa Cruz Islands earthquake of 2 September, 2007, occurred along the boundary between the Pacific plate and Australia plates. In the region of the earthquake, the Australia plate moves to the east-northeast with respect to the Pacific plate at a velocity of about 91 mm/year. The Australia plate thrusts under the Pacific plate at the North New Hebrides trench and dips to the east-northeast.



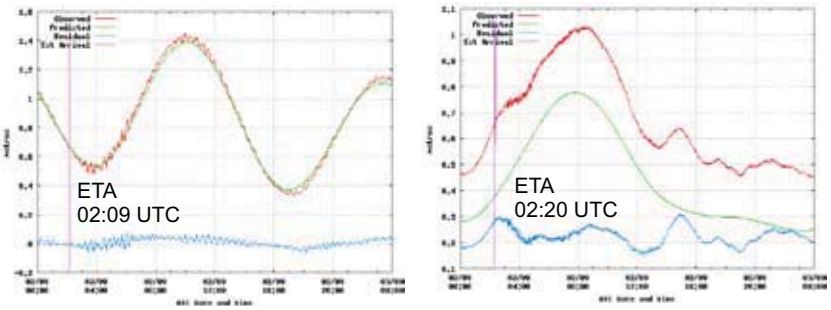
Right. Historical seismicity (1990-present) with the recent earthquake epicenter and depth marked by a star. Map courtesy of USGS National Earthquake Information Center (NEIC)

Santa Cruz Island, *continued*

The Santa Cruz Islands region experiences a very high level of earthquake activity, with over a dozen shocks of magnitute 7 and larger recorded since the early decades of the Twentieth Century. The subducting Australia plate is seismically active to depths of about 250 km beneath the islands.

The tsunami arrival at Port Vila is estimated by Australia's BOM to be 2:09 UTC 2 September, and at Honiara 2:20 UTC, or 11 minutes later.

Port Vila, Vanu- Honiara, Solomon Islands



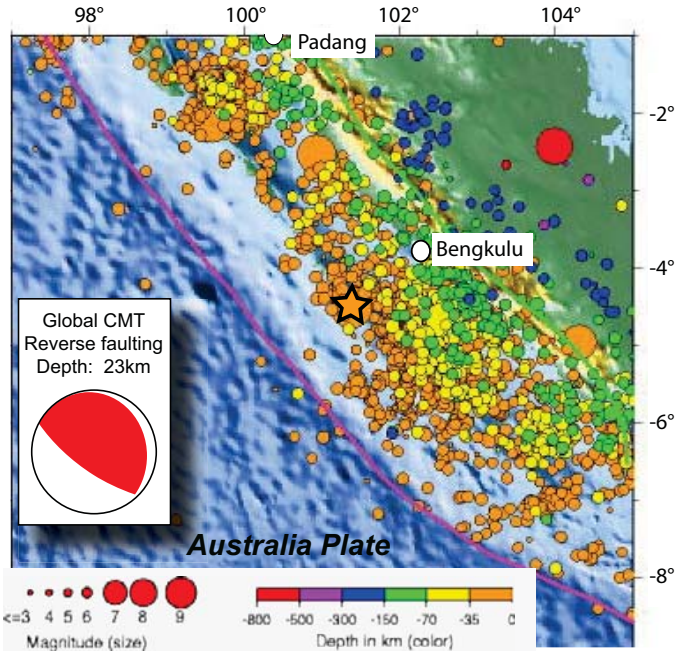
Sea level records showing the wave of 2 September at Honiara (left) and Port Vila (right). Courtesy of Australia's Bureau of Meteorology (BOM) National Tidal Centre.

South Sumatra Island, Indonesia, 12 September 2007, 11:10 UTC, M_W 8.4

An earthquake, occured on 12 September 2007 11:10 UTC (6:10 pm local time), measuring 8.4 (Mw). A second earthquake. measuring 7.9 (Mw), and located 225 km to the northwest occurred roughly 12 hours later.

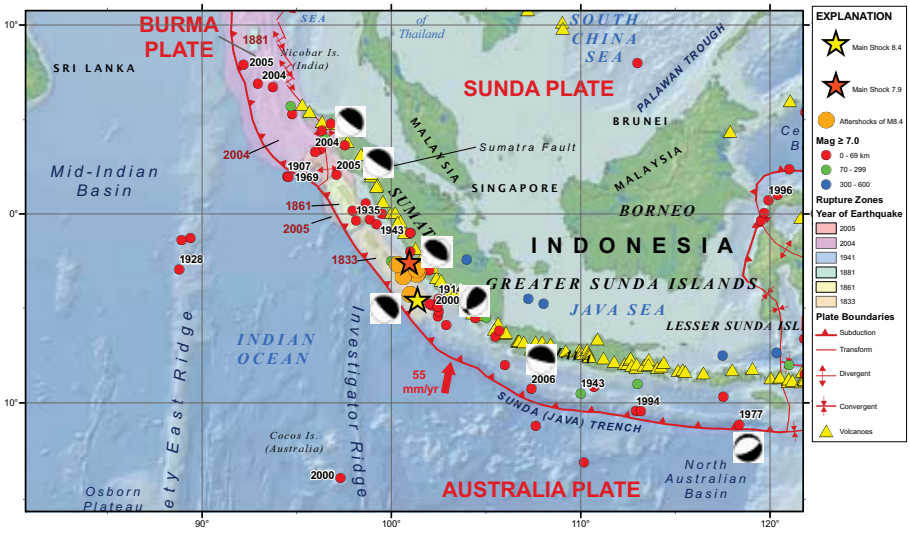
At least 25 people were killed and 161 injured, with 52,522 buildings damaged or destroyed in Bengkulu and Sumatera Barat. Power and telephone outages occurred. The earthquake was felt by people as far away as Jakarta, Malaysia, Singapore and Thailand.A seiche was observed in Khlong Saensaep in Bangkok, Thailand and sink holes which may have been caused by the earthquake appeared at 3 locations in Ipoh, Malaysia.

A tsunami was generated which caused some of thebuilding damage mentioned above in the Serangai area, north of Bengkulu. Tsunami wave heights (in cm, peak-to-trough) were recorded at the following tide stations in the Indian Ocean: 24 at Cocos Island, Australia; 9 on Diego Garcia; 227 at Padang, 52 at Cilacap, 42 at Prigi, 30 at Sibolga, 16 at Sabang and 4.5 at Benoa, In-



Above. Historical seismicity (1990-present) of the area with with recent earthquake location and depth marked by a star. Map courtesy of USGS National Earthquake Information Center. (NEIC).

Tectonic setting of the earthquakes of 12 September, Mw 8.4 and 7.9



Left. The magnitude 8.4 and 7.9 (M_W) earthquakes of 12 September 2007 occurred as the result of thrust faulting on the boundary between the Australia and Sunda plates. At the location of these earthquakes, the Australia plate moves northeast with respect to the Sunda plate at a velocity of about 60 mm/year. The Nias Island earthquake of 28 March 2005, 8.6 (M_W) ruptured a northern segment of the same plate boundary.

The M_W 8.4 earthquake of 12 September 2007 is the fourth earthquake of M_W greater than 7.9 to have occurred in the past decade on or near the plate boundaries offshore of western Sumatra.

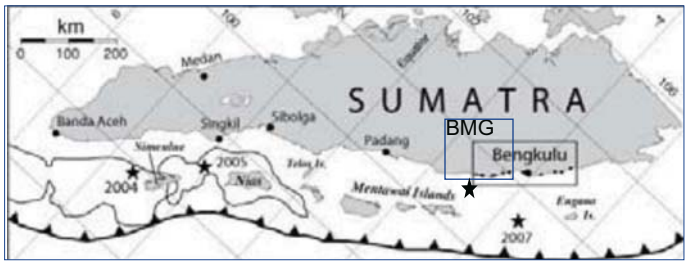
The great M_W 9.1 earthquake of December 26, 2004, which produced that day's devastating Indian Ocean tsunami, ruptured much of the boundary separating the India and Burma plates. Courtesy of USGS.

Sumatra, *continued*

donesia; 8 at Lamu, Kenya; 23 at Hanimadu, 21 at Male and 13 at Gan, Maldives; 114 at Rodrigues, Mauritius; 131 at Salalah and Sur Masirah, Oman; 40 at Point La Rue, Seychelles; 60 at Colombo and at Trincomalee, Sri Lanka; 8 on Phuket, Thailand.

Two post tsunami survey teams have reported on their findings along the coastline north and south of Bengkulu, one reported here in its entirety. Additionally, a formal IOC post–event assessment of the IOTWS was made to evaluate the Indian Ocean tsunami warning system response. It was published as IOC Technical Series Report No. 77 and is available on the Internet through the UNESCO IOC online document search engine at *http://ioc-unesco.org/.*

Fortunately the tsunami energy was no larger than it was, for the waves occurred at near high tide. In the surveyed areas north of Bengkulu, from about Lais, severe ground shaking from the earthquake led to severe damage and destruction to buildings including a school. Further to the north, elevation kept many villages from being affected by the tsunami. Because the earthquake had been felt in the areas in and around and north of Bengkulu, most fled coastal areas at that time, or once

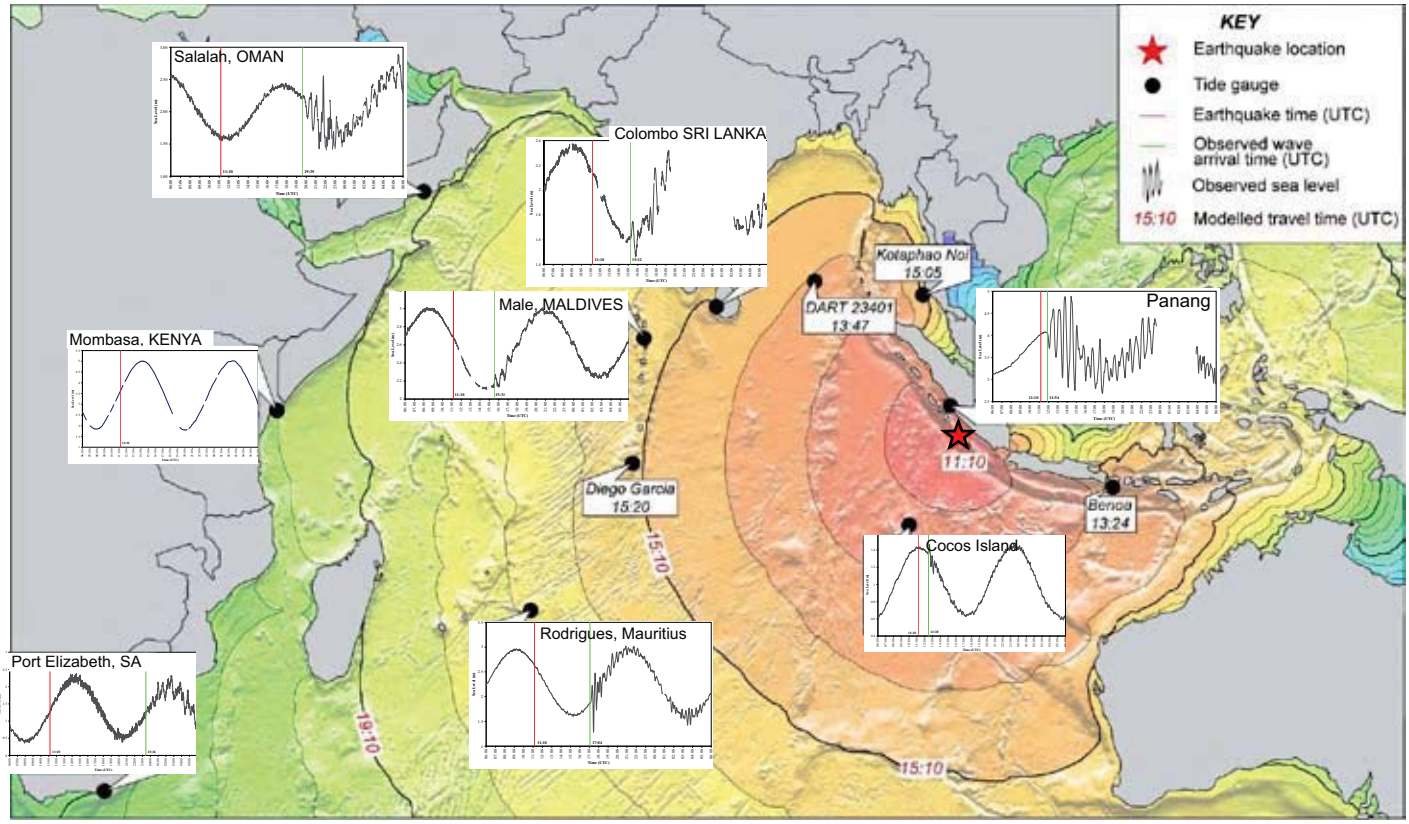


Map showing the area of two post tsunami surveys for this event in rectangles, blue box indicating coastline surveyed for the report on the following page (BMG), while the other box (Bengkulu) indicates the 300 km of coastline surveyed by the team led by Jose Borrero. Stars show epicenters of major earthquakes labeled with the years they occurred. The barbed line represents the Sunda and Indian Ocean plate boundary Map courtesy of J. Borrero.

the ocean appeared to recede. Where witnesses were found, their accounts of times and conditions were recorded. Generally, points further north received the waves within 15-20 minutes of the earthquake with multiple (up to seven) distinct waves within the next several hours. Further south, predominately three waves were observed anywhere from 15 minutes to two hours after the earthquake and in most cases witnesses claim the last wave was the largest.

The area south of Benkulu was difficult to survey as

Tsunami travel time isochrones and sea level time series for the 12 September 2007 tsunami event



Tsunami travel time isochrones and sea level time series for the 12 September 2007 tsunami event. Tide gauges and observed sea level at various stations around the Indian Ocean marked with Earthquake time (red vertical lines) and observed wave arrival time (UTC) indicated with green vertical lines in the station records. From "IOTWS 12 September 2007 Indian Ocean Tsunami Event : Post-event assessment of IOTWS performance", IOC Technical Series No. 77 at http://ioc-unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=2200.

Scenes from Murara Maras, where inundation reached nearly 300 m. This is the only area south of Bengkulu, which experienced tsunami damage. Evidence of runup from the 26 December 2004 tsunami remains to compare to the more recent event on the door to this veranda (right).

A field survey was conducted by Jose Borrero (University of Southern California, Tsunami Research Center and ASR Ltd, New Zealand), Rahman Hidayat and Suranto (both of Badan Pengkajian dan Penerapan Teknologi-BPPT), shown here, right to left, with Freddy, their local driver.

Tsunami field observation in Bengkulu

Indonesian Meteorological and Geophysical Agency (BMG) Survey Team; Indra Gunawan, Andi Suhandi,and Bambang Suryo.

The team went to the area to measure the tsunami run up and to interview people about their experience of the tsunami. The maximum run up is 3.6 meters found in Muko-Muko beach, which is about 200 km north of the epicenter. The beach in Bengkulu city, about 130 km from the epicenter, is very close to the epicenter, but no tsunami is observed. Unfortunately no tide gauge has been installed in Bengkulu city. After Aceh tsunami 2004, not only people in Bengkulu, but also most people in Indonesia are aware of tsunami prior to strong ground shaking. The team found that most people along the beach evacuated the area after the strong earthquake. People in Muko-Muko saw the ocean recede a few minutes after the strong shaking by the earthquake, so they evacuated to higher ground. They came back to the beach in the morning, but due to strong aftershock very close to Muko-Muko (M_W 7.7), people once again evacuated to higher ground and came back a few days later. BMG also issued a tsunami warning for this aftershock.

Tsunami debris in Serangai area, cleared from road by local people.

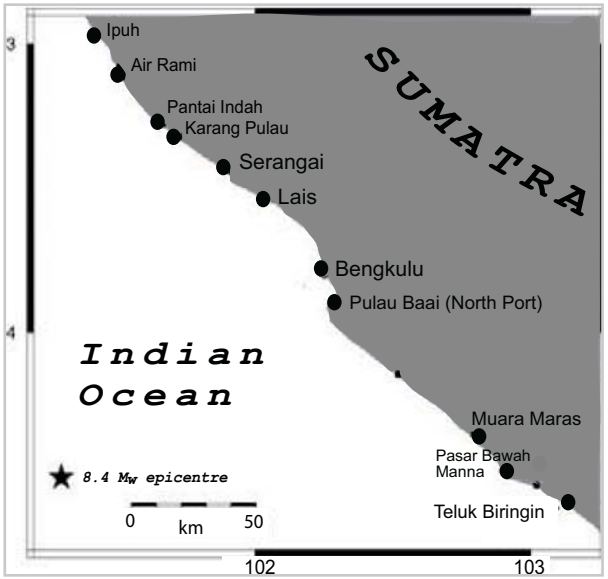
Beach	Location	Run up	Inundation
Pantai Panjang Benteng Malbourgh	03° 48' 03.5" S, 101° 15' 01.7" E	-	-
Pulau Baii Harbor	03° 54' 24.5" S, 101° 18' 12.7" E	-	-
Desa Seranga	03° 25' 47.2" S, 101° 54' 02.1" E	2.35 m	250-300 m
Pantai Pasir Indah 1	02° 35' 17.5" S, 101° 06' 46.2" E	2.75 m	250-300 m
Pantai Pasir Indah 2	02° 35' 15.4" S, 101° 06' 45.3" E	2.15 m	300-350 m
Pantai Pasir Indah 3	02° 35' 08.4" S, 101° 06' 42.1" E	3.60 m	200-250 m
Air Rami	03° 06' 06.3" S, 101° 31' 35.1" E	1.80 m	200-250 m

Table 1. Observation of tsunami high and inundation.

Three photographs above show observations in Pantai Pasir Indah Mukomuko.

Sumatra, *continued*

the highway parallels the coast some 20 km inland through this area. At Muara Maras the highway returns to the coast and tsunami inundation was very much in evidence with much flooding due to increasingly larger waves, with the third wave flooding areas across the highway. Though buildings were flooded, damage was mainly confined to structures with unreinforced rock walls. Runup was higher south of Muara Maras at Pasar Bawah Manna.



Date/time (2007, UTC)	Location	Runup (m)	Inundation Distance (m)
17 Sept 17:45	South Ipuh	2.2	93
17 Sept 15:00	Air Rami	1.8	172
17 Sept 12:00	Pantia Indah	2.0	150
17 Sept 11:15	Karang Pulau	3.3	45
15 Sept 17:15	Lais 2	3.0	35
15 Sept 16:45	Lais 1	3.9	30
15 Sept 11:15	Bengkulu 4	1.4	151
15 Sept 10:45	Bengkulu 3	1.7	130
18 Sept 11:45	Port North	1.2	64
16 Sept 12:30	Muara Maras	0.9-1.7	281
16 Sept 14:00	Pasar Bawah Manna	3.5	56
16 Sept 16:30	Teluk Biringin	1.4	20

Summary of arrival time, runup heights and inundation reported by Borrero and team in conducting their post-tsunami survey. The time/date refers to when the measurement was made. The complete results will be published in Geophysical Journal International, by Jose Borrero and others. (jborrero@usc.edu).

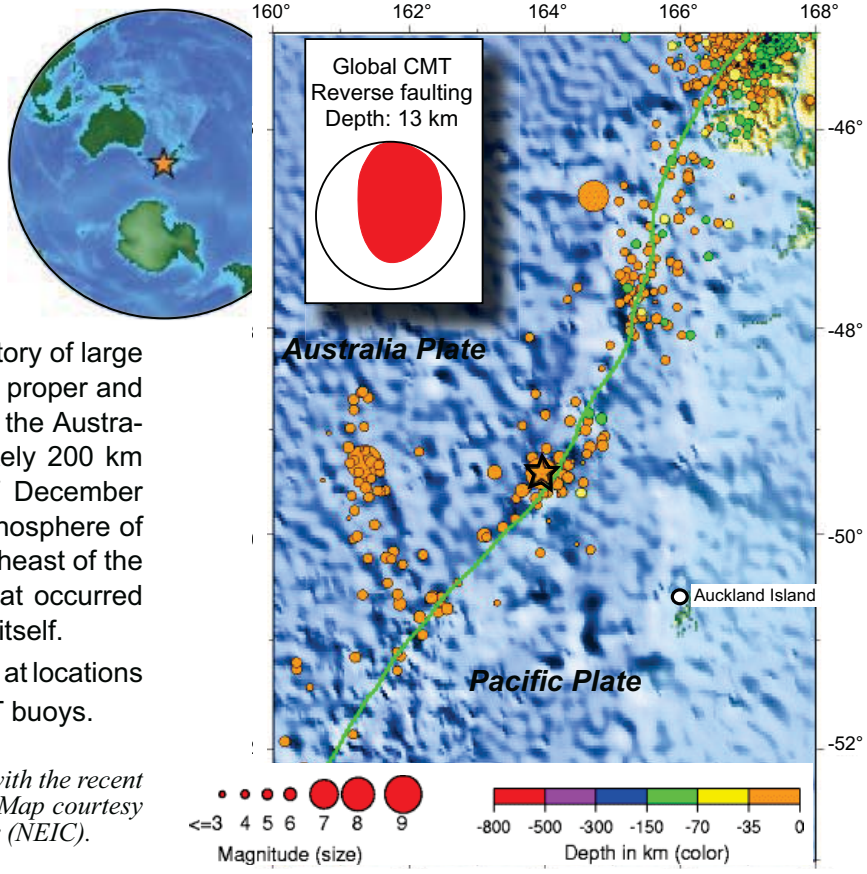
Auckland Islands, New Zealand, 30 September 2007, 05:24 UTC, M_W 7.4

An earthquake of magnitude 7.4 occured 30 September 2007 at 05:24 UTC (04:23 PM local time and in New Zealand, 11:23 PM MDT, 29 Sept 2007). No reports of damage or casualties were reported.

It was the largest earthquake in the region since the magnitude 7.6 strike-slip event less than 100 km to the north in May 1981.

The Australia–Pacific plate boundary region west of the Auckland Islands has a history of large earthquakes both along the plate boundary proper and also west of the plate boundary internal to the Australian plate. This event occurred approximately 200 km east of the magnitude 8.1 earthquake of December 2004, which occurred within the oceanic lithosphere of the Australian plate, and about 450 km northeast of the magnitude 8.0 earthquake of May 1989 that occurred along the Macquarie Ridge plate boundary itself.

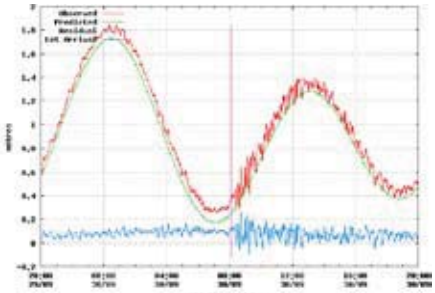
A tsunami was recorded on sea level gauges at locations in Australia and New Zealand and on DART buoys.



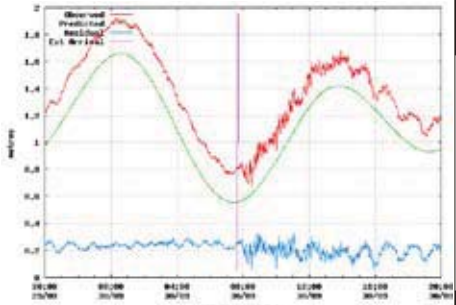
Right. Historical seismicity (1990 to the present) with the recent earthquake location and depth marked by a star. Map courtesy of USGS National Earthquake Information Center (NEIC).

Sea Level Data for Tsunami of 30 September 2007

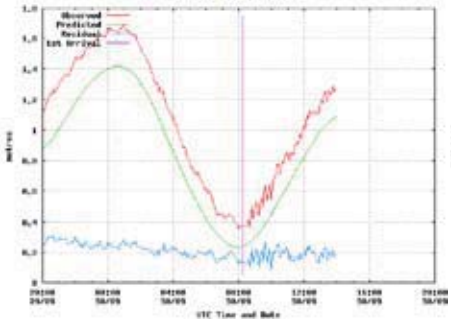
Port Kembla, New South Wales
(34° 28' 25.5" S, 150° 54' 42.7" E)
Estimated arrival time 08:07 UTC



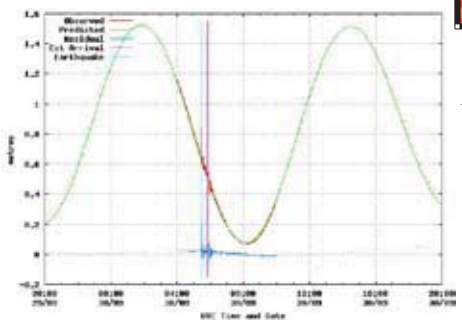
Spring Bay, Triabunna, Tasmania
(42° 32' 45.1" S, 147° 55' 57.8" E)
Est. arrival time 07:40 UTC

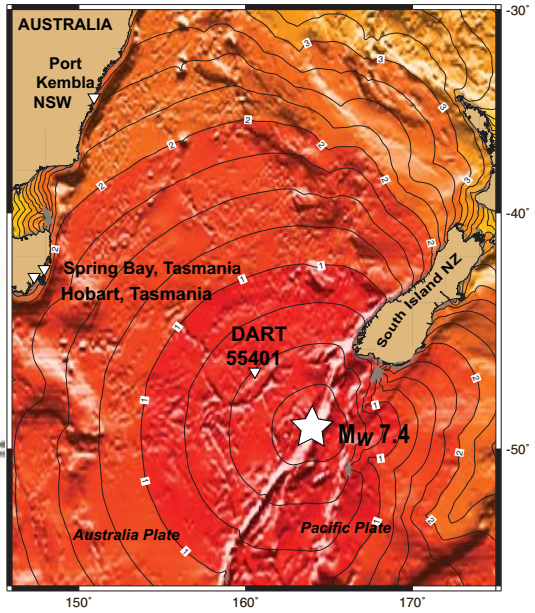


Hobart, Tasmania
(42° 53' S, 147° 20' E)
Est. arrival time 08:16 UTC



DART 55401*
(46° 55' 20"S, 160° 33'44" E)
Est.arrival time 05:52 UTC





Tide records and corresponding data on this page courtesy of Australia's Bureau of Meteorology (BOM)'s National Tidal Centre,who bears the copyright to this material. Thanks to Paul Davill (Data Manager, National Tidal Centre, BOM) for posting the site information to the Tsunami Bulletin Board. Map above, tsunami travel times calculated using the epicenter as a point source for the tsunami.

** DART 55401 is ca. 600 nm SE of Hobart.*

IOC NEWS

Tsunami Unit Report to IOC General Assembly Paris, France, 19-28 June 2007

The IOC General Assembly XXIII in Paris, 21-30 June 2005, confirmed the immediate action and response to the 2004 tsunami and adopted resolutions to create three regional Intergovernmental Coordination Groups (ICGs); a) the Indian Ocean (IOTWS), b) the North-East Atlantic and Mediterranean (NEAMTWS) and c) the Caribbean and adjacent seas (CARIBE-EWS). Together with the existing system for the Pacific (PTWS) and other relevant UN bodies, they contribute to the work of the IOC's Global Coordination Group on Tsunami and Other Ocean-related Hazards Early-warning Systems (GOHWMS). By June 2006, the IOC had created the Tsunami Coordination Unit, with its main goal to assist in the development of common governance structures, standards and instrumental capabilities.

In June 2007, the Head of the IOC Tsunami Unit, Mr. Peter Koltermann, presented a report to IOC General Assembly XXIV in Paris. A summary of the main points of the report follows:

* Interim coverage of the Indian Ocean is still being maintained by the initial system provided by Pacific Tsunami Warning System and the Japan Meteorological Agency until 2009, when the IOTWS plans to be autonomous.
* National warning systems increasingly focus on the 'downstream' part of tsunami warnings, working with other UN bodies, such as ISDR, IFRC and NGOs.
* All ICGs have created their own working groups to define, develop and implement details of the warning systems under their responsibility. Progress has been made by identifying and adopting technical references on training, education and outreach. Numerous workshops have been organizied on special aspects of warning systems' operations, definitions of products, new services or staff training. ITIC is playing a major role in directly or indirectly providing required material and resources. A Tsunami Information Centre has been established for Indonesia, and another for the Caribbean is planned but can not be established without additional funding.
* A multi-hazard approach has been adopted by some of the ICGs to varying degrees. Cooperation with the World Meteorological Organization (WMO) through the Joint Technical Commission of Oceanography and Marine Meteorology (JCOMM) is ensured through

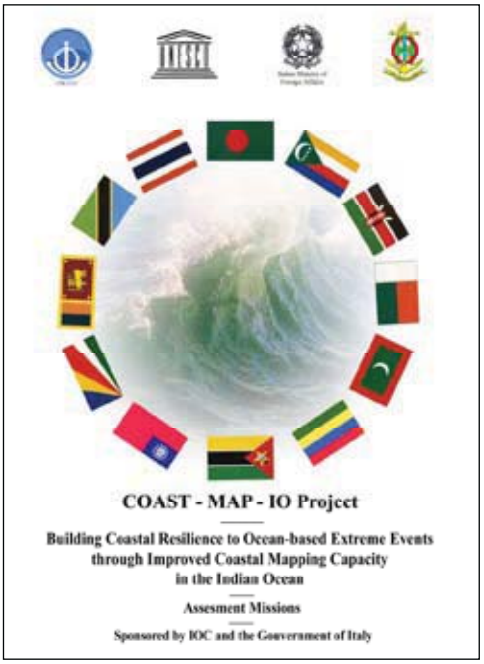
Tsunami Unit, *continued*

commonalities and mechanisms.

* The terms of reference and objectives of GOHWMS will focus on overall governance issues, development of a common structure for all subsystems and a common strategy for development and implementation of a set of standards, including the definition of resources.
* Membership status among ICGs varies and terms of reference for ICG working groups currently makes it difficult to develop synergies across systems. Terms of references should be mutually consistent with a view toward the development of global structure.
* ICGs and their working groups should be developing sets of common documentation, standards and procedures. For example, implementation plans have been published for the IOTWS and for the NEAMTWS (IOC Technical Series Report No. 71 and 73, respectively).
* Similarly, for the IOTWS an interim communication plan is being revised and standard operating procedures are being worked on in Indonesia. He proposed development of a master template for common operations, to use as a global standard.
* Primary detection (real-time seismic monitoring) and verification of tsunamigenic events (through real-time sea-level) are critical. A backbone of seismic monitoring available through agreement between the IOC and the Preparatory Commission for the Comprehensive Nuclear Test Ban Treaty (CTBTO) is the CTBTO International Monitoring System (IMS). Once a Member State has established a tsunami warning centre, they can apply to use this data from the IMS. Existing international academic seismic networks are already providing real-time, freely shared data such as IRIS Global Seismic Network, GEOSCOPE and a number of countries contributing through the IRIS Data Management Center (DMC). On the other hand, requirements for real-time monitoring of sea level changes need to be addressed through the Global Sea-Level Observing System (GLOSS).
* For devloping operations procedures and for defining and resolving common issues, the IOC's ITIC, Hawaii has been instrumental. A number of workshops or training seminars have been conducted in regional areas focussing on a more regional approach in the PTWS. IOC will further develop common elements to serve the regional owners of the systems and to provide a global commonality.
* The Unit has been funded entirely by extra-budgetary resources. Details of the support are provided in IOC-XXIV/2 Annex 4 Parts 1-2. The next biennial UNESCO Programme and Budget, 2008-2009 (found in IOC-XXIV/2 Annex 11) has a new Main Line of Action (MLA7); to provide enhanced visibility of IOC's commitment to meeting increased demand to develop early warning systems for natural ocean-related hazards.

COAST-MAP-IO Project Phase I Complete

Eight of the assessment missions that make up Phase I of the COAST-MAP-IO Project have been completed and findings published in a report. Sponsored by the Government of Italy, along with the International Hydrographic Bureau and the IOC, COAST–MAP–IO Project is part of the larger proposal (TSU–REG–05/CSS10–REGION) "Indian Ocean Tsunami Warning System" presented at the Second IOTWS meeting in Mauritius (14–16 April 2005) and responds to the concerns for development of high resoution near shore bathymetry and preparation of tsunami inundation maps for the region. With the aim of capacity building through high resolution data sets for both disaster mitigation and coastal planning, evaluations were made of eight Indian Ocean countries; Bangladesh, Comoros, Kenya, Madagascar, Maldives, Mauritius, Mozambique, Myanmar, Seychelles, Sri Lanka, Tanzania and Thailand. The report looks at each country individually to assess the existing structure in mapping agencies, resources available, existing products or data, and makes recommendations how to best accomodate future mapping efforts.



In the wake of the 26 December 2004 tsunami, a project is underway to help countries in the Indian Ocean develop high resolution near shore bathymetry to aid in disaster mitigation and coastal management. The COAST-MAP-IO Project report is available at http://www.ioc-tsunami.org/components/com_pdffarm/files/Assessment_COAST-MAP-IO.pdf.

ICG/PTWS

French Tsunami Risk Report

In response to the 26 December 2004 tsunami, the French Parliament undertook a study to describe the risk posed by tsunamis to all French coasts, including the French coasts in the Mediterranean, the Pacific, West Indies and the Indian Ocean. The study, was led by Senator Roland Courteau, who visited Martinique, Brussels, French Polynesia, USA (Hawaii), Japan, and Italy. The report, *Evaluating and Preventing the Tsunami Risk for France's Metropolitan and Overseas Coasts*, concluded that in order to decrease its tsunami vulnerability, a national early-warning system should be established with a pre-established operational plan for alerting the concerned populations, and that this must also be complemented by activities which create an informed and aware population that will respond appropriately to a tsunami emergency. The report, concerned with establishing a system in the Mediterranean, will be presented at ICG/NEAMTWS-V in November 2008. It is available in French and English from ***http://www.senat.fr/opecst/english_report_tsunami/english_report_tsunami.html.***

While in Hawaii in February 2007, Senator Courteau (right) visited governmental agencies involved with tsunami warning and mitigation. Pictured here with Delores Clark, NOAA Public Affairs Officer (centre) and Brian Yanagi, ITIC Disaster Management Specialist (left).

Hard copies of the English version are also available on request from the ITIC.

Thailand Full Scale Coastal Evacuation Drill along Andaman Coast 25 July 2007

Bernardo Aliaga, Tsunami Unit Programme Specialist,and Technical Secretary for ICG/CARIBE EWS, 1 Rue Miollis 75732 Paris CEDEX 15, b.aliaga@unesco.org

Thailand's 3,219 km coastline borders either the Andaman Sea on the west or the Gulf of Thailand on the east. The December 26, 2004 tsunami inundated the Andaman coast of Thailand at Phuket, Pang-nga, Krabi, Trang, Satun, and Ranong causing 5,396 casualties. As an immediate response to this tragedy, Thailand formed the Committee on the Study of the Disaster Early Warning System on 11 January 2005 and established the National Disaster Warning Center (NDWC) on 30 May 2005, under the Ministry of Information and Communication Technology.

A full-scale evacuation drill for the tsunami early warning system took place on 25 July 2007 in six Andaman coastal provinces under the coordination of NDWC. The exercise aimed at testing the system of 79 warning towers and the social infrastructure of evacuation plans made by 24 working groups, each affiliated with a school. These working groups were developed to work with particular schools and the community around them, using Adaptive Learning in Disaster Management for Community Awareness and Resilience (ALDC) . ALDC is an approach which focuses on enhancing people's learning and participation in the planning and coordinating of disaster response and recovery. The aim is to build up awareness and resilience at the community level through involvement. It targets school children, their teachers, local administrative organizations (LAOs), village leaders and government officers from various departments that are potentially involved in hazards. The participation of the communities with these target groups is critical to effective disaster prevention decision making.

Photos showing the various extent of involvement in the full-scale evacuation drill held in six Andaman coastal providences in Thailand on a single day.

Using the ALDC philosophy for this exercise in Thailand, the school was the focus as a sustainable, grassroots level governmental institution, mandated for education. Using basic maps and technical information revolving around the village, schoolchildren and their communities are able to participate in planning and organizing themselves to increase their capacities for learning from past disasters for their future safety.protection and to improve disaster risk reduction measures.

Preliminary results indicated that a "bottom-up" strategy

Thai drill, *continued*

like ALCD, which puts schools at the center of community preparedness and response to emergency situations was a good starting point, but further strengthening of community response requires in-depth surveys of households and further refinement of evacuation routes. Inundation maps will further confirm and support a scientific definition of 'safe place'. The adaptive learning concept in disaster management needs local knowledge as well as scientific integrity to be effective.

(This article is based on the abstract of a paper presented at the PTWS-XXII Workhop by B. Aliaga and others, and found online at http://www.ioc-tsunami.org/images/stories/File/ptws/documents/6thIntlTsuWS_ABSTRACT_ALL.doc.)

Learning Exchange from Banten, Indonesia to Hawaii on State and Local-Level Tsunami and Island Hazard Early Warning Systems 21-25 August 2007

Stacey Tighe, Indonesian Program Coordinator, US-IOTWS Program, e-mail: stighe@cbn.net.id

An exchange between Banten Province and the State of Hawaii on local disaster warning took place 21-25 August 2007 and provided valuable inputs into Banten's plan for a tsunami warning simulation in December 2007. Banten and Hawaii share many characteristics, including coastal tourism, threats from local tsunamis, and volcanoes. The Governor of Banten, Ms. Atut Chosiah and Dr. Andi Sakya from the Indonesian Meteorology and Geophysics Agency led the delegation of 10 Indonesians, including Banten provincial department chiefs and the Mayor of Banten's capital city, Serang. The exchange was sponsored by the U.S. Agency for International Development's Indian Ocean Tsunami Warning System (US-IOTWS) Program and by the Government of Indonesia, and while in Hawaii the delegation was hosted by Mr. Ed Young of NOAA's Pacific Region National Weather Service and the Mayor of Hawaii, Mr. Harry Kim. The Indonesian team visited emergency management offices for the State of Hawaii and Honolulu and Hawaii counties. Tours were also made of NOAA's Pacific Tsunami Warning Center and the International Tsunami Information Center, Kilauea National Volcano Park and other relevant agencies. A meeting between the Indonesian delegation, Governor Atut and Governor Linda Lingle and key members of her staff opened possibilities for on-going collaboration on disaster and response planning, economic partnerships, and sister-state relationships.

The Indonesian delegation from Banten, led by the Govenor of Banten, Ms. Atut Chosiah (front,center), met with the US delegation and Ed Young (front, left), at NOAA's National Weather Service Pacfic Region Headquarters, where they were introduced to the NWS staff and orientation was made to the Hawaiian segment of their trip. The author stands on the far right.

The Indonesian delegation included: Ms. Ratu Atut Chosiyah, Governor of Banten Province; Mr. Akhmad Taufik Nuriman, Regent/Mayor of Serang (Area with coastal tourism); Mr. Achmad Hilman Nitiamidjaja, Secretary of Banten Province (Highest civil servant, manages day-to-day operations of province); Dr. Andi Eka Sakya, Executive Secretary of Indonesian Meteorology and Geophysics Agency (BMG) (Develops institutional strategy) and 6 Additional Directors and senior staff of Banten, supported by Indonesia. The US coordinators and facilitators were Ms. Jennifer Lewis, International Analyst, NOAA National Weather Service and Dr. Stacey Tighe, Indonesian Program Coordinator, US-IOTWS Program.

SE Asia Tsunami Training Sessions

Bangkok, Thailand, 20-24 August 2007

A training course in GPS, Seismology and Tsunami Warnings was conducted from 20-24 August 2007 in Bangkok. The US Geological Survey (USGS), the International Tsunami Information Center (ITIC), and Chulalongkorn University, Bangkok arranged the five day training course. The training was supported by the US Government Indian Ocean Tsunami Warning System Program (IOTWS), the Asian Disaster Preparedness Center (ADPC), the Thailand National Disaster Warning Center (NDWC), and the Intergovernmental Oceanographic Commission (IOC). Fifty one participants attended from the Thailand Meteorology Department, the NDWC, the Mineral Resources Department, and universities or technical agencies within Thailand. The Thai participants were joined by six international participants from Sri Lanka, Maldives, Singapore, and the Philippines.

The training course had three components: GPS; seismology; and tsunami warnings. The GPS component was led by Dr. Rebecca Bendick (University of Montana). The component consisted of four lectures, one "hands-on" session, a summary and a discussion session. The second component, covering advanced seismology, was led by Prof. Emile Okal (Northwestern

Training, *continued*

University) and Dr. Walter Mooney (USGS). The component consisted of ten lectures (each ending in a discussion session), and two "hands-on" sessions. The third component, with topics related to tsunami warnings, was led by Dr. Laura Kong (ITIC) and Dr. Annabel Kelly (USGS). It consisted of two lectures and three "hands-on" sessions.

At the end of the course the participants were asked to complete an evaluation form of the training. Feedback forms were completed and returned by 32 participants (56% response rate), indicating that course was successful, with almost 97% of the replies stating that the overall standard of the course was either excellent or above average.

Petaling Jaya Malaysia, 27-30 August 2007

A regional training program in advanced seismology and tsunami warnings was held in Petaling Jaya, Malaysia, 27-30 August 2007. The US Geological Survey (USGS), ITIC, and Malaysian Meteorological Department (MMD) arranged the four-day training course. It was supported by the US Agency for International Development's IOTWS, the MMD, the US Trade and Development Agency, and the IOC of UNESCO. Forty five participants attended from Malaysia, Indonesia, Sri Lanka, the Maldives, and Vietnam.

The training course covered topics in advanced seismology and tsunami warnings. The seismology sessions were led by Professor Emile Okal and Dr. Annabel Kelly. The component covered two days and consisted of nine lectures (each ending in a discussion session), and two "hands-on" sessions. The tsunami component also covered two days; with the first day reviewing warning center standard operating procedures (SOPs) and the second day discussing emergency response for tsunamis. The tsunami sessions were led

Participants and trainers at the Regional Training Program in Advanced Seismology and Tsunami Warnings, Petaling Jaya, Malaysia, 27–30 August 2007.

by Dr. Laura Kong (IOC ITIC), Mr. Brian Yanagi (IOC ITIC), Mr. Masahiro Yamamoto (IOC Paris), Dr. Annabel Kelly, and Dr. Jane Cunneen (IOC Perth).

At the end of the course the participants were asked to complete an evaluation form on the training. Feedback forms were returned by 32 participants (71% response rate) and implied the course was very successful, with 88% of the replies indicating that the overall standard of the course was either excellent or above average.

6th International Tsunami Mitigation Workshop 14-15 September 2007, Guayaquil, Ecuador

The sixth International Workshop on tsunami mitigation entitled, "New Insights in Tsunami Research, Preparedness, Warning and Mitigation," was held 14–15 September 2007 in Guayaquil, Ecuador.

Jointly organized by INOCAR, UNSECO IOC, and IUGG Tsunami Commission (TC), with financial support from IOC for workshops, and the local logistical support from INOCAR. Over a hundred participants represented over ten countries. Twenty–three presentations, in four

Participants and trainers at the Thailand Training Course in GPS, Seismology, and Tsunami Warnings, 20–24 August 2007.

Ecuador workshop, *continued*

sessions, are summarizied below:

Presentations in Session 1:

- Wong reported numerical simulation from recent earthquake near Taiwan, comparing linear and non-linear computations.
- Satake reviewed inverse and geological approaches to estimate the tsunami source, which is important for tsunami forecast.
- Gusiakov reviewed tsunami magnitude and intensity scales and showed dependence of intensity on moment magnitude M_W.
- Reymond proposed a new simple formula on trans-Pacific tsunami, considering directivity, earthquake size, focal depth and site effects.

Presentations in Session 2:

- Ivelskaya reported their field-survey results of the 2006/2007 Kuril Island tsunamis on Urup (6 m), Simushir (> 10-15 m) and Ketoy (8-10 m) Islands.
- Rabinovich focused tsunami data in South America (up to ~ 1m) from the Kuril earthquakes, which had strong directivity toward South America.
- Rabinovich also compared the South American tsunami records from the 1960 Chilean and 2004 Sumatra tsunamis.
- Enriquez examined tsunami generated by landslide in Aysen Fjord in April 2007 and introduced their modeling efforts for future landslides.
- Rosales estimated tsunami effects in Buenaventura bay in Colombia from several possible earthquake sources.
- De La Torre introduced high resolution bathymetric and geological data of Ecuadorian Continental Margin and discussed its use for tsunami risk assessment.

Presentations in Session 3:

- Arreaga reported the computed results of tsunami travel times from earthquake off Ecuador, that are as short as 5 minutes.
- Renteria discussed tsunami inundation map based on GIS with the 1953 earthquake tsunami as an example.
- Toulkeridis discussed possible mega-tsunami from landslide on unstable flanks of Roca Redonda volcano, Galapagos.
- Pazmino discussed morphology of Ecuadorian platform, Galapagos and three segments along Ecuador trench, and suggested possible sources of future tsunami.
- Dunbar spoke about NGDC's natural hazards database and discussed quality control on HTDB at NOAA with comparison with the Novosibirsk database.
- Soto described the tsunami warning system in Puerto Rico with emphasis on TsunamiReady program.

Presentations in Session 4:

- Bartomioli discussed his experience in community-based tsunami disaster risk management and preparedness in Esmeraldas, Ecuador.
- Torrealba spoke of the elements of end-to-end early warning systems for natural hazards, including tsunamis.
- Kong talked about the role of the media for tsunami warning systems that communicate national warning system messages to public, including ways to communicate with the media.
- Guerrero introduced a telecommunication and information technology system as a tool for tsunami risk management in Ecuador.
- Aliaga reported of Thai tsunami evacuation exercise on July 2007, where schools acted as center of community preparedness and response (*see story p. 16-17*).
- Vegas reported the Camana (2001) and Pisco (2007) tsunamis in Peru, and discussed lessons learned.

At the conclusion of the workshop the following recommendations were made:

- Interaction between research, operational and emergency management communities is very important. This kind of workshop should be continued in the future.
- Collaboration between seismic, oceanographic and emergency management organizations are necessary for comprehensive and regional (international) tsunami warning.
- "Last mile" approach to public awareness is the most important and effective aspect in mitigating tsunami disasters. Effective and accurate ways to communicate with media and communities should be established.
- Permanent curriculum in school education is also important and effective in reducing tsunami hazard.
- The historical tsunami database should be continuously maintained and updated to include the most recent scientific results. Multiple management systems may be necessary to develop.
- Various methods, either numerical or empirical, which estimate coastal tsunami heights from earthquake sources ned to be improved and implemented in tsunami warning systems.
- Past tsunami data, such as tide gauge records or run-up heights, are valuablet for tsunami warning and tsunami research, hence need to be preserved and shared.

Ecuador workshop, *continued*

- Bathymetric, geological and geophysical data is also important for assessing future tsunami events, seismic or aseismic (e.g. landslide induced), and should be utilized and shared by the community.

ICG/PTWS–XXII Executive Summary: TWENTY-SECOND SESSION OF THE INTERGOVERNMENTAL COORDINATION GROUP FOR THE PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM
17–21 September 2007, Guayaquil, Ecuador

The Twenty-second Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS) was held in Guayaquil, Ecuador, 17–21 September 2007 under the session chairmanship of Dr François Schindelé, Past Chairman of the ICG/PTWS. It was attended by 45 participants from 19 ICG/PTWS Member States, officers from the ICG/CARIBE-EWS, ICG/IOTWS, and ICG/NEAMTWS, and representatives from four organizations, and observers.

The Session reviewed progress during the inter-sessional period from May 2006 to September 2007 as reported by Working Groups in the areas of seismological and sea level monitoring and evaluation, hazard identification, emergency management and resilience, and interoperable systems, and sub-regionally in the Southwest Pacific and on the Central America Pacific Coast. The ICG reviewed the report by the Task Team on Messages and its proposed changes to improve the clarity and timeliness of the PTWC messages, and discussed the next Pacific-wide exercise, Exercise Pacific Wave '08. The ICG further discussed the PTWS and ITIC work plan and budget for 2008 and 2009 in view of the current budget of UNESCO/IOC, and also heard on the progress on the PTWS Medium-Term Strategy.

The ICG reaffirmed that each Member State has the responsibility to issue warnings within its respective territories and of their commitment to open, free and unrestricted sharing of tsunami-relevant real-time observational data as fundamental for a successful early warning.

The ICG concluded as a matter of urgency to: (i) enhance the establishment and maintenance of tsunami warning centres in the regions as a key for faster and locally-relevant early warning response; (ii) implement better methods to rapidly detect near-field earthquakes and possible tsunami; (iii) enhance, update, and modernize the capabilities of the seismic and sea-level monitoring networks; (iv) provide standard operational system description documents; and (v) accelerate the provision of strengthening support to Member States that have not yet sufficient capacity to develop tsunami warning and mitigation systems.

Accordingly, the ICG approved eight recommendations on (1) sea-level measurement, data collection and exchange, (2) working group on pacific emergency communications; (3) the PTWS Operational Users Guide, (4) the Pacific-wide tsunami exercise, (5) Sub-regional Pacific Tsunami Warning and Mitigation Systems: Northwest Pacific, South China Sea, and Western Pacific Marginal Seas, (6) the Pacific Warning and Mitigation System, (7) Improved strategic planning and budgeting (8) Working Group on rapid near-field recognition of tsunamigenic earthquakes and associated tsunamis.

At the PTWS front table sits (left to right) Lt. Luis Morales, INOCAR, Patricio Bernal, Executive Secretary IOC, François Schindelé, former ITSU Chair and Laura Kong, ITIC.

The ICG established or continued eight inter-sessional working groups. The working groups are on (i) sea-level measurements, data collection and exchange; (ii) interoperability of regional, sub-regional and national tsunami warning and mitigation systems in the Pacific, (iii-v) Sub-regional working groups for tsunami warning and mitigation development (Central American on the Pacific, Southeast Pacific, and Southwest Pacific), (vi) Pacific emergency communications, (vii) Rapid near-field recognition of tsunamigenic earthquakes and associated tsunamis, and (viii) Exercise Pacific Wave '08.

The ICG recommended that the IOC Working Group on Tsunamis and other Hazards related to Sea-level Warning and Mitigation Systems (TOWS-WG) organizes a sea-level design and implementation workshop in 2008, involving similar Working Groups from the other ICGs.

It further recommends that the IOC Executive Council, at its 41st Session, adopt a resolution which includes its formal authorization of the interim tsunami advisory service for the South China Sea conducted by the PTWC, WC/ATWC and NWPTAC.

PTWS Ecuador, *continued*

The ICG also requested the IOC to convene a scientific-technical conference to review the state-of-art of detecting near-field earthquake and possible tsunami in early 2008.

The ICG endorsed the recommendations of the 6th International Workshop on Tsunami Mitigation: New Insights in Tsunami Research, Preparedness, Warning and Mitigation, co-organized by the IOC, ICG/PTWS, the IUGG–Tsunami Commission, and the host institution, INOCAR of Ecuador, that was held on 14 September 2007 in Guayaquil, Educator prior to the Session.

The ICG elected new officers for the inter-sessional period, welcoming Mr Michael O'Leary of New Zealand as Chairman, Mr Giorgio de la Torre of Ecuador and Mr Yohei Hasegawa of Japan as Vice-Chairmen,

The ICG decided to organize its Twenty-third Session in 2009 and accepted the offer of Samoa to host the Twenty-third Session. The ICG further accepted the offer of Japan to host the Twenty-fourth Session in 2011.

Working documents for this conference are online at: *http://www.ioc-tsunami.org/index.php?option=com_content&task=view&id=68&Itemid=71.*

WORKSHOP AND MEETING SUMMARIES

IUGG Tsunami Commission Business Meeting 12 July 2007, Perugia, Italy

Chair Kenji Satake reported on the following activities of the Commission in the last two years.

The Commission co-organized the Workshop "Tsunami Hazard Mitigation and Risk Assessment" with the International Coordination Group for the Tsunami Warning System for the Pacific (ICG/PTWS) and ONEMI. The workshop was held in Santiago, Chile, 29–30 September 2005. Twenty papers were presented, ranging from overviews of local and regional tsunami vulnerabilities to case studies of several of the largest tsunamis in the Pacific and the Indian oceans. Thirty registrants from eleven countries attended the Workshop; many were international delegates attending ICG/ITSU-XX held in Valparaiso, Chile, 3-7 October 2005.

The Commission published a topical issue *Tsunami and its Hazards in the Indian and Pacific Oceans* in Pure and Applied Geophysics (Volume 164, Numbers 2-3). The editors are Satake, Okal and Borrero. The topical issue includes 20 papers, mostly presented at the 2005 International Tsunami Symposium. It was published in book form by Springer–Birkhäuser (ISBN: 978-3-7643-8363-3).

For the IUGG XXIV General Assembly (July 2007), the Inter-association Joint Session (JSS02) *Tsunami; Generation and Hazard* a topical workshop on sea-level measurements was organized. The conveners were Satake, Pelinovsky, Dunbar, Papadopoulos and Imamura. More than 100 abstracts were submitted but only two days were scheduled for oral presentations to the session, so the conveners needed to restrict the number of oral presentations for each participant. In the end, 43 posters and 45 talks were presented. (In addition, Satake presented a Union Lecture 13 July on behalf of the TC.)

The Commission organized a workshop entitled "New Insights in Tsunami Research and Tsunami Preparedness, Warning and Mitigation", with Ecuador's Instituto Oceanográfico de la Armada (INOCAR), co-sponsored by UNESCO IOC ICG/PTWS. The workshop is planned for 14–15 September 2007 in Guayaquil, Ecuador, the week before IOC ICG/PTWS XXII, with a field trip along the Ecuadorian coast on 15 September, for those scientists interested in learning about the geology and tectonics of this active subduction zone.

Reports were made on the activities of three working groups (field survey data, tide gauge data and satellite data of the 2004 Indian Ocean tsunami) formed at the previous business meeting (2005).

For the WG on field survey data of the 2004 Indian Ocean tsunami, Gusiakov and Fujima reported on their collected data. Fujima also made a presentation in the scientific session about his compiled data, displayed with the Google Earth system. Because both datasets need to be merged and the formats need to be unified, it was agreed that the WG will continue.

For instrumental data, Rabinovich published a paper in a Pageoph topical issue on the records in the Indian Ocean, and made a presentation during the scientific session about the records in the Atlantic Ocean. Because the WG needs to collect tide gauge data from the Pacific Ocean, it was requested and approved that the WG continue its activity with Diana Greenslade (Australia) and Yuichiro Tanioka (Japan) as new members. The data archive was also discussed and NGDC proposed to archive the data collected by the WG.

For the WG on satellite data, Titov reported that all the relevant data are available through the website, *http://rads.tudelft.nl/rads/index.shtml,* which is linked to

IUGG business meeting, *continued*

from *http://nctr.pmel.noaa.gov*. With the task of the WG completed, the WG was terminated.

New members elected were: Paula Dunbar (USA), Laura Kong (USA), William Power (NZ), Josef Cherniawsky (Canada), Phil Cummins (Australia), and Diana Greenslade (Australia)

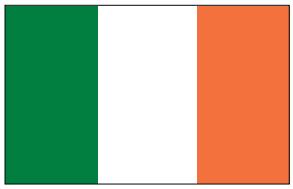
Nomination and approval was followed by the election of new officers for the next term, 2007-2011. Serving as Chair is Kenji Satake (Japan), with Vice Chairs Gerassimos Papadopoulos (Greece) and Vasily Titov (USA). Acting as Secretary is Paula Dunbar (USA).

For the 2009 International Tsunami Symposium, two invitations were submitted to the chair. One from Novosibirsk (Gusiakov) and the other from Puerto Rico (Mercado). Gusiakov made a short presentation about Novosibirsk. As was the case in 1989, they hope to combine the ITS with other meetings. Satake read an invitation letter from the Chancellor of the University of Puerto Rico. A vote was taken, with the members deciding that the 2009 ITS meeting will be held in Novosibirsk (Akademgorodok—Science Center of SDRAS).

IUGG 2007 proceedings will be published in two volumes as a Pageoph topical issue in 2008/2009.

Ireland's National Assessment Mission, 8-11 July 2007, Dublin, Ireland

Experts from various UN, Irish and European agencies, met in Dublin to assess a proposal to establish a tsunami early warning and mitigation system (TWS) for Ireland. The regional coordination system for Europe and North Africa, in which Ireland is actively participing is the Intergovernmental Coordination Group for the establishment of a North-East Atlantic, the Mediterranean and Connected Seas Tsunami Warning and Mitigation System (ICG/NEAMTWS). The system shall be owned and operated by the Member States or the corresponding regions, and will be built upon national capabilities and centres; ensuring the System will 'plug-in' into existing natural disaster management systems and civil defense structures.



The meeting addressed Ireland's risk assessment and various capabilities in light of forming a national tsunami early warning system. By meeting's end the IOC Mission Team found the proposal appropriate and made several recommendations. A report of the meeting is at *http://www.ioc-tsunami.org/components/com_pdffarm/files/TWS%20Assessment%20-%20Ireland_v1.5.pdf.*

UNESCO-IOC Workshop on Indian Ocean Tsunami Hazard Assessment 17-18 July 2007, Bandung, Indonesia

Following recommendations made by IOTWS working groups on risk assessment (WG3) and modelling, forecasting (WG4) at ICG/IOTWS III in Bali, August 2006, the workshop was held to develop an Indian Ocean tsunami hazard map based on earthquake sources and deep ocean propagation models. The workshop was funded by the Australian Agency of International Development (AusAID) with host organisational support from the Center for Diaster Mitigation, Bandung Institute of Technology (ITB) in Indonesia. The question addressed was whether or not enough information exists about tsunamigenic earthquakes in the region to assume the probabilities and magnitudes are accurate for tsunami hazard analysis.

Discussion included the tectonic context of the Indian Ocean region, and how evidence from geological and historical sources could help determine the liklihood of tsunamigenic earthquakes. Given that the historic record is quite short, the best studies to improve the record are geologic studies that identify and interpret traces of tsunami impact. These consist of a) paleotsunami research into tsunami evidence along both near and distant coastlines and b) application of paleotsunami techniques, such as analysis of coral reef growth patterns to identify uplift and subsidence associated with large tsunamigenic earthquakes in subduction zones. The islands off the western coast of Sumatra are the only area in the Indian Ocean where this type of research has started. Likewise, geodetic monitoring could prove a useful tool in recognizing areas of built up stress potentially released in tsunamigenic earthquakes.

The workshop adopted two recommentations to aid in the urgent need for hazard mapping,while awaiting the outcome of research to enhance existing information and add fundamental data:

1. *Assess Indian Ocean tsunami hazards while acknowledging levels of uncertainty, update assessments periodically, and aid mutual benefit by tailoring assessments for emergency managers' and planners' use.*
2. *Support assessments with geology, geodesy, and written history through paleotsunami studies of all Indian Ocean coastlines. Furthermore, monitor and expand measurements of subduction-zone deformation thoroughout the ocean basin, with better regional coordination of effort.*

The complete report is found at: http://www.ioc-tsunami.org/images/stories/File/ICG-IOTWS-V/IO-HazWkshp_Report_final.pdf

Opening remarks, *continued*

tsunami which fortunately was not destructive, but it demonstrated quite effectively that the ICG/PTWS needs to continue to place a high priority on conveying information to the media and the general public which is both timely and clearly understood, and that we need to continue to integrate new software tools and graphic information products into our warning and dissemination processes so that only at-risk coastal areas need to take action.

During the intersessional period, the International Tsunami Information Centre supported the operational needs of the PTWS, as well as the IOTWS and CARIBE-EWS. ITIC provided a number of workshops, training sessions and consultations in the Pacific, Indian Ocean and Caribbean regions. The ITIC Director and staff were particularly active in SE Asia and in the SW Pacific, and have established an excellent working relationship with the Member States in those regions, and with organizations such as ASEAN and SOPAC. In April 2007, ITIC welcomed Yohko Igarashi to Honolulu. Yohko is a secondee from Japan's JMA and she will work at ITIC for a period of one to two years.

The PTWS Training Programme was held in 2006 with participation from Colombia, Ecuador, Samoa and Tonga. The next Training Programme is presently scheduled for November 2007. The TsunamiTeacher resource kit was completed in September 2006 and is now available through the web or on DVD. It is available in either English or Indonesian, and both Spanish and French versions are planned.

The USA–led DART buoy network in the Pacific continues to expand and its importance has been demonstrated several times during the intersessional period. There are presently 29 operational DART buoys, including an Australian buoy and a Chilean buoy, and these three Member States have plans to install nine more buoys. In addition, several countries, including Canada and Japan, are in the process of installing offshore cabled networks.

There are a large number of coastal water level gauges in the Pacific, and data from many of these is received by PTWC and other regional warning centers. But not all stations provide data at a transmission interval suitable for regional and local tsunami events. Through cooperative efforts with GLOSS and NESDIS, many priority stations will soon be upgraded within the GOES area of coverage, to a five minute transmission interval. The ICG/PTWS is working with these organizations to maximize the benefits these changes will bring.

Although there has been excellent progress in many areas during the intersessional period, one area where this Group must focus its attention is on governance – how we operate now that we are an "Intergovernmental" group, what commitments and responsibilities this places on each Member State, and how we interact effectively with the other regional warning systems, the Tsunami Coordination Unit, and other UN agencies in the context of tsunamis and other ocean-related hazards. I encourage all Member States to be active participants in this process through our Working Groups and other means.

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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