NOVEMBER 2004 - SEPTEMBER 2005 VOLUME XXXVII, NUMBER 1

TSUNAMI NEWSLETTER

International Tsunami Information Centre

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In this issue, we summarize tsunamis that were observed between November 2004 and September 2005, and the Pacific activities that the ICG/ ITSU and its Officers have been involved in since the occurrence of the Indian Ocean earthquake and tsunami of 26 December 2004. The year's activities have been characterized by unprecedented information sharing on tsunamis and their dangers, and how the Pacific has implemented its system of comprehensive mitigation. The ITSU Officers, in coordination with the IOC Executive Secretary and Tsunami Secretariat in Paris, and indeed, all of our ITSU Members States have given freely of their time and energies to inform and guide the nations of the Indian Ocean on how to set up a warning system, how emergency agencies should respond to inform and evacuate its citizens, how nations must use science and communities to develop inundation and evacuation scenarios, and foremost, how every nation must ensure that awareness, preparedness, and educational activities are sustained so that future generations will never have to witness a tsunami catastrophe hit their shores again.

ITIC Director Dr. Laura Kong

SUMMARY OF EARTHQUAKES

Occurring November 2004 - September 2005

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

DATE	TIME (UTC)	LOCATION	LATITUDE	LONGITUDE	DEPTH (km)	M_w	M_s	PTWC ACTION	ACTION TIME	TSUNAMI? DAMAGING?
2-Nov	10:02	Vancouver Island Region	49.305 N	128.781 W	10	6.6 (G) 6.7 (H, P)	6.4	TIB	10:11	Yes No
9-Nov	23:58	Solomon Islands	11.150S	163.706 E	13	6.9 (G,H) 7.0 (P)	6.7	TIB	00:11 (10 Nov)	No No
11-Nov	17:35	Solomon Islands	11.136 S	162.193 E	10	6.6 (H) 6.7 (G,P)	6.6	TIB	18:17	No No
11-Nov	21:27	Timor Region, Kepulauan Alor, Indonesia	8.149 S	124.870 E	10	7.4 (G,P) 7.5 (H)	7.3	TIB	21:41	Yes Yes
15-Nov	9:06	Off Near W. Coast of Colombia	4.695 N	77.502 W	15	7.1 (G,H) 7.2 (P)	7.1	TIB	9:20	No No
22-Nov	20:26	Off W.Coast of South Island New Zealand	46.656 S	164.707 E	10	7.1 (G,H) 7.2 (P)	7.1	TIB	20:40	No No
26-Nov	2:25	Irian Jaya Region, Papua Indonesia	3.613 S	135.387 E	10	7.0 (G) 7.1 (H, P)	7.2	TIB	2:39	No No
28-Nov	18:32	Hokkaido, Japan	42.995 N	145.114 E	39	7.0 (G, H, P)	6.7	TIB	18:44	Yes No
6-Dec	14:15	Hokkaido, Japan	42.907 N	145.200E	35	6.8 (G,H,P)	6.4	TIB	14:27	No No
23-Dec	14:59	North of MacQuarie Island	50.145 S	160.365 E	10	7.9 (P) 8.0 (G) 8.1 (H)	N/A	TIB	15:19	Yes No
26-Dec	0:59	Off West Coast of Northern Sumatra	3.308 N	95.874 E	30	8.0 (P1) 8.2 (G) 8.5 (P2&3) 9.0 (H)	8.8	TIB 1 TIB 2 TIB 3	1:14, 2:04, 15:37 (Dec 27)	Yes Yes
26-Dec	4:21	Nicobar Islands	6.885 N	145.200 E	40	7.1 (G,H)	7.5	--		
26-Dec	9:20	Nicobar Islands	8.886 N	92.357 E	9	6.6 (G,H)	6.6	--		

Earthquake list, *continued.*

DATE	TIME (UTC)	LOCATION	LATITUDE	LONGITUDE	DEPTH (km)	M_w	M_s	PTWC ACTION	ACTION TIME	TSUNAMI? DAMAGING?
1-Jan	6:26	Off West Coast of Northern Sumatra	5.099 N	92.304 E	12	6.5 (G) 6.6 (H,P)	6.7	TIB	6:40	No No
16-Jan	20:18	Western Caroline Islands (Yap)	10.934 N	140.842 E	25	6.6 (G,H) 6.9 (P)	6.7	TIB	20:30	No No
19-Jan	6:12	Off the East Coast of Honshu Japan	34.064 N	141.491 E	28	6.4 (G) 6.5 (H)	6.4	none	--	Yes No
22-Jan	20:30	Solomon Islands	7.73 S	159.48 E	29	6.4 (G,H) 6.6 (P)	6.5	TIB	20:46	No No
5-Feb	3:34	Mariana Islands (Anatahan Region)	16.011 N	145.867 E	143	6.5 (G,P) 6.6 (H)	6.6	TIB	3:53	No No
5-Feb	12:23	Mindanao Philippine Islands	5.293 N	123.337 E	525	7.1 (G,H) 6.9 (P)	7.1	TIB	12:38	No No
8-Feb	14:48	Vanuatu Islands	14.252 S	167.259 E	206	6.7 (H) 6.8 (G,P)	6.8	TIB	15:04	No No
9-Feb	18:46	Bonin Islands	26.09 N	144.00 E	24	6.3 (G,H) 6.5 (P)	6.3	TIB	19:00	No No
19-Feb	0:05	Sulawesi, Indonesia	5.592 S	122.109 E	10	6.4 (H) 6.5 (G,P)	6.3	TIB	00:19	No No
26-Feb	12:57	Off West Coast of Northern Sumatra	2.926 N	95.557 E	27	6.7 (H,P) 6.8 (G)	6.8	TIB	13:13	No No
2-Mar	10:42	Banda Sea	6.532 S	129.940 E	201	7.1 (G,H) 7.2 (P)	7.1	TIB	10:56	No No
20-Mar	1:54	Western Honshu, Japan	33.795 N	130.108 E	10	6.5 (G) 6.6 (H) 6.7 (P)	6.7	TIB	2:19	No No
28-Mar	16:10	Northern Sumatra Indonesia	2.074 N	97.013 E	30	8.1 (G) 8.5 (P) 8.7 (H)	8.4	TIB 001 002	16:29 18:41	Yes No
28-Mar	22:10	Northern Sumatra Indonesia				5.8 (P)		003	22:10	No No
10-Apr	11:14	Southern Sumatra Indonesia	1.714 S	99.779 E	30	6.6 (G) 6.7 (H,P)	6.7	TIB	10:47	Yes No
11-Apr	17:09	Loyalty Islands Region	21.975 S	170.612 E	68	6.7 (P) 6.8 (G,H)	6.8	TIB	17:26	No No

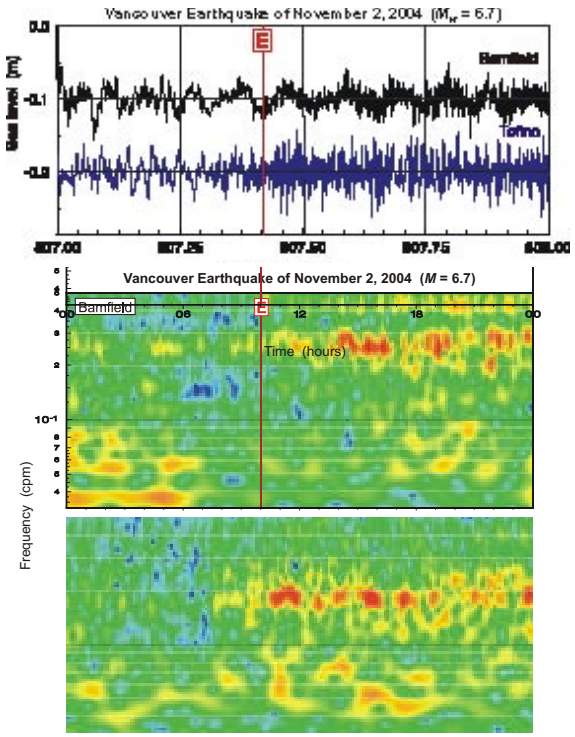
Earthquake list, *continued.*

DATE	TIME (UTC)	LOCATION	LATITUDE	LONGITUDE	DEPTH (km)	M_w	M_s	PTWC ACTION	ACTION TIME	TSUNAMI? DAMAGING?
16-Apr	16:38	Northern Sumatra Indonesia	1.812 N	97.662 E	31	6.3 (G) 6.4 (H) 6.7 (P)	6.2	TIB	16:57	No No
5-May	19:12	South of Panama	5.720 N	82.838 W	10	6.4 (G) 6.5 (H) 6.9 (P)	6.5	TIB	17:24	No No
14-May	5:05	Northern Sumatra Indonesia	.567 N	98.444 E	34	6.8 (G,H) 6.9 (P)	6.8	TIB	5:21	No No
16-May	3:54	South of Kermadec Islands	32.546 S	179.341 W	34	6.6 (G,H) 6.7 (P)	6.4	TIB	4:11	No No
19-May	1:55	Northern Sumatra Indonesia (Nias Region)	1.989 N	97.041 E	30	6.7 (G) 6.8 (P) 6.9 (H)	6.9	TIB	2:10	No No
13 June	22:44	Northern Chile (Tarapaca, Chile)	19.987 S	69.197 W	116	7.8 (G,H,P)	7.8	TIB	22:59	No No
14 June	17:10	Rat Islands, Aleutian Islands	51.232 N	179.406 E	51	6.6 (G) 6.8 (H) 6.9 (P)	6.8	TIB	17:19	No No
15 June	2:51	Off the Coast of Northern California	41.301 N	125.970 W	10	7.1 (G) 7.2 (H) 7.4 (P)	7.2	TIB	2:59	Yes No
17 June	6:22	Off the Coast of Northern California	40.768 N	126.574 W	10	6.6 (G) 6.7 (H) 6.9 (P)	6.5	TIB	6:28	No No
2 July	2:17	Near Coast of Nicaragua	11.245 N	86.172 W	27	6.6 (G,H) 6.7 (P)	6.4	TIB	2:27	No No
5 July	1:52	Northern Sumatra Indonesia (Nias Region)	1.819 N	97.082 E	21	6.6 (G) 6.7 (H) 6.8 (P)	6.8	TIB	2:07	No No
24 July	15:42	Nicobar Islands, India	7.926 N	92.174 E	16	7.2 (G) 7.3 (H,J)	7.5	JMA	16:02	No No
16 Aug	2:46	Near East Coast of Honshu, Japan	38.252 N	142.077 E	36	7.0 (P) 7.1 (G) 7.2 (H)	6.8	TIB	2:57	Yes No
9 Sept	7:27	New Ireland Region, PNG	4.540 S	153.402 E	91	7.3 (P) 7.5 (G,H)	7.7	TIB	7:44	No No
26 Sept	1:56	Northern Peru	5.678 S	76.399 W	117	7.5 (G,H.P)	7.5	TIB	2:10	No No
29 Sept	15:50	New Britain Region PNG	5.461 S	151.820 E	37	6.5 (G) 6.7 (H) 6.8 (P)	6.6	TIB	16:04	No No

WEST COAST VANCOUVER ISLAND, CANADA, M_W=6.7, 2 NOVEMBER 09:30 UTC

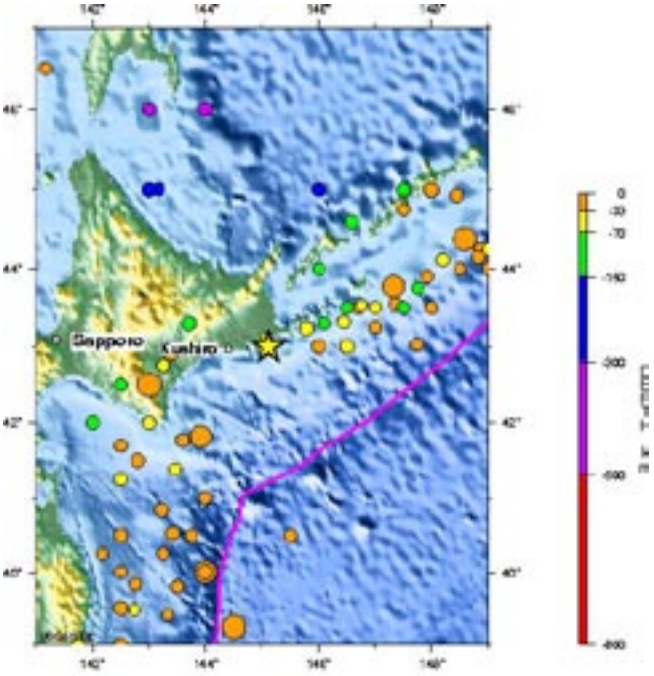
Alexander Rabinovich, Institute of Ocean Sciences Sidney, B.C. Canada, RabinovichA@pac.dfo-mpo.gc.ca

A series of earthquakes occurred off the west coast of Vancouver Island, beginning at 9:30 UTC on November 2, 2004. The main shock with magnitude Mw = 6.7 occurred at 10:02:12 UTC at a depth of 9 km (Pacific Geoscience Centre CMT solution). The epicentre of this earthquake was located in the Explorer Plate region, off the west coast of Vancouver Island (lat/long 49.012 N, 129.181 W) about 230 km west from Tofino. The event was reported as being mildly felt at Port Alice, Bamfield, and Alert Bay, B.C. Careful examination of the digital records of nearby tide gauge stations by the Canadian Hydrographic Service (Tofino, Winter Harbour, Bamfield, Port Hardy and Victoria) revealed that this earthquake generated a weak tsunami that was recorded at two stations: Tofino and Bamfield (see plots, wave arrival indicated by line labeled as "E"). The tsunami travel time to Tofino is about 30 min, very close to theoretically estimated (for Bamfield it is not clear), tsunami trough-to-crest wave heights are 11 cm in Tofino and 6.5 cm in Bamfield. The relatively short observed periods of the recorded tsunami waves (5-6 min for Tofino and 3.5-4 min for Bamfield) indicate that the source length was not more than 40-60 km.



Sea level records from M_W6.7, 2 November 2004 local earthquake (top). Tsunami arrival times were distinguished after spectral analysis. Higher spectral amplitudes with wave periods of 3.5-6 minutes (reds) were observed starting at 1000 Z (bottom).

HOKKAIDO, JAPAN M_W=7, 28 NOVEMBER 18:32 UTC



Historical seismicity (M>7.0) since 1900. Location of the 28 November 2004 earthquake shown by yellow star.

An earthquake of magnitude Mw 7.0 (HRV) occurred at 18:32 UTC on November 28, 2004 about 60 km east of Kushiro, Hokkaido, and 990 km north-northeast of Tokyo, Japan. The Harvard CMT solution indicated thrust faulting at a depth of 47 km along the northeast-southwest trending fault. At least 24 people were injured with damage observed to roads, docks and buildings. The Japan Meteorological Agency (JMA) issued a Tsunami Attention four minutes after the earthquake for the eastern part of the Pacific Coast of Hokkaido, but cancelled the Attention at 1950 UTC. Small tsunamis were recorded at Hanasaki and Kushiro, Hokkaido closest to the earthquake source. (*Data courtesy of JMA.*)

Tsunami observations

Station	Beginning time	Maximum height	
		Time	Height cm
Hanasaki	28/ 18:54	28/ 20:03	12
Kushiro	28/ 18:56	28/ 19:06	7

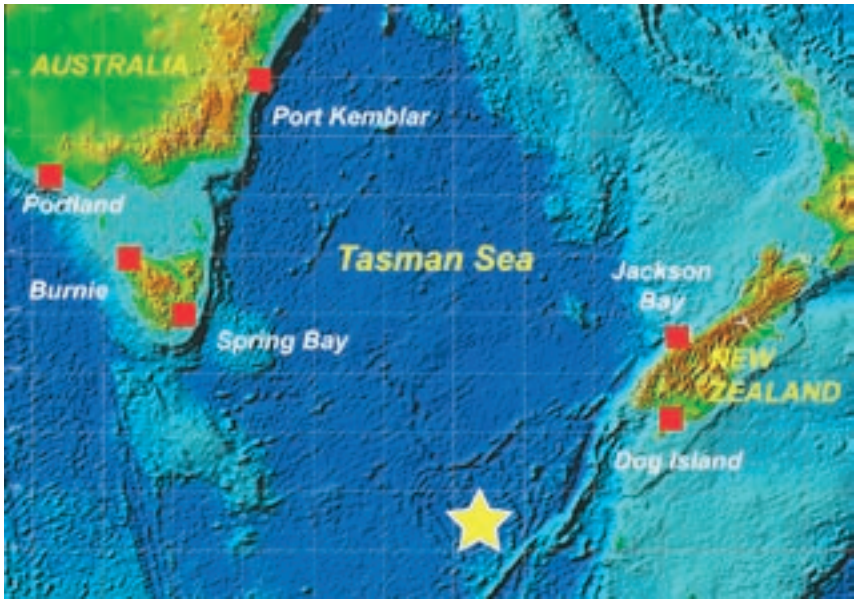
NORTH OF MACQUARIE ISLAND, M_W=8.1, 23 DECEMBER 14:59 UTC

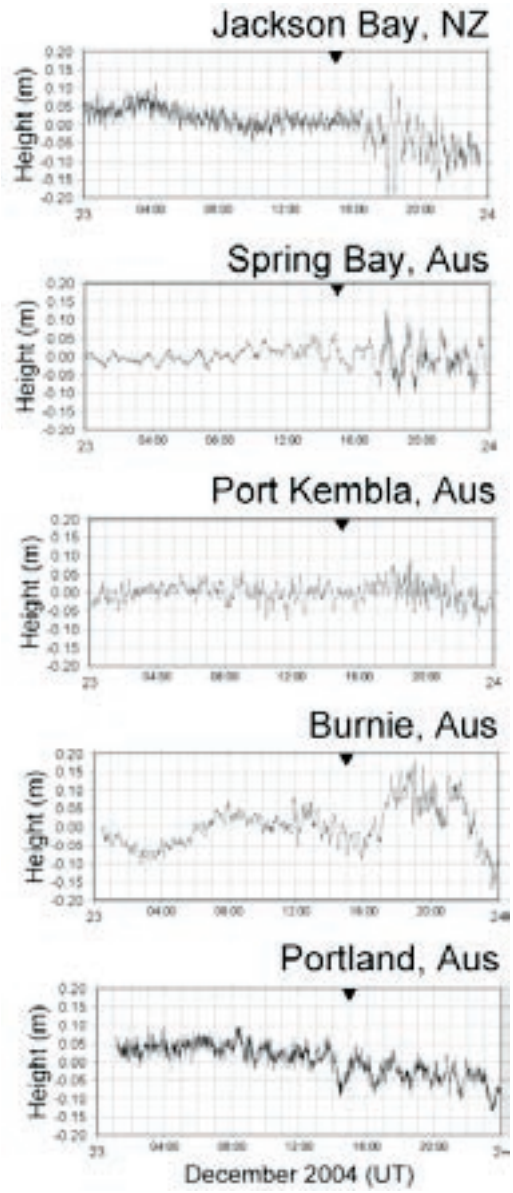
An earthquake of magnitude M_W 8.1 (HRV) occurred at 14:59 UTC on 24 December 2004, north of Macquarie Island and 405 km west of Auckland Island, New Zealand. The Harvard CMT suggests a 28-km focal depth along a transform fault line trending roughly northeast southwest.

The earthquake was felt throughout Tasmania, Australia and over much of the South Island, New Zealand.

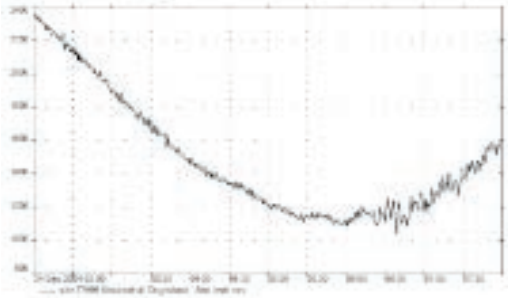
A small tsunami (0.2 m crest-to-trough) was observed on the Dog Island sea level gauge located offshore from Bluff Harbor, New Zealand National Institute of Water and Atmospheric Research(NIWA). The National Tidal Centre (Bureau of Meteorology, Australia) also reported that small tsunamis were observed at Jackson Bay, New Zealand (0.3 m crest-to-trough, 24-min period), Spring Bay, Tasmania (0.15 m), and Port Kembla, New South Wales (0.10 m).

No tsunami was detectable above the background noise at Burnie, Tasmania or Portland, Victoria.





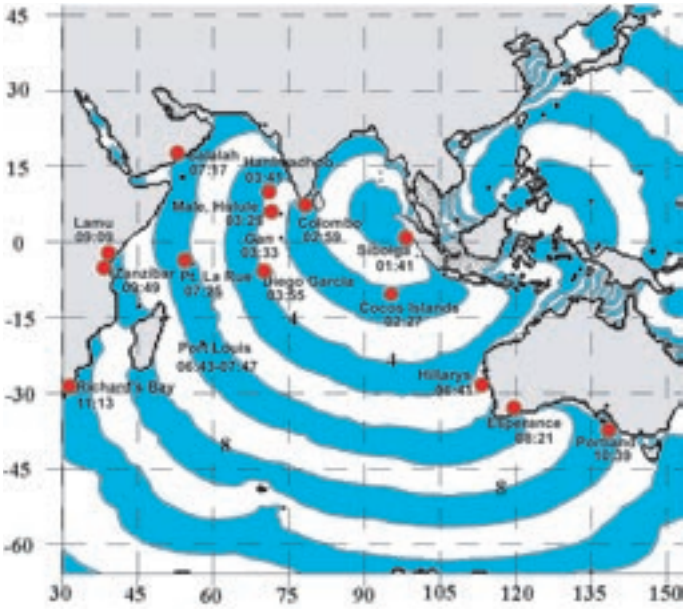
Dog Island, NZ



New Zealand and Australia 1-minute sample sea level records. The time of the earthquake is indicated by the triangle (above). (Data courtesy of James Chittleborough, National Tidal Centre, Bureau of Meteorology, Australia.)

Left: Dog Island, NZ sea level record. Data courtesy Rob Bell, National Institute of Water and Atmospheric Research.

OFF NORTHERN SUMATRA, M_W=9.0, 26 DECEMBER 00:59 UTC



Above: Tsunami travel time map for the 26 December 2004 Indian Ocean Tsunami. Contour interval and color change every hour. The red dots show the locations of sea level stations which measured the tsunami in the Indian Ocean along with the observed tsunami travel time to each station.

Data from Tide Gauge Observations of the Indian Ocean Tsunami, December 26, 2004, Geophysical Research Letters, 32, L090603, doi:10.1029/2005GL022610; M. A. Merrifield, Y. L. Firing, G. Brundrit, R. Farre, B. Kilonsky, W. Knight, L. Kong, C. Magori, P. Manurung, C. McCreery, W. Mitchell, F. Shillington, E. M. S. Wijeratne, P. Caldwell, J. Jardin, S. Nakahara, F.-Y. Porter, and N. Turetsky.

Below: Arrival times correspond respectively to 1) the first change, and 2) the crest of the 1st wave, in hours:minutes, December 26, 2004 (UTC) (exceptions: at Belawan, Sibolga, Lembar, and Prigi, times correspond to the first trough and first crest; Rodrigues station was destroyed and time corresponds to the last transmitted data; Port Louis time range corresponds to the data gap), with the parenthesized number representing the sample rate in minutes. Travel time is the difference between the time of the earthquake (00:59 UTC) and the time of the arrival of the first crest (or trough). Absolute height is the height of the first crest above the mean for each station. Non-tidal height is the height above the mean when a tidal fit has been removed. Heights in parentheses correspond to the largest measured crest (when the the first was not the largest), and Max. time is the corresponding time (hours:minutes, December 26, 2004, UTC).

Tsunami Characteristics at Indian Ocean Stations

Station	Arrival time	Travel time	Absolute height (m)	Non-tidal height (m)	Max. time
Belawan	01:40, 03:30 (10)	00:41	0.23(1.30)	0.51(0.93)	09:30
Sibolga	02:40, 03:10 (10)	01:41	0.28(1.21)	0.43(1.32)	06:50
Lembar	03:20, 04:00 (10)	02:21	-0.24(1.02)	0.15(0.25)	15:10
Cocos Islands	03:17, 03:26 (1)	02:27	0.03	0.33	
Colombo	03:52, 03:58 (2)	02:59	1.92	2.17	
Prigi	04:10, 04:30 (10)	03:11	0.05(0.74)	0.15(0.28)	11:20
Hulule, Male	04:16, 04:24 (4)	03:25	1.42	1.46	
Panjang	04:29 (30)	03:30	-0.01(1.02)	0.11(0.45)	12:59
Gan	04:20, 04:32 (4)	03:33	0.80	0.88	
Hanimaadhoo	04:32, 04:40 (2)	03:41	1.83	1.71	
Diego Garcia	04:48, 04:54 (6)	03:55	0.34	0.56	
Rodrigues	06:40+ (2)	05:41+			
Hillarys	07:28, 07:40 (1)	06:41	0.41(0.87)	0.35(0.57)	10:25
Port Louis	07:42-08:46 (4)	06:43-07:47	(1.66)	(1.45)	09:26
Salalah	08:12, 08:16 (4)	07:17	-0.28(0.74)	0.28(1.64)	10:04
Pt. La Rue	08:16, 08:24 (4)	07:25	0.61(1.18)	1.09(1.58)	09:12
Esperance	08:57, 09:20 (1)	08:21	0.08(0.03)	-0.01(0.26)	22:25
Lamu	09:56, 10:08 (4)	09:09	-0.23(0.35)	0.28(0.50)	10:44
Zanzibar	10:44, 10:48 (4)	09:49	0.31(-0.79)	0.29(0.32)	18:12
Portland	10:48, 11:38 (1)	10:39	0.17(0.46)	0.17(0.58)	26:32
Richard's Bay	12:03, 12:12 (3)	11:13	0.69(0.74)	0.16(0.79)	17:24
Port Elizabeth	13:21, 13:27 (3)	12:28	1.03(1.07)	0.26(1.81)	19:18

Sumatra, *continued.*

PTWC SPEAKS OUT AFTER 26 DECEMBER 2004 TSUNAMI

To put it simply ... "On 26 December 2004, there was no tsunami warning system in the Indian Ocean." Specifically, there was no warning center, inadequate regional seismic networks, no network of remotely reporting sea level gauges, no designated national authorities for tsunami warnings, no communications methods to reach potential authorities, no tsunami-educated emergency managers or local tsunami experts, no communications to disseminate warnings to coastal regions at risk, and painfully little tsunami awareness.

On that quiet afternoon of Christmas Day in Ewa Beach, Hawaii, the three PTWC staff who responded were confronted with an extraordinary event off northwestern Sumatra, Indonesia—one which evolved over hours and the next days to result in the world's worst tsunami catastrophe. The casualties and destruction occurred across the Indian Ocean basin, striking Indonesia then Thailand, Sri Lanka, India, and the Maldives, and then Somalia, northeastern Africa eight hours afterward. Altogether, it is estimated that nearly 250,000 people lost their lives in the great earthquake and ensuing tsunami, and it was these circumstances that immediately bolted the world's leaders on 6 January 2005 to call for the establishment a tsunami warning system to protect against this fatal, though infrequent hazard.

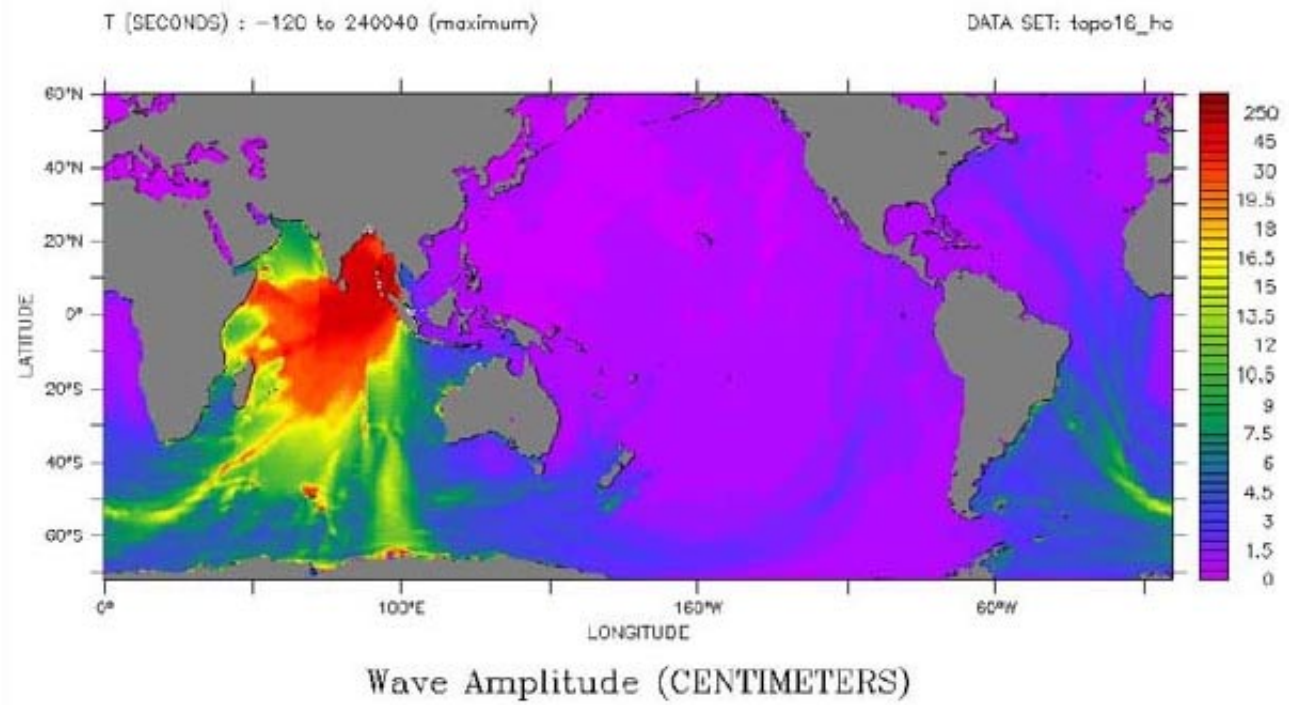
The following is a Comment by PTWC that was published in the American Geophysical Union's EOS weekly newspaper in July, 2005. Tsunami warnings are just one part of what must be in place to enable an effective tsunami response that will move people out of harm's way before the tsunami's arrival.

Comment on "A Strategy to Rapidly Determine the Magnitude of Great Earthquakes" by W. Menke and V. Levin

by S. A.Weinstein, C. McCreery, and B. Hirshorn, U.S. NOAA, Richard H. Hagemeyer Pacific Tsunami Warning Center, 91-270 Fort Weaver Road, Ewa Beach, HI 96706, USA, Stuart.Weinstein@noaa.gov, and P. Whitmore, U.S. NOAA, West Coast/Alaska Tsunami Warning Center, 910 S. Felton Ave., Palmer, AK 99645, USA, Paul.Whitmore@noaa.gov

Eos, 86:28 (12 July 2005) p. 263-264.

We appreciate W. Menke and L. Levin's comments (*Eos, 86:19 (10 May 2005), p.185+,*) on the need to develop new seismological techniques to more accurately determine the magnitude of great earthquakes quickly. However, in the first few paragraphs, Menke and Levin suggest that the many thousands of people died because an accurate assessment of the true nature of the 26 December 2004 Sumatra earthquake was not known within the first hour after it occurred. Although this may serve as a wake-up call to seismologists on the importance of better and more rapid magnitude estimation procedures, it should not be used to obscure the most urgent need, which is to establish an effective global tsunami warning system.



Maximum calculated global wave heights (cm) from the December 26, 2004 Indian Ocean tsunami. Waves were recorded on sea level gauges in Antarctica, and along the coasts of South and North America and Canada in both the Pacific and Atlantic Oceans. (NOAA Pacific Marine Environmental Laboratory)

Sumatra, *continued.*

Photo Mosaic of Banda Aceh, Indonesia

The primary reason many thousands of lives were lost in the Sumatra tsunami is that there was no tsunami warning system for the Indian Ocean. Rather than focusing on the failure of seismologists to accurately estimate the magnitude of the 26 December earthquake, we should understand that what the world needs to prevent another tsunami tragedy on this scale is, first and foremost, a global tsunami warning system. Faster seismological techniques for more accurate magnitude estimation and source characterization will certainly help the warning system. However, such improvements will be of little benefit to nations or regions where there is still no tsunami warning system.

In the aftermath of the Sumatra tsunami, there was considerable confusion about what exactly a tsunami warning system is. Many people still seem to believe that warning centers themselves are the warning system. This is a misconception that we are trying to dispel.

A successful warning system is composed of three main components: tsunami hazard and risk assessment, warning guidance, and preparedness. Each component must be functioning; otherwise the system collapses.

Warning centers are the trip wires; the centers' responsibilities include determining the location and magnitude of an earthquake as quickly as possible, evaluating potential tsunami threat, issuing message products, and monitoring sea level gauges for evidence of tsunami activity.

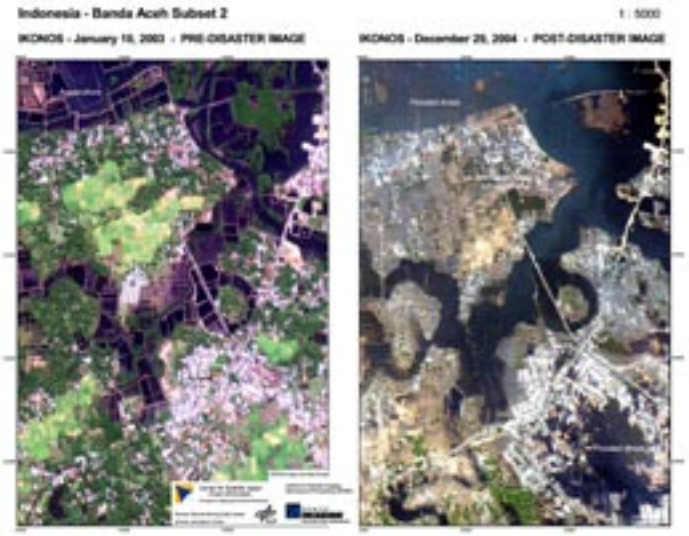
Emergency managers evaluate warning center message products (with the help of local tsunami advisors, when possible), plan evacuation routes and shelters, and develop a communications system to alert the public to a tsunami emergency.

Tsunami awareness also is vital. The public needs to be educated about what actions to take to save their lives during a tsunami emergency. For example, if you are near the shore and feel a strong earthquake, you should immediately head inland and/or uphill. Likewise, a proper understanding of some basic properties of tsunamis and their causes can save lives, even in the epicentral region. One sure sign of an approaching tsunami is the ocean draw-down, i.e., when the ocean recedes in an unnatural way.

How would the Pacific tsunami warning system react if a 26 December type event were to occur in the Pacific Basin? With an initial Mw estimate of 8.0, and based on predetermined conservative criteria, the U.S. National Oceanic and Atmospheric Administration's Richard H. Hagemeyer Pacific Tsunami Warning Center (NOAA PTWC) and the agency's West Coast/Alaska Tsunami Warning Center would issue warnings, watches, and advisories to their respective clients in the Pacific.

(NOAA's tsunami warning centers work with a number of U.S. agencies, including the U.S. Geological Survey and other NOAA organizations. Internationally, the warning centers work with Australia's National Tidal Center, Chile's Servicio Hidrográfico y Oceanográfi co de la Armada, the Japan Meteorological Agency, and other organizations. Through such collaborations, NOAA's warning centers obtain the information needed to provide timely tsunami threat warnings.)

To provide timely warnings, the earthquake must be evaluated as fast as possible. Warning centers understand that evaluating the first 100 seconds of signal may not indicate the size of a great earthquake with a rupture time of several hundred seconds.



IKONOS satellite images before and after the tsunami over Banda Aceh, northeast tip of Sumatra island, Indonesia. The coastal plain was fully inundated, all vegetation stripped and mud and sediment deposited. Some area still remain flooded 3 days after the event when this image was taken. The region was formerly used for aquaculture, settlements, and agriculture.

Sumatra, *continued.*

However, the initial estimate can be used to determine if an earthquake is over a warning threshold.

Had the 26 December event occurred in the Pacific, all regions within three hours of tsunami travel time would have been placed in a tsunami warning status based on the initial determination of an M_W of 7.9 or greater. More limited regional warning bulletins are issued for earthquakes in the Pacific with an M_W as small as 7.55, and local warnings are issued for earthquakes with an M_W as small as 6.8.

Although destructive tsunamis resulting from an earthquake with an M_W as small as 6.8 are extremely rare, they are not impossible. For example, such an earthquake could potentially trigger landslides, or the earthquake could be a slow earthquake (sometimes referred to as a tsunami earthquake) resulting in a much larger than expected tsunami given the earthquake's seismic moment.

Fortunately, the tsunami warning system of the Pacific has an extensive network of over 130 remotely reporting sea level gauges including several deep-ocean pressure sensors. These gauges are a critical asset for tsunami warning that was completely missing in the Indian Ocean on 26 December.

The Pacific network of sea level gauges allows warning centers to confirm the existence or nonexistence of tsunami waves following a warning based solely on the seismic data. Most Pacific warnings are canceled within 2–3 hours after they are issued, based on the sea level data. Without the network of sea level gauges, the entire Pacific Basin would have unnecessarily been placed in a warning status many times during the past 40 years over which the tsunami warning system of the Pacific has been operational.

Aside from causing a significant disruption to normal activities in coastal zones, frequent false warnings cause them to be discredited, and make warnings of real threats ineffective.

On 26 December 2004, there was no tsunami warning system in the Indian Ocean: there was no warning center, inadequate regional seismic networks, no network of remotely reporting sea level gauges, no designated national authorities for tsunami warnings, no communications methods to reach potential authorities, no tsunami-educated emergency managers or local tsunami experts, no communications to disseminate warnings to coastal regions at risk, and painfully little tsunami awareness.

We hope we have made it clear that what is vitally important is a functioning tsunami warning system. Better seismology for such events is something that can help; but with respect to mitigating loss of life from tsunamis, it is of secondary importance to the establishment of a global tsunami warning system.

We are always seeking ways to improve the warning system. Currently, the tsunami warning centers employ the M_{wp}, M_m, and M_s methods to estimate the size of earthquakes at teleseismic distances. In particular, the M_{wp} (P-wave moment method, *Tsuboi et al., 1995*) and M_m (mantle magnitude method, *Okal and Talandier, 1988*) are methods that are designed to reduce the effects of saturation (underestimation of the earthquake magnitude when source duration significantly exceeds the seismic wave period at which the magnitude is measured) and yield quality seismic moment estimates of great earthquakes in near real time. While these methods underestimated the 26 December earthquake, they performed superbly for the 28 March 2005 earthquake, a Harvard Seismology CMT magnitude M_W = 8.6 event as estimated by Harvard Seismology that the Pacific Tsunami Warning Center reported in its initial bulletin as an M_W 8.5 just 19 min after the event. Further analysis by Weinstein and Okal (2005) shows that extending the M_m method to longer periods gives a value for the 26 December Sumatra earthquake of 8.9.

We appreciate Menke and Levin's efforts directed at developing new seismological techniques that could improve the warning system's capability to more accurately assess great earthquakes in a timely fashion, and look forward to any other such advances that may emerge from the scientific community at large in the wake of the 26 December event.

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IOC NEWS

GLOBAL TSUNAMI ACTIVITIES

The December 26, 2004 Indian Ocean tsunami has tragically demonstrated the urgent need for early warning systems that provide timely, understandable warnings which motivate ordinary citizens to quickly move out of harm's way. While implementation of the Indian Ocean tsunami warning and mitigation system is being pursued with highest urgency, the tsunami hazard exists in all oceans and seas and it is likely that the next tsunami catastrophe will occur outside the Indian Ocean. In response and drawing upon the experience of the 40-year system in the Pacific (ICG/ITSU - *http://www.tsunamiwave.info*), the IOC of UNESCO is leading the effort to build tsunami warning systems globally. At the 23rd Session of the IOC (June 2005), Intergovernmental Coordination Groups for the Indian Ocean (ICG/IOTWS - *http://ioc.unesco.org/indotsunami/*), Tsunami and other Coastal Hazard Warning System for the Caribbean and Adjacent Regions (ICG/CARTWS), and the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and Connected Seas (ICG/NEAMTWS-*http://ioc3.unesco.org/neamtws/index.htm*) were established, demonstrating the high-level commitment by governments to initiate comprehensive tsunami risk reduction programmes. An ad hoc Working Group was also established to prepare a framework for the global tsunami and other ocean-related hazards early warning system, and will report back at the 39th Session of the IOC Executive Council in June 2006.

The programme activities will include hazard risk assessment, warning guidance, and mitigation, education, and preparedness targeted at all levels within the government and down to households at the community level. All components of risk reduction need to be undertaken simultaneously and sustained for a warning system to save lives and property. Because of the infrequency of the tsunami hazard, the systems are being developed in the context of other ocean-related hazards and under the umbrella of the GEOSS platform that encourages the use of environmental instrumentation for multiple purposes.

CARIBBEAN

In the Caribbean region, CDERA and the IOC's Regional Programme IOCARIBE have taken leadership roles in convening consultations to build support and develop an action plan for strengthening the real-time monitoring network, improving evaluation capabilities, and ensuring effective early warning dissemination. In 2005, a number of consultations took place in the Caribbean. These included a 21 February 2005 CDERA-sponsored meeting in Barbados in response to the 15th Caribbean Community Council of Ministers meeting for establishment of an EWS. The meeting, which brought together seismic, disaster management, coastal, oceanography officials from 12 agencies to review existing monitoring networks, examine data sharing among the networks, and plan a programme of action. At the 7th Biennial Conference of the Faculty of Pure & Applied Science, University of the West Indies, in Jamaica 18 May 2005, participants endorsed the Mona Resolution, calling for tsunami awareness and risk-reduction programmes, including tsunami warning arrangements, to be implemented in the Caribbean.

As a means to move forward, the International Conference for the Development of a Tsunami and Coastal Hazards Warning System for the Caribbean Sea and Adjacent Regions, was held on 1-3 June 2005 in Mexico City. Altogether, 60 participants from 17 countries and eight regional and international organizations, representing national disaster management organizations, scientists, and other tsunami mitigation specialists, endorsed the *Caribbean TWS Communiqué*. The *Communiqué* recognizes and supports the creation of an integrated, and sustained regional system for the detection, forecasting, warning, and mitigation of tsunami and other coastal hazards, and requests the PTWC to extend its warning guidance to the wider Caribbean Region on an interim basis until such time as this capability can be managed independently within the region. The newly established ICG/CARTWS will conduct its first session 10-12 January 2006 in Barbados. High level advocacy and resources for implementation are still needed to realize the system. Although the USA has announced over USD $35 million to support seismic and sea level network upgrades and enhancements in tsunami operations in the Caribbean and the Pacific to strengthen warnings of US residents, further support is still required to improve instrumental monitoring of the southern and eastern Caribbean region.

IOC Global activities, *continued.*

SMALL ISLAND DEVELOPING STATES

Excerpt from Report from Expert Meeting on Disaster Warning and Response Systems in Small Island Developing States Regions, Christ Church, Barbados, 8 – 9 August 2005, Summary of Findings and Recommendations to the Regional Secretaries General, prepared by the Commonwealth Secretariat.

In an effort to further support the development of adequate early warning systems in small island developing states, the Commonwealth Secretariat sponsored an inter-regional consultation on disaster warning and response on 8-9 August 2005. The Expert Consultation included representatives from the Inter-Governmental Organisations (IGOs) from the Pacific, Indian Ocean and Caribbean Regions, representatives

Participants of the Inter-regional Consultation on Disaster Warning and Response, 8-9 August 2005, Barbados. The meeting included representatives from the Caribbean Epidemiology Center, CARICOM, CDERA, COI, EU, IOC, Puerto Rico Seismic Network, Umvoto Africa (PTY) Ltd, USAID, World Bank, local technical organizations, universities and emergency agencies, and the Commonwealth Secretariat.

from regional specialist organisations, and various experts in tsunami and hydro-meteorological early warning, geohazard assessment, medical disaster response and community empowerment. The IOC was represented by the ITIC Director who provided information on the current progress of the IOC and its United Nations partners (primarily the ISDR and WMO) for the Indian Ocean Tsunami Warning and Mitigation System, and general expertise in building programmes in the Pacific and Caribbean.

In the aftermath of the 26 December 26 tsunami, the Secretaries-General of the Commonwealth, Caribbean Community, Indian Ocean Commission and the Pacific Islands Forum, following their informal meeting 13 January 2005 prior to the United Nation's International Meeting to Review the Implementation of the Barbados Programme of Action (BPoA) on the Sustainable Development of Small Island Developing States (SIDS), decided to examine ways in which they could collectively reduce the future impact of natural disasters by strengthening advance warning networks across international borders. They noted that in some areas, there were already advance disaster warning networks in place. In other areas, new investment and fresh initiatives were required. With this in mind, each region collated information and prepared a report on its warning and response systems (Disaster Warning and Response Systems in Small Island Developing States (SIDS) Regions, A Report for the Commonwealth Secretariat, September, 2005). The Report was then considered at the 8-9 August 2005 Consultation of technical experts from the three regions. The meeting reviewed the present effectiveness of the disaster warning and response systems, identified gaps in the systems, and identified potential measures required to address the gaps.

Among the conclusions were the following key findings:

- *The regions face a similar hydrometeorological hazards and are generally well organised with respect to early warning for tropical storms and cyclones, but lack co-ordinated early warning mechanisms for tsunamis of local and/or regional origin. All regions also identified the need for capacity building at the community and various leadership levels as being a priority gap that needs to be addressed.*
- *Each region identified specific issues that need to be addressed. In the Indian Ocean region, a critical concern is the establishment of a regional technical institution (and the development of requisite skills) of the kind that exist in other SIDS regions. In the Pacific, one concern is the need to upgrade existing communications systems to meet present-day needs, especially at the community level. In the Caribbean, there is a need to give effect to disaster-related policies and strategies, and to allocate resources at the national level. The issue here is the extent to which Intergovernmental Organisations, by working together at a political level within the international community, can help to highlight these concerns and work to address them.*

The recommendations for action by Secretaries-General will focus on their capacity to highlight issues at a high political level, facilitate and support action by regional specialist bodies, and then to mobilise resources for mitigation.

IOC Global activities, *continued.*

INDIAN OCEAN TSUNAMI WARNING AND MITIGATION SYSTEM

http://ioc.unesco.org/indotsunami

In the Indian Ocean, interim tsunami advisory information is being provided by the existing centers in Hawaii and Japan, and instrument networks are being enhanced to continuously monitor seismicity and confirm when a destructive tsunami is generated. Over USD $150

Train derailed by tsunami wave, Peraliya, Sri Lanka. The wave lifted the train tracks off the ground, twisting and overturning the railroad car, causing about 1500 casualties. (Saman Photo, Nawanama, Meetiyagoda, Tel 0776-719920/0776-829081)

million dollars has been committed to building national tsunami monitoring and warning systems in Australia, India, Indonesia, Iran, Malaysia, Pakistan, Thailand and other nations, and protocols for emergency response and the dissemination of warnings are being developed by all countries bordering and within the Indian Ocean.

While the IOC expects the core IOTWS monitoring system to be operational by July 2006, enhancements will continue for years after, and it is steadfast that the system must serve all countries to be successful. As envisioned, the system should consist of a coordinated network of national systems whose assets are owned and operated by each of them. The systems should be developed within a multi-hazard framework using up-to-date global information systems and international data sharing standards to support national monitoring, warning and response, and with national coordination that builds local community-based empowerment for tsunami preparedness, education, and response.

Core characteristics of the monitoring and warning system being set up through IOC coordination include, since April, the immediate use of the existing warning centers to provide interim tsunami warning advisories using existing seismic and sea level networks and through the Global Telecommunications System supported by the World Meteorological Organization, incorporation of data streams from the networks of instruments used for nuclear test monitoring under the Comprehensive Nuclear Test Ban Treaty Organisation, and upgrade of the IOC GLOSS sea level network.

Even once a real-time monitoring system is in place though, a system must exist for disseminating those national warning and wave forecasts to specific regions and for local emergency officials to decide when a warning means that an evacuation is needed for their coastal communities. So, preparedness needs to occur to educate every citizen on the dangers of tsunamis and what to do, and emergency response plans need to be put in place for every at-risk area - this effort could take years.

IOC First International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework, Paris, France, 3-8 March 2005

The International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework was held at UNESCO Headquarters between 3 and 8 March 2005. The Meeting was attended by nearly

The 4-day Paris meeting gave participants an overview of the components of a tsunami warning and mitigation system and a status of the present capabilities globally.

300 participants from 21 countries in the Indian Ocean region, 25 other IOC Member States, and 24 organizations. This was the first meeting in a series that is leading to establishing the technical and 'legal' framework for the establishment of the Indian Ocean System. UNESCO received a clear mandate from the international community to coordinate the

IOC Global activities, *continued.*

establishment of the System during the course of several international and regional meetings, including the World Conference on Disaster Reduction (Kobe, Japan, 18–22 January 2005), and the Phuket Ministerial Meeting on Regional Cooperation on Tsunami Early Warning Arrangements (Phuket, Thailand, 28-29 January 2005).

UNESCO Director General Koichi Matsuura addresses delegates at the International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework 3-8 March 2005.

The meeting was funded with funds pledged in response to a UN/OCHA First Flash Appeal (January 2005) submitted jointly by the ISDR and IOC for the *Evaluation and Strengthening of Early Warning Systems in Countries Affected by the 26 December 2004 Tsunami in South East and South Asia* (TSU-REG-05/CSS06-REGION). For this, a total of USD $11 million was pledged for a core system implementation, integrated risk knowledge, public awareness and education, community level approaches, and project coordination. The IOC received about USD $3.5 million for coordinating the governance, core system observational network, and capacity building.

The first three days of the meeting ensured that Indian Ocean Member States were fully informed at the technical level, on tsunami warning and mitigation programmes at the national, regional and global levels. The Meeting adopted a *Communiqué* that provided guidance to all partners regarding the required actions that will lead towards the establishment of an Indian Ocean Tsunami Warning and Mitigation System. The system should be based on a coordinated network of national systems and capacities, with each Member State responsible for issuing warnings within their respective boundaries. The Meeting also recommended the establishment of an *Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS)* and drafted terms of reference for the Group.

The fourth day covered the Indian Ocean System within a Global Framework. Since every ocean and sea basin can be impacted by a tsunami, the next tsunami can occur anywhere and at anytime. Thus, there is a need to design a Global Tsunami Warning and Mitigation System.

Presentations were made on the development of tsunami warning and mitigation systems for the Caribbean and Central West Atlantic Region, the Mediterranean and North East Atlantic; the Southwest Pacific Region; and improving the ITSU system in the Pacific. Future subregional operational tsunami warning systems must be linked to the regional tsunami warning centres such as the Pacific Tsunami Warning Center. It would be the responsibility of the regional centres to warn the national centres and countries when a basin wide tsunami is generated.

The Second International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean held in Mauritius 14-16 April 2005 was attended by 153 participants from 32 nations and 23 organizations.

To sustain operational tsunami warning systems over the long term will require the implementation of the system within a multi-hazard context where more frequently occurring hazards can exercise the common elements of the technical monitoring, alert, and response system. The Global Ocean Observing System (GOOS) is an example of an effective and sustained effort to serve data for ocean-based hazard warnings since sea leavel data is also essential for monitoring storm surge and infering climate-change from global ocean data. Additionally, the seismological efforts established nationally or through multi-lateral agreements will contribute to the existing framework and standards established by the global Federation of Digital Seismograph Networks.

On a broader scale, all data systems should be linked

IOC Global activities, *continued.*

under the Global Earth Observation System of Systems (GEOSS), that was formed in response to appeals made at the World Summit on Sustainable Development (Johannesburg, 2002) for the integration of space-based and 'in situ' observations covering the land, the ocean, the atmosphere and ecosystems. Currently, 61 nations are part of the GEOSS plan of action, which calls for coordination at the highest ministerial levels to build a sustainable earth observing system. The GEOSS project is envisioned as a large national and international cooperative effort to bring together existing and new hardware and software to enable the sharing of data and information streams to many at little or no cost.

IOC Second International Coordination Meeting for the Development of a Tsunami Warning System for the Indian Ocean, Grand Baie, Mauritius, 14-16 April 2005

The Second International Coordination Meeting for the Development of a Tsunami Warning System for the Indian Ocean, held 14-16 April 2005 in Grand Baie, Mauritius, informed Indian Ocean countries on the interim advisory information system and progress in sea level upgrades and other mitigation initiatives, and sought to coordinate donor support. The *Mauritius Declaration* adopted at the meeting also included the request to assess the technical and non-technical requirements of Member States for implementation of an effective warning and mitigation system. The results of the assessment studies will be used to finalize the technical plans for both the national and regional systems.

From May through September 2005, the IOC led international missions involving IOC, World Meteorological Organization, and ISDR designated experts on tsunamis, communications, and disaster management to countries to obtain national information on a broad spectrum of topics ranging from technical requirements and instrumentation to communication channels and public education programmes. In total, 16 countries were visited, with 4 countries still to be done, or rescheduled for visit. The reports are being compiled to obtain a regional summary for discussion on capacity building requirements at the Second ICG/IOTWS to be held 12-16 December in Hyderabad, India.

Tsunami tens of meters high carried barges and boats inland, depositing them on roads and in this case, on top of a building which was strong enough to support the barge after the tsunami wave retreated. (Photo courtesy of George Plafker, Pacific Gas and Electric).

Donor nations attending the Mauritius meeting, including Belgium, Finland, and Norway, pledged USD$5million over and above earlier contributions for specific activities linked to the tsunami warning and mitigation system. Several others, including Australia, France, Italy, Japan, Germany and the United States of America, along with the European Commission, also indicated their continuing support and their willingness to provide more financial aid as the plans for the system became more clearly defined.

A Second UN/OCHA Flash Appeal Proposal (Immediate additional needs for Core System implementation: TSU-REG-05/CSS10–REGION) was submitted at the midterm review by the IOC to further support the core deployment of the warning system. The requested budget amounts to US$ 12million and is currently open for donor pledging.

ICG/IOTWS-I held in Perth, Australia 3-5 August 2005. It was attended by over 80 participants from 18 countries and 6 organisations.

First Meeting of the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS), ICG/IOTWS-I, Perth, Australia, 3-5 August 2005

The First ICG/IOTWS, held 4-6 August 2005 in Perth, Australia, focused on the technical aspects of the warning system. Six technical intersessional working groups were established that will report at the Second ICG/IOTWS. The working groups are: Seismic Measurements, Data Collection, and Exchange, Sea Level Data Collection and Exchange (including deep-ocean tsunami detection instruments, DART), International DART Partnership, Tsunami Hazard Detection and Characterisation (including modelling prediction and scenario development), Intercomparison Modelling Workshop, and Interoperable Operational Centres.

IOC Global activities, *continued.*

PUBLIC TSUNAMI WARNING LIST SERVE AVAILABLE

The UNESCO IOC has set up a public tsunami warning list serve for the public to receive by email tsunami warning centre information messages as they are issued. To subscribe to this service, visit *http://ioc.unesco.org/indotsunami/subscribe_warning.htm*.

This is not an operational service and these messages should not be considered as official warning messages. The IOC cannot guarantee that this service will be operational 100% of the time and that there will be no delays in the receipt of the messages by subscribers. Official warning messages are assured of delivery only to the tsunami national focal points. This service went into operation on 31 Dec 2004 and broadcast messages posted by the Pacific Tsunami Warning Center and the West Coast/Alaska Tsunami Warning Center for the 1 January 2005, 0625 UTC, M6.5 earthquake that occurred in the same region. The warning centres posted these messages about 15 minutes after the earthquake occurred. The warning centres contributing to this service are the Pacific Tsunami Warning Center, the West Coast/Alaska Tsunami Warning Center, and the Japan Meteorological Agency. Currently, there are several thousand people subscribing to this free public service.

ITIC NEWS

ITIC STAFFING

In July and August 2005, the NOAA National Weather Service (NWS) added three full-time staff to the ITIC. The ITIC Staff now consists of the Director (seconded to IOC by NOAA, Dr. Laura Kong), Associate Director (provided by Chile, Emilio Lorca), Deputy Director/Office Manager (NWS, Brian Yanagi), Technical Information Specialist (NWS, Linda Sjogren), Information Technology Specialist (NWS, Tammy Kaitoku), and Secretary (1-year temporary, Pauline Benjamin). Later this year, the IOC will formally designate the ITIC as a Programme Office of the IOC.

ITIC ACTIVITIES

ITIC has been very busy since the 26 December 2004 Indian Ocean tsunami disaster and is now playing a global role in establishing a tsunami warning and mitigation system. Both the PTWC and ITIC Directors have traveled extensively to provide information on ITSU and how the Tsunami Warning System in the Pacific operates.

In the first two weeks after the tsunami, the ITIC received about 500 email messages to its general email addresses, and the ITIC Director individually received more 1200 messages. The ITIC Director in turn responded with more than 1000 emails. The ITIC received more than 300 media or other information requests by phone, FAX, and by written communication. Starting immediately after the event, the ITIC and IOC worked to post high-quality scientific information on the tsunami on the ITSU web site hosted in Paris. The ITIC and IOC also set up a public notification mailing list through its ITSU and Indian Ocean sites for the public to sign up for the immediate, but non-operational, delivery of tsunami information messages (*see related article*).

At the same time, the ITIC facilitated the organization of Post Tsunami Scientific Survey Teams through its hosting of the Tsunami Bulletin Board (TBB), a listserve for scientists and government officials which provides a technical forum for the sharing and immediate dissemination of tsunami-related information. Currently, more than 300 professionals are members. In the first two weeks after the tsunami, more than 300 messages had been posted on the science of the tsunami event. The TBB has hosted the sharing of survey results from more than 15 surveys involving more than 100 scientists; these data are being collected and compiled and made available to the impacted countries for their use in developing national tsunami warning systems. The U.S. National Science Foundation is currently funding the University of California San Diego Supercomputer and Oregon State University for the development of a tsunami data preservation portal, in collaboration with the World Data Center/National Geophysical Data Center and the International Tsunami Information Centre. When operational, the IOC will host a mirror site hosted by the IOC IODE Project Office in Ostende, Belgium. The portal will also be capable of supporting the multi-media tsunami data preservation needs for all historical and future tsunami events.

In March 2005, ITIC web site was moved from its host site at the NOAA National Weather Service Pacific Region to the Intergovernmental Oceanographic Commission (IOC) (*http://www.tsunamiwave.info*). The ITIC site now acts as the information service for ITSU and provides information for the general public, as well as technical and other ICG/ITSU reports and other technical documents.

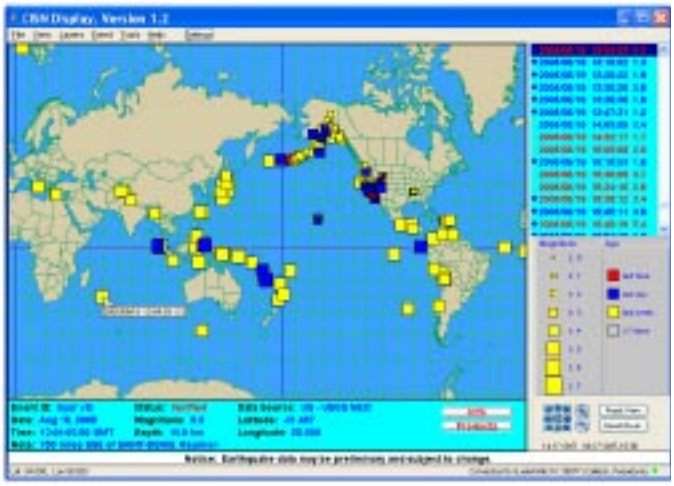
ITIC news, *continued.*

NEW PRODUCTS AND SERVICES

In 2005, the ITIC developed and is making available several additional services to government officials in charge of tsunami warning for their countries. These include a Real Time Earthquake Display and Alerting System (RTED) developed by the U.S. Geological Survey (USGS) in partnership with California Institute of Technology and the State of California Emergency Services, and a heads-up SMS text messaging service for PTWC tsunami messages through the RANET Project.

Real Time Earthquake Display

For the RTED, ITIC has worked with the USGS and its development partners to offer this free multi-platform, internet-based, GIS-capable earthquake broadcasting toll to government and other official agencies. More robust tsunami warning notifications are being built by the end of 2005 that will upgrade and improve the software. The ITIC will act as the local administrator for requests from Member States globally with tsunami alert interests. To sign up, send email to *l.kong@unesco.org* or *itic.tsunami@noaa.gov.*



Sample screen from RTED display showing epicenter map (coded by magnitude and origin time), event listing (upper right, with analyst-reviewed events in red), and hypocentral parameters of most recent event (lower left). The display, alarm triggering, and earthquake alerting is user-selectable and the maps can be localized through the import of GIS shape files

SMS Tsunami Alerts

The USAID-funded RANET Project is currently providing a heads-up alerting service for PTWC-generated tsunami bulletins through cellular phone SMS text messaging. The ITIC Director and the RANET Project Leader Kelly Sponberg (NOAA NWS International Affairs) have implemented this pilot service to provide a heads-up alert to a limited number of government and emergency officials that an official message has been sent by the PTWC. Worldspace satellites along with cellular providers are being used to reach Africa, Indian Ocean, and the Pacific. The RANET Project has been successful in Africa in providing rural communities with eduational and environmental information through community radio stations, and is being piloted in the Pacific in collaboration with Australia's Bureau of Meteorology. For the past few years, the ITIC has been in discussions with RANET to request that the project be able to provide time-critical warnings (e.g., tsunami warnings) to remote customers through its community radio stations in rural communities. The SMS-tsunami alert service is not a replacement to the official PTWC bulletins issued through official channels.

Tsunami Warning and Evacuation Training Video and B-Roll Available

With funding from the U.S. National Tsunami Hazard Mitigation Program and in collaboration with NOAA Public Affairs, the ITIC produced two informational videos. Content lists are posted at *http//:www.tsunamiwave.info* under Products and Services. The products are available on request from ITIC.

The training video is a compilation of news announcements and stories aired during the 1986 and 1994 tsunami evacuations in Hawaii. Actual footage is shown of the evacuation of coastlines and boats in harbors, sirens and voice alert systems, emergency officials working to clear beaches prior to the first-wave arrival, the traffic problems, and the issuance of the "all-clear" announcement when the non-destructiveness of the tsunami was determined. The video also includes rare footage of the 1946 tsunami, the 1995 Greenland tsunami wave, and simulations of tsunami waves destroying a parking lot and building. It was developed for use by emergency managers and other government officials for education and training. The video is 11.5 minutes long and is available in DVD format.

The Tsunami B-Roll (Background information video) is a collection of interviews, tsunami science and numerical tsunami propagation animations, and other graphics for use by Broadcast Media as filler or background footage during a television news presentation or a documentary program. It may also be useful to emergency managers, educators, and for training. The subject matter covers the science of tsunamis, the U.S. tsunami warning programs and centres in Hawaii and Alaska, the U.S. Tsunami Hazard Mitigation Program, Tsunami Ready preparedness programs, and the ITIC. The video runs 57 minutes and is available in Beta-SP and DVD format.

ITIC news, *continued.*

Customizable Public Awareness Products

The ITIC has revised and updated several english-language informational brochures, and will make these available in an electronic format that enables easy translation and localization of graphics. Additionally, hard copies of existing materials are available upon request. The electronic files are available for download from the ITIC web site as both PDF-format and layered Microsoft Word files in which the text and graphics are separated into separate objects for manipulation. Newly revised 2005 editions of the following products are available:

- *Tsunami: The Great Waves, June 2005. This booklet was revised to include information about the Indian Ocean tsunami and more strongly emphasize that tsunami mitigation programmes must include comprehensive efforts at hazard risk assessment, warning guidance, and preparedness and education.*
- *Tsunami Glossary, November 2005. The Glossary is being updated to include information on the recent establishment of global intergovernmental coordination groups for tsunami warning and mitigation, and to include and improve the definition of terms.*
- *Tsunami Warning! June 2005. This children's booklet with cartoon-like illustrations describes what happens when an Alaskan earthquake causes a tsunami warning and evacuations to be issued in Alaska and in Hawaii. The format of the document allows easy customization for the source event and national/local response. A Spanish language version exists for a Chile earthquake and tsunami warning response in Mexico that was produced by CICESE.*
- *Tsunami Safety Poster, December 2005. The poster that can serve as a template for national or local tsunami safety posters and be customized using local languages and photos or graphics. The original design (A3-size) was done in collaboration with Sri Lanka National Science Foundation and the Department of Meteorology for its 3-month Awareness Programme to commemorate tsunami victims on the first anniversary starting from October 26, 2005 and ending on January 26, 2006.*

IOC TsunamiTeacher

In the aftermath of the Indian Ocean tsunami of 26 December 2004, national authorities across the region have been charged with developing tsunami educational and resource materials for schools, as well as information and awareness packages for the media, decision-makers and the general public. The IOC's Pacific-based ITIC has extensive experience in developing print and visual resources on the subject, and it has widely shared this documentation with national authorities globally. While individual in-country and sub-regional efforts are underway to develop specific materials of local relevance, access to a consolidated source of new and existing, reliable and verified international tsunami warning and response information – and training modules aimed at stakeholder groups affected by or responsible for mitigating tsunami impacts – would hugely benefit on-going capacity-building at all levels.

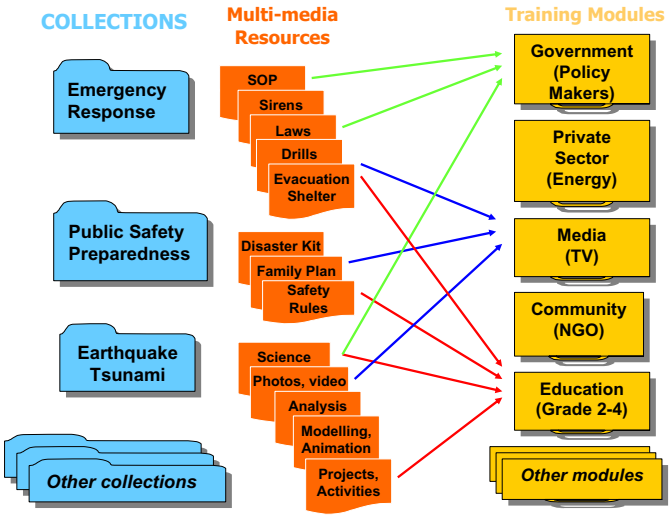
The rationale of the project is to enable governments and stakeholders to be able to:

- *Share the valuable body of research and good practice already undertaken on tsunamis, including that by a variety of United Nations agencies.*
- *Adapt high quality generic materials appropriately to local contexts.*
- *Grow stakeholder and public awareness and understanding of tsunamis.*
- *Develop responses that can potentially save lives and mitigate tsunamis impacts.*

Modeled after UNESCO-IOC's Ocean Teacher, TsunamiTeacher will be a web-based, easily accessible distance-learning product that can also be delivered as DVD training packages. The five stakeholder audiences are: Media, Education systems, Governments, Community groups, and the Private sector. TsunamiTeacher will be comprised of:

- *An updatable "collection" of reliable tsunami-related information and material arranged in "folders" and including, for example, brochures and documents, graphics, multi-media materials, strategies and school curricula resources.*
- *Continually produced training modules targeting different audiences with specific training and resources – linked to the "collection" – that build awareness and understanding of, and capacity to mitigate tsunamis.*

ITIC news, *continued.*



IOC TsunamiTeacher

Modules for different audiences, such as the media, schools, or governments, would contain storylines in chapters that link to relevant resources in the "collection". None of the modules would use all of the resources, but different audiences could utilize the same materials. Training modules can be adapted to make them locally relevant so that they take into account local demographics, social structures, or geography, or modules could be remotely created from scratch by simply choosing different parts of the "collection" resources. The "collection" would be continually updated, pulling in new developments and documents.

The TsunamiTeacher concept and content framework was constructed at a technical workshop of experts and education specialists held by UNESCO-IOC in Paris on 5 and 6 September 2005. Participants were Professor Sirimali Fernando, Sri Lanka National Science Foundation Chair; Dr Laura Kong, ITIC Director; Karen MacGregor, specialist education writer and trainer, South Africa; and Peter Pissierssens, Bernardo Aliaga and Martin Hadlow of UNESCO-IOC.

The TsunamiTeacher project will be based at the IOC-ITIC, and the website maintained by the IOC IODE project in Oostende, Belgium. Components of TsunamiTeacher will be available starting in January 2006. The language of the project would be English, and partnerships are being sought to translate the materials into French and Spanish.

PTWC NEWS

ACTIVITIES

Stuart Weinstein, PTWC Tsunami Warning Science Officer

If there is a positive outcome from the Sumatra disaster, it is that there is now a global spotlight on tsunamis and the mitigation of destruction and loss of life by tsunamis. And as a result of the 26 December 2004 tsunami, both the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC) and the West Coast / Alaska Tsunami Warning Center (WC/ATWC) are implementing a number of enchancements to strengthen operations and staffing to meet the new challenges and responsibilities placed upon them.

Starting immediately after the December 26 event, steadily though at a slower pace today, the PTWC receives ongoing media coverage, as reporters, news agencies and documentary makers ask for live and taped interviews for local, national, and international television shows and video productions. The PTWC staff gratefully acknowledges the assistance of NOAA Public Affairs Officers, Delores Clark and Jim Milbury,

JMA TWC Director Mashiro Yamamoto (left) with McCreery.

in helping to organize these media requests and accomodate as many as possible.

In recognition that a tsunami threat exists in all oceans, both US warning centers have received additional operational resources to allow them to expand their areas of responsibility. Since April 2005, PTWC and JMA have been cooperatively providing interim tsunami advisory information to the countries of the Indian Ocean, and will continue until an Indian Ocean Tsunami Warning System is formally established. Within days

PTWC news, *continued.*

following the disaster, the PTWC began developing formal contacts for emergency communication with the nations of the Indian Ocean and strengthened its existing contacts with ITSU members that have borders with the Indian Ocean. The PTWC issued a tsunami advisory to the Indian Ocean for the 28 March 2005 earthquake near Nias Island, Indonesia. This earthquake had a M_W of 8.6 (Harvard) and produced measurable, but non-destructive tsunami waves that crossed the Indian Ocean; in the vicinity of Nias Island, a local tsunami was observed.

In addition to the Indian Ocean, PTWC has expanded its area of responsibility to the Caribbean, and the WC/ATWC's area of responsibility has expanded to include all US coastlines. Currently, PTWC is testing communications with the Puerto Rico Seismic Network operated by the University of Puerto Rico at Mayaguez, the NWS San Juan Forecast Office and the US Virgin Islands. Formal message products for large earthquakes in that region will be then be developed.

The Director of the PTWC, Dr. Charles McCreery, has travelled extensively during the past year as his expertise has been much sought for the development of the Indian Ocean Tsunami Warning System. Many reciprocal visits have ensued, with the PTWC hosting many visitors from the Indian Ocean, including government officials, emergency managers, military personnel and scientists. Each visiting group is briefed on the operations of the Tsunami Warning System of the Pacific by PTWC staff, and given a tour of the operations center. At the end of July, PTWC staff participated in the ISDR-IOC Hawaii Tsunami Warning System Study Tour for Indian Ocean countries. (*see related article*)

The PTWC, in cooperation with the USGS, is upgrading its seismic and sea level networks in Hawaii. The upgrade will include the addition of eight STS-2 very broadband seismometers and a number of accelerometers. The upgrades are needed to support PTWC's mandate to issue tsunami bulletins to the State of Hawaii within 90 seconds of any large earthquake occurring in the Hawaiian Islands. In order to achieve this goal, the PTWC will transition its staffing from standby/on call duty schedules to an operations center that operates 24 hours-a-day/7-days-a-week with two staff physically in the operations center at all times; presently, the two watchstanders only need be on the PTWC grounds. In order to provide 24/7 services, PTWC is in the process of hiring a number of additional staff.

To help oversee the enhancement of tsunami operations, the PTWC has created a Deputy Director position, and appointed longtime PTWC geophysicist Dr. Stuart Weinstein to that position. In terms of new staffing, Dr. Victor Sardina, Brian Shiro and Dr. Gerard Fryer have joined the PTWC staff in the last few months, and in October, they will be joined by Dr. Stuart Koyanagi and Dr. Vindell Hsu. PTWC also said farewell to oceanographer Dr. David Burwell, who took a position with the tsunami group at NOAA/PMEL under the direction of Dr. Frank Gonzalez in September. While we were sad to lose Dave, his knowledge of our operations will prove invaluable to PMEL as they continue to work on products for use by the U.S. tsunami warning centers.

From 12-15 September 2005, the JMA Tsunami Warning Center Director, PTWC Director, and the ITIC Director met to coordinate issues of rapid sharing of earthquake parametric data between the warning centers prior to the issuance of tsunami information for the Indian and Pacific Oceans, to standardize the message formats and content sent be each center so that consistency is provided to Member States regarding hypocentral, magnitude, and tsunami evaluation, and to agree on a protocol message issuance and for calculating and providing estimated tsunami arrival times to designated forecast points. Specifically, the message products of the PTWC and the JMA's Northwest Pacific Tsunami Advisory Center and its Interim Indian Ocean Tsunami Information Service were reconciled, and the warning services provided by Japan will be incorporated into a single Communications Plan for the Interim Indian Ocean Tsunami Warning System, and for the Tsunami Warning System in the Pacific.

SEA LEVEL NETWORK

Niue

In October 2004, PTWC in collaboration with the Niue government and local contractors reestablished the tsunami/tide system damaged by Cyclone Emani. The initial work was performed by local contractor Graham Marsh with coordination by Richard Saint Clair, representing the local Internet/Communications Provider. Actual system installation and the GOES transmission upgrade were carried out by PTWC Senior Electronics Technician (SET) Richard Nygard.

PTWC news, *continued.*

To provide for additional protection for the system, the Niue government arranged for permission to locate the equipment at Alofi Wharf and at the Niue Fisheries Building.

Left: Tsunami/tide system looking from sensor (lower left) on Alofi Wharf up towards Niue Fisheries Office where Data Collection Platform (DCP) and other electronics (solar panel, GOES antenna) are located. Center: Richard Nygard in front of that DCP enclosure (Niue FO) . Right: Palau sea level station.

Atico, Peru sea level station. DCP, solar panel and GOES antennae in back of group. From left to right, in back, José Grandez V. (Mechanic), Freddy Rivera (Electrician), Daniel Olcese (geological engineer), and in front, Richard Nygard (PTWC), Lt. Cdr. Atilio Aste E. (Head of Oceanography Division).

The Peru Navy Hydrological Office provided excellent logistical and technical staff, and funding to accomplish the station installation and maintenance work. From left to right, Engineer Daniel Olcese H., Cdr. Yerko Jara S. (Head of Environment Department), Richard Nygard (PTWC), Lt Cdr. Atilio Aste E., and First Lt. Renzo Withembury B (Head of Numerical Modelling Department).

Peru

In January 2005, PTWC in collaboration with the Peru Navy carried out sea level station upgrades in Peru. At Atico, a new tsunami/tide system was installed. In Callao, the existing system was repaired and upgraded. PTWC also provided a new tsunami/tide system and training to the Peru Navy staff for the installation and re-establishment of a station at Lobos Island that was scheduled for completion in July 2005.

Majuro, Yap, Palau

In March 2005, PTWC upgraded and carried out maintenance on sea level stations in Majuro, Yap and Palau. In Majuro, the data transmission frequency through the GOES satellite was increased to 15-minute transmissions. For Yap and Palau, data transmissions were upgraded to 12-minute transmissions through the Japanese GMS satellite, with coordination between NOAA/NESDIS and the Japan Meteorological Agency (JMA). The Yap systemequipment was upgraded with a new Vaisala 555 DCP and new support hardware. The work was coordinated by and assistance provided by the Weather Service Meteorological Offices on each of the islands.

ITSU NEWS

NEW ITSU MEMBERS and NATIONAL CONTACT UPDATES

In the last several months, ITSU Member State numbers have increased in number and now there are 28 Member States. Malaysia, and Vietnam have joined the intergovernmental organization. There have also been changes to National Contact information for China, Ecuador, Fiji, Malaysia, Peru, Singapore and Thailand. Brunei and Panama have inquired as to membership. This issue of the newletter contains the most recent list of contact information.

ITSU OFFICERS MEETING, Honolulu, Hawaii, 6-10 December 2005

The ITSU Officers meeting was held 6-10 December in Honolulu, Hawaii. The meeting was hosted by the ITIC, and attended by the ITSU Chair, Dr. François Schindelé, Vice-Chair and PTWC Director, Dr. Charles McCreery, ITIC Director, Dr. Laura Kong, ITIC Associate Director, Emilio Lorca, IOC Tsunami Programme Secretary, Peter Pissierssens, and the Chile ITSU National Contact, Captain Roberto Garnham whose country will host the XXth session of the ICG/ITSU. During the meeting, the

ITSU news, *continued.*

Officers reviewed the progress achieved by the ICG/ITSU since ITSU-XIX (29 September – 2 October 2003), identified problems encountered in the programme implementation and identified actions needed for the successful preparation of ITSU-XX, paying special attention to the limited resources available for the Tsunami Programme.

From left to right, Emilio Lorca (SHOA), Captain Roberto Garnham (SHOA), Dr. Chip McCreery (PTWC), Dr. Laura Kong (ITIC), Dr. François Schindelé (France), Peter Pissierssens (IOC), Dr. Costas Synolakis (University of Southern California).

Among the topics identified for action were

1. *the need to update the ITSU Master Plan taking into account the important components identified by the Working Group on a Comprehensive Tsunami Hazard Reduction Program,*
2. *the need to improve the real-time availability of sea level data in the Pacific through upgrades to existing systems, installation of new stations, and enabling of more frequent transmissions,*
3. *the desire to enable capability for real-time access to all sea level data by other centres through, for example, an Auto-Data Request Manager system,*
4. *the plan for the redesign and restructuring of the ITSU web site as the ITIC web site hosted in Paris,*
5. *the need for increased support and service to Central America and the Southwest Pacific who have indicated an interest in establishing sub-regional warning systems;*
6. *the need to conduct the ITSU Programme Review.*

For the programme review, the ITSU Officers met with the ITSU Review Committee Chair Dr. Costas Synolakis of the University of Southern California to identify a plan of action. The ITSU Officers also met with the Chair for the GLOSS Group of Experts Dr. Mark Merrifield, Director of the University of Hawaii Sea Level Center (UHSLC), to discuss closer coordination and collaboration with GLOSS and the UHSLC for upgrades and maintenance.

On 9 December 2005, the Officers attended the semi-annual meeting of the Hawaii Tsunami Technical Review Committee (TTRC), where the ITSU Chairman made a presentation. The TTRC is sponsored by the Hawaii State Civil Defense as the statewide all-stakeholder tsunami coordination committee.

The Summary Report can be found at *http://ioc3.unesco.org/itic/files.php?action=viewfille&fid=290&fcat_id=193*.

CENTRAL AMERICA

On the Pacific Coast of Central America, The Centro de Coordinación de la Prevención de Desastres Naturales en América Central (CEPREDENAC), the regional disaster reduction organization for Central American, with support from ITIC, hosted a workshop April 25-27, 2005, in Managua, Nicaragua. The meeting brought together technical experts from the seismological and hydrometeorological fields, civil protection and emergency management personnel, representatives from education and capacity building institutions, telecommunications, and cooperating agencies, to discuss and identify further action towards the implementation of the Regional Tsunami Warning System for Central America on the Pacific Coast that was elaborated upon after the ISDR Hemispheric Consultation on Early Warning in Guatemala in 2003. For success, inter-ocean coordination will need to occur between the Caribbean and Pacific systems with countries that share both oceans. Coordination amongst the technical agencies and national disaster management organizations continues to be challenging in this region where funding has been minimal.

Tsunami impact broke apart structures and buildings, generating floating debris (including cars) which then acted as an additional damage-causing mechanism as the moving water flooded further inland. (Photo courtesy of K. J. Elwood, Dept of Civil Engineering, University of British Columbia, and M. Saatcioglu, Dept of Civil Engineering, University of Ottawa.)

ITSU news, *continued.*

SOUTHWEST PACIFIC

For the southwest Pacific Ocean, the IOC's ICG/ITSU and SOPAC continue to build upon the work programme developed during the South Pacific Tsunami Awareness Workshop in 2004. Priorities are for the establishment of a sub-regional tsunami warning service for the seismically active southwest Pacific, and for the urgent need for disaster managers to develop, implement, and exercise national tsunami response plans and build capacity in disaster prevention to mitigate future losses. To support the warning service, Australia has announced USD $2 million for technical capacity building. Of particular note, however, is that despite its proximity to the Indian Ocean and the known fact that more than 80% of the observed tsunamis occur in the Pacific, no significant investment beyond that offered by Australia has been identified to target proactive tsunami risk reduction of SIDS member states. *(See related article on SOPAC Regional Planning Meeting, and USA increases in support for the Pacific.)*

UNITED STATES

In June, the U.S. Congress appropriated $857 million for relief and reconstruction activities in the tsunami-affected Indian Ocean region. Of that, $16.6 million will be devoted to tsunami early warning and disaster response, divided among the U.S. Agency for International Development (USAID), National Oceanic and Atmospheric Administration (NOAA), U.S. Trade and Development Agency, U.S. Geological Survey (USGS), and the Forest Service of the U.S. Department of Agriculture (USDA). Plans address key components to an ideal tsunami warning and response system including risk assessment; detection; warning; response plans; and an informed and ready public, and ask NOAA to coordinate U.S. efforts both domestically and internationally.

To strengthen its warning systems that provide services in the Pacific, Caribbean, Atlantic and Indian Ocean, the U.S. will also commit $37.5M to improving tsunami monitoring systems by mid-2007. NOAA will receive $24M and the USGS will receive $13.5M over a two year period. This includes $22.6M ($14.5M for NOAA and $8.1M for USGS) included in an Emergency Supplemental in FY 2005 and an increase of $14.9M ($9.5M for NOAA and $5.4M for USGS) in the FY 06 President's Budget.

ITIC Director, Laura Kong with former ITSU Chair (1976-1984) Gerhard Dohler, who was vacationing in Hawaii just after the tsunami.

Plans call for improving the capacities of both US NOAA operated tsunami warning centers (PTWC and WC/ATWC) through the addition of more staff. Additionally, 32 Deep Ocean Assessment and Reporting of Tsunamis (DART) buoys will be deployed in the Pacific and the Caribbean/Atlantic/Gulf region, and 38 new sea level stations will be installed for sea level/tsunami monitoring. In 2005, WC/ATWC began transmitting tsunami bulletins to the Atlantic and Gulf Coast region. The U.S. has met with Canada to coordinate tsunami warning services to Canada's eastern seaboard in the near future.

The United States Geological Survey (USGS) plans to enhance its seismic monitoring and information delivery of data from the Global Seismic Network to improve earthquake detection, with increased focus on upgrading the network and communications infrastructure in the Caribbean; altogether 20 stations will be upgraded. Funding is also available for additional research on tsunami forecast modeling and inundation mapping and preparedness, including the assessment of vulnerable inner coastal areas, improvement in response capacity through enhanced emergency warning systems, development of robust community response plans, and an increase in public education programs.

The U.S. National Tsunami Hazard Mitigation Program (NTHMP) is currently expanding its membership from the five Pacific coast states (Alaska, Washington, Oregon, California, and Hawaii) to over 30 states, islands, territories, and Commonwealths. The purpose of the NTHMP is to develop and coordinate U.S. tsunami policies, budget and activities among Federal agencies (NOAA, USGS, Federal Emergency Management Agency, and National Science Foundation) and the States. For more information on the NTHMP, see *www.pmel.noaa.gov/tsunami-hazard*.

WORKSHOP AND MEETING SUMMARIES

INTERNATIONAL WORKSHOP ON TSUNAMI DISASTER MITIGATION, 17-18 January 2005 WORLD CONFERENCE ON DISASTER REDUCTION, Kobe, Japan 18-22 January 2005

Excerpts from Report of the World Conference on Disaster Reduction

The United Nations World Conference on Disaster Reduction (WCDR) was attended by more than 6,000 participants, including representatives of governments, UN specialized agencies, and other intergovernmental and non-governmental organizations. The WCDR aimed to increase the international profile of disaster risk reduction, promote its integration into development planning and practice, and strengthen local and national capacities to address the causes of disasters that hamper development in many countries. The Conference adopted three resolutions:

1. *The Hyogo Declaration;*
2. *The Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters;*
3. *Report of the Credentials Committee*

The Conference provided a unique opportunity to promote a strategic and systematic approach to reducing vulnerabilities and risks to hazards. It underscored the need for and identified ways of building the resilience of nations and communities to disasters. The scope of this Framework for Action encompasses disasters caused by hazards of national origin and related environmental and technological hazards and risks. It thus reflects a holistic and multihazard approach to disaster risk management and the relationship, between them which can have a significant impact on social, economic, cultural and environmental systems, as stressed in the Yokohama Strategy.

The Conference adopted the following definitions for use of vulnerability, and hazard:

- *Vulnerability is defined as: "The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards". UN/ISDR. Geneva 2004.*
- *Hazard is defined as: "A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation. Hazards can include latent conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards)" UN/ISDR. Geneva 2004.*

Speakers making presentations at the International Workshop on Tsunami Disaster Mitigation 17-18 January 2005. Participants included international scientists from the USA, Turkey and Japan representing universities, government laboratories and emergency response agencies.

TSUNAMI-RELATED SESSIONS

The Conference convened a number of tsunami-related sessions. In the morning of 19 January, a WCDR Thematic Session, *Promotion of tsunami disaster mitigation in the Indian Ocean – Towards establishment of tsunami early warning systems in the Indian Ocean by sharing experiences in the Pacific Ocean*, sponsored by Japan, the Asian Disaster Reduction Center, and the UNESCO IOC, was convened. The Session was chaired by Mr. K. Nagasaka (Director-General, Japan Meteorological Agency). The Session was opened by Mr. Nagasaka, and Mr. K. Matsuura (Director General UNESCO). This was followed by a keynote speech by the ITIC Director, and reports on the operation of the Pacific Tsunami Warning Center in the Pacific by Dr. C. McCreery (USA) and Japan by Mr. N. Nishide (Japan). Country reports were presented and a Panel Discussion on the possible actions for establishment and operation of tsunami early warning system was held. The Session issued a Session Report outlining actions needed to be taken urgently and over the long-term to build the tsunami early warning system in the Indian Ocean. After the session, the ITIC Director participated in a Press Conference with the IOC Executive Secretary, the IOC

WCDR, *continued.*

ITSU Technical Secretary, the and the ITSU Chair.

In the afternoon of 19 January, the ITIC Director and US NOAA PMEL Director combined to present a Keynote Speech on the US National Tsunami Hazard Mitigation Program and International Tsunami Hazard Mitigation Program in a WCDR Public Forum *Symposium on Sea Coast to Reduce the Impact of Tsunamis*, sponsored by National Association of Sea Coast Associations, Japan Society of Civil Engineers, and the Japan Government. The official launch of the International Early Warning Programme – IEWP was held in the evening; the event was organized by UN-ISDR with partner organizations (WMO, UNESCO, World Food Programme) providing introductions regarding their activities.

From left to right, ITSU Chair Dr. François Schindelé, ITSU Tsunami Programme Secretary Peter Pissierssens, and IOC Executive Secretary Dr. Patricio Bernal.

On 20 January, the Conference held a special session entitled *Indian Ocean Disaster: Risk Reduction for a Safer Future*. Remarks were made on early warning systems and preparedness, international emergency response, lessons learned and of the importance of transition within a risk reduction framework, and followed by a short review of country experiences and perspectives, and common outcome statements made by Member States, Organizations, and Observers. At the conclusion of the special session, the Conference issued a *Common statement of the special session on the Indian Ocean disaster: risk reduction for a safer future*.

On 21 January, a WMO/JMA Public Forum Workshop *Reducing Risks of Weather, Climate and Water extremes through Advanced Detecting, Monitoring, Early Warnings and Opportunities of Information Society* was convened. The ITSU Chair Dr. François Schindelé gave a presentation on the state of tsunami science and early warnings, including the technical components of tsunami monitoring in which geophysical and space-borne data can be used for tsunami detection and evaluation. On 21 January, the PTWC Director gave a presentation on tsunami people-centered early warning systems in the session *People-Centered Early Warning Centres*.

On 22 January, the ISDR and IOC convened an ad-hoc *scoping* meeting of national representatives, UN organizations and experts to assist in the coordination of the many initiatives being started or being planned to develop tsunami early warning systems, with particular reference to the countries of the Indian Ocean region, but also with reference to the need for more effective tsunami early warning systems globally. The Session was chaired by the Salvano Briceno, ISDR Director, and Dr. Patricio Bernal, IOC Executive Secretary. The session featured presentations by the ITIC Director on national early warning systems, including operational and institutional components, and mechanisms for regional and international support and coordination, and by the ITSU Technical Secretary Peter Pissierssens on the role of the IOC and its proposal for governance, capacity building and technical warning system implementations based on its Pacific experiences. During the meeting, the ITIC Director, PTWC Director, and ITSU Chair held extensive discussions with their UNESCO IOC colleagues to further develop the plan of action for the Indian Ocean Tsunami Warning System.

Prior to World Conference, the ITIC Director and PTWC GIC participated in the International Workshop on Tsunami Disaster Mitigation 17-18 January sponsored by the Japan Port and Airport Research Institute. During the Symposium, the ITIC Director chaired the Special Session on Indian Ocean Tsunami, gave a presentation entitled *Risk Reduction Initiatives in the Pacific: Regional Tsunami Warning Systems and Frameworks for Effective Emergency Response*, and participated as part of the Discussion Panel.

Tsunami arrival times can be estimated by looking for clocks which stopped working upon tsunami impact, Banda Aceh, Indonesia. (Photo courtesy of George Plafker, Pacific Gas and Electric).

CHINA-ASSOCIATION OF SOUTHEAST ASIAN NATIONS (ASEAN) WORKSHOP ON EARTHQUAKE-GENERATED TSUNAMI WARNING, Beijing, China, 25-26 January 2005

The China-Association of Southeast Asian Nations (ASEAN) Workshop on Earthquake-Generated Tsunami Warning was held in Beijing on 25-26 January 2005 as a follow-up action to the Special ASEAN Leaders' Meeting on Aftermath of Earthquake and Tsunami in Jakarta, Indonesia on 6 January 2005 to help ASEAN countries to establish a strong earthquake and tsunami warning network. The Workshop aimed to exchange experiences and lessons learned from the Indian Ocean tsunami disaster, exchange information on the technology of tsunami warning, and explore ways to carry out joint activities in the field of tsunami early warning through earthquake monitoring. The ITIC Director represented the IOC of UNESCO, providing briefings on the IOC's Tsunami Programme, the operations of the Pacific Tsunami Warning Center, and the IOC Action Plan for the Development of the Indian Ocean Tsunami Warning System, as well as closing remarks at the end of the workshop.

The meeting discussed the needs and priorities of ASEAN nations, and included participation from

ITIC Director Dr. Laura Kong and USGS Seismologist Walter Mooney discuss the need to identify new operational methods to be able to determine the magnitude of great earthquakes in near real-time.

Opening ceremonies of China-ASEAN Workshop on Earthquake-Generated Tsunami Warning.

Indian Ocean countries and other experts, including representatives from Australia, China, India, Japan, Korea, Maldives, Seychelles, Sri Lanka and the USA (USGS, IRIS, Columbia University). Organizational representatives were present from the ASEAN Secretariat, UN/OCHA, UN/UNESCO, UN/ESCAP, UN/ISDR, UN/WMO, Asian Disaster Preparedness Center (ADPC) and Asia Seismology Commission (ASC).

The Meeting endorsed an *Action Plan to Formulate the Technology Platform for Earthquake-Generated Tsunami Warning System*. The Action Plan included the establishment of a warning system in the Indian Ocean and the Southeast Asian Region, establishment of the Asian Regional Seismographic Network (ARSN), and the support by China for capacity building and provision of earthquake information.

WMO MULTIDISCIPLINARY WORKSHOP and GTS EXPERT MEETING ON THE EXCHANGE OF EARLY WARNING AND RELATED INFORMATION INCLUDING TSUNAMI WARNINGS IN THE INDIAN OCEAN, Jakarta, Indonesia, 14-18 March 2005

Left to right, delegates from Germany, Japan, China, Indonesia and the ASEAN Earthquake Information Center, and Australia.

The WMO held a multi-disciplinary workshop to address the immediate needs for national meteorological services to provide tsunami warnings in the Indian Ocean. The ITIC and PTWC Directors attended. The ITIC Director, as the IOC representative, made two presentations, one summarizing the outcomes of the 1st IOC International Coordination held the previous week, and the second on the planned IOC GLOSS sea level station upgrades in the Indian Ocean and the IOC's vision for the global implementation of a tsunami warning and mitigation system. The PTWC Director made a presentation providing guidance on the design and implementation of national tsunami warning centers. During the Expert GTS meeting, the PTWC Director chaired the Ad Hoc Working Group on the Technical GTS Requirements for Tsunami Warning Centers; specifically, the group, which included the Director of the JMA Tsunami Warning Center and representatives from Australia, specified a minimum requirement for sea level data of 15-minute transmissions of 1-minute sampled data. The Expert

WMO, *continued.*

meeting resulted in the identification of weaknesses in the IO GTS for strengthening in the next 6-12 months to ensure timely tsunami warnings (e.g., receipt within two minutes), and identified as a priority the implementation of satellite broadcast capability of tsunami warning messages as a means of ensuring timely receipt of the information.

During the meeting, as a representative of the IOC, the ITIC Director met with Head of the Gravity Field and Tidal Division of the National Coordinating Agency for Survey and Mapping (BAKOSURTANAL) to discuss the proposed installation of new GLOSS Sea Level stations in Indonesia that were previously planned by NOAA and the IOC, and to further discuss upgrades to other GLOSS sites for real-time data transmission for tsunami monitoring. The meeting positively facilitated the planned April visit of the NOAA-funded University of Hawaii Sea Level Center that upgraded and installed the GLOSS station at Sibolga, on the western coast of Sumatra, Indonesia.

NORTHWEST PACIFIC TSUNAMI ADVISORY CENTER, Tokyo, Japan, 10–11 March 2005

The Japan Meteorological Agency (JMA) began operations of the Northwest Pacific Tsunami Advisory Center (NWPTAC) on 28 March 2005. The NWPTAC, as an ITSU Regional Tsunami Warning Center, currently provides supplementary tsunami information to the Russian Federation, Republic of Korea, China, the Philippines, Indonesia and Papua New Guinea for events in and around Japan and the northwest Pacific. Further expansion of its services is being considered for the future. A technical meeting was convened from 10-11 March 2005 in Tokyo with representatives from each country, and the PTWC and ITIC, to assist in the smooth start-up of the services.

The NWPTAC is the result of discussions within ICG/ITSU since 1978 requesting the establishment of regional tsunami warning centers in tsunami hazardous regions. At the 14th Session of the ICG/ITSU (Tokyo, 1993), the Republic of Korea proposed to Japan to initiate a regional center for the Northwest Pacific region, and at the 17th session of the ICG/ITSU (Seoul, 1999), JMA proposed to provide tsunami information for earthquakes in Japan Sea to Russia and the Republic of Korea starting in January 2001. In addition, JMA had been requested to expand to include the Yellow Sea coast, the East China Sea coast, and the Northwest Pacific Ocean region in its region of responsiblity. With the start of the NWPTAC, Japan has fulfilled Member States' requests to provide regional tsunami warning services for the northwest Pacific.

NWPTAC provides user friendly and regionally tailored advisory messages which include tsunami height forecasts. The NWPTAC issues its message as a supplement and in conjunction with the tsunami bulletins of the PTWC, but the messages are advisory only since it should be the responsibility of each nation to take actions to alert its own citizens and to announce evacuations if they are justified. Detailed operations of the NWPTAC are described in the Communication

Kick-off meeting participants viewing the NWPTAC services in the JMA Tsunami Operations Center. From left to right, sitting, Lawrence Anton (Papua New Guinea), Dr. Bart Bautista (Philippines), Dr. Tatiana Ivelskaya (Russia), Dr. Han, Se-Sub (Republic of Korea), Dr. Wu Shahua (China), D, Masashi Kiyomoto (JMA), Dr. Lan Youchang (China); Standing, Tatsuo Kuwayama (JMA), Dr. Prih Harjadi (Indonesia), Takafumi Amano (Japan Weather Association), Dr. Kiyoshi Sakuma (JMA), Masahiro Yamamoto (JMA TWC Director), and Naohia Koidei (JMA).

Plans for the Tsunami Warning System in the Pacific, which is being revised and will be reissued in October by the PTWC.

The NWPTAC issues messages only when it detects a shallow earthquake of M6.5 or greater occurring in its coverage area. The NWPTAC determines the location and magnitude of an earthquake using data from global and Japan national seismological networks. The NWPTAC evaluates the earthquake's tsunamigenic potential, and estimates tsunami height and arrival time for the forecast points using JMA's tsunami forecast system based on numerical tsunami simulation techniques and at forecast points agreed by ICG/ITSU. In the case of deep earthquakes, the NWPTAC will not be issue a message even through PTWC will issue an information bulletin since the event is not tsunamigenic. When the location or/and magnitude of the earthquake is re-estimated using additional seismic data and/or an unexpectedly severe tsunami is observed, the NWPTAC will issue a revised message.

NWPTAC, *continued.*

The NWPTAC advisory will contain focal parameters (origin, epicenter, name location, depth, magnitude), tsunamigenic potential evaluation, estimated height and arrival time of tsunami, and observations of tsunami. Dates and times are given in Coordinated Universal Time (UTC). The NWPTAC evaluates tsunamigenic potential of the earthquake occurring in the sea for earthquakes with depths of less than 100 km, according to the following criteria:

M > 7.8 Possibility of an ocean-wide destructive tsunami

7.8 ≥ M > 7.5 Possibility of destructive regional tsunami within 1,000km of the epicenter

7.5 ≥ M > 7.0 Possibility of destructive local tsunami within 100km of the epicenter

7.0 ≥ M > 6.5 Very small possibility of destructive local tsunami

The NWPTA is to be provided primarily via the GTS, though e-mail and facsimile are also considered depending on the circumstances of the recipient countries. The NWPTAC will conduct a communications test approximately on a quarterly basis to verify that communications links to recipient organizations are functioning properly.

PACIFIC TSUNAMI AWARENESS KIT, Kihei, Hawaii, USA, 9-12 May, 2005

The Pacific Tsunami Awareness Kit (TAK) project is a joint effort of the South Pacific Applied Geoscience Commission (SOPAC), the Pacific Disaster Center (PDC), and the IOC ICG/ITSU. The Project will provide national disaster management offices of Pacific Islands with an informational kit that can be used to brief stakeholders, government officials, and communities on the potential impacts and hazards resulting from tsunamis. The kit will also provide information that a community can use both to respond to a tsunami, and to lessen its vulnerability to the destructive impacts of tsunamis. A joint design committee consisting of representatives from the PDC; PTWC; ITIC; SOPAC; SOPAC member countries (Fiji, Papua New Guinea, and Vanuatu); and the University of Hawaii, Hilo, has been formed to oversee the development of the kit.

The Tsunami Awareness Kit (TAK) is to be composed of products including maps, booklets, checklists, brochures, reference materials, and visualizations or movie clips. Kit materials will be both general in nature, applicable to all geographic regions, and country-specific for the cases of hazard maps, event history, emergency procedures, and warning. Country-specific materials will require development by the individual nations. Government officials and stakeholders, emergency management personnel, and the general public are identified to be the primary user groups of the TAK.

On 9-12 May 2005, the PDC hosted a review and evaluation meeting attended by representatives from Papua New Guinea, Fiji, Vanuatu, the PTWC, the ITIC, and the University of Hawaii, Hilo. At the meeting, committee members shared and reviewed available materials, and developed a list of recommended information sources. A sample Tsunami Awareness Kit for Fiji was compiled and presented at the 12th Regional Disaster Managers Conference, Madang, Papua New Guinea, 6-8 June 2005, and at the SOPAC Enhancing Early Warning Systems for the Pacific Island Countries Regional Planning Workshop 5-6 September 2005.

Fiji's Lasarusa Vuetibau, Senior Seismologist and Tsunami Coordinator, at work in the Seismological Laboratory of the Mineral Resources Department of Fiji. Fiji's Tsunami Awareness Kit (TAK) is being used as template for other countries.

ASIA PACIFIC ALL HAZARDS WORKSHOP: REALIZING TSUNAMI AND DISASTER RESILIENCE THROUGH NEW PARTNERSHIPS AND TECHNOLOGIES Honolulu, Hawaii, USA, 6-10 June 2005

This Workshop Executive Summary was provided by the sponsoring agencies. ITSU Member States Australia, China, Indonesia, Malaysia, Mexico, Philippines, Russia, Singapore, Thailand, USA, Vietnam, and SOPAC participated. The ITIC Director was represented the IOC and provided a Progress on the Indian Ocean Tsunami Warning and Mitigation System. The ITIC Director also made a presentation on behalf of the UN International Strategy for Disaster Reduction. The IOC GLOSS programme was represented by the University of Hawaii Sea Level Center.

The U.S. Trade and Development Agency (USTDA) and the National Oceanic and Atmospheric Administration (NOAA), in partnership with the Asia-Pacific Economic Cooperation (APEC) and with the cooperation of other U.S. government agencies, conducted the Asia Pacific All Hazards Workshop on June 6-10, 2005 in Honolulu, Hawaii. The Workshop brought policy and

All Hazards, *continued.*

technical representatives from Indian Ocean Region economies impacted by recent tsunami and earthquake disasters together with leaders from major international organizations, private industry solution providers, and donor economies in an effort to assist them in preparing for future natural disasters and other hazards through the development of regional end-to-end, all-hazard disaster risk management systems.

The Workshop's 179 registrants included representatives from 16 out of 21 APEC member economies and three other tsunami-impacted countries. Seven non-governmental/international organizations also participated, including the World Meteorological Organization and the Intergovernmental Oceanographic Commission, both United Nations agencies. United States participation spanned nine federal agencies and five states, plus several private-sector solution vendors.

The Workshop agenda was designed to advance APEC's *Strategy on Response to and Preparedness for Emergency and Natural Disaster*, which emphasizes the leveraging of APEC's high-level political commitment, multi-sector participation, and regional reach to enable member economies to recover from recent tsunami and earthquake disasters while preparing for future mishaps. Complementing the APEC strategy, the Workshop themes focused on designing and implementing a vertically (local-national-regional) and horizontally (end-to-end, all-hazard) integrated approach to data collection, forecasting, warning dissemination, and protective action that is not only technically viable but also sustainable over the long term.

The Workshop agenda included conceptual and technical presentations on the elements of such an approach; a showcase of best practices that have successfully been used to reduce loss of life and property in the U.S. and elsewhere by means of early warnings, trusted and accurate forecasts, and related capabilities; and an overview of appropriate technology solutions such as tide gauges, buoys, and modeling and warning systems that are available from both public- and private-sector providers. The fourth and fifth days of the Workshop featured a round-robin series of one-on-one meetings that provided a structured environment in which delegates could interact closely with donor agencies, solution providers, and – perhaps most important – one another to explore ways in which they might augment their own capabilities in the context of regional cooperation. These meetings

Tsunami waves carried barge and boat far inland in Banda Aceh, Indonesia. (Photo courtesy of K. J. Elwood, Dept of Civil Engineering, University of British Columbia, and M. Saatcioglu, Dept of Civil Engineering, University of Ottawa).

also provided valuable opportunities for discussion of potential partnerships with the private sector and with international/intergovernmental organizations such as the World Meteorological Organization and the Intergovernmental Oceanographic Commission as well as discussion of the U.S. Government's role in supporting interoperability, system and data standards, and inter-organizational coordination in the development of all-hazards, end-to-end disaster risk management systems in the Region.

In addition to information sharing, the Workshop provided a venue for the U.S. Government to validate and refine its strategy for providing interoperable and sustainable early warning systems and other recovery and preparedness assistance to the Indian Ocean Region. Delegates were universally receptive to the all-hazards, end-to-end concept and exhibited a strong willingness to work collaboratively in a regional context. NOAA and USTDA conducted one-on-one meetings with the delegations from India, Indonesia, Maldives, Sri Lanka, and Thailand, identifying unmet needs in the areas of human resources, systems and equipment, data, and direct financial aid that currently hinder the implementation of risk management strategies in their countries. Based on each country's expressed needs, NOAA, USTDA, and the U.S. Agency for International Development (USAID) committed to providing U.S. assistance in the form of technical and programmatic consultation, capacity building, and multilateral coordination support. Subsequent U.S. Government action is expected to comprise tailoring and delivering a package of assistance to each country as appropriate to ensure its success at implementing a regional end-to-end, all-hazards disaster risk management system.

SIXTH SESSION OF THE IOC SUB-COMMISSION FOR THE WESTERN PACIFIC (WESTPAC–VI), Nha Trang, Vietnam, 23-27 May 2005

The UNESCO Assistance Director General and IOC Executive Secretary Dr. Patricio Bernal, IOC ITSU Technical Secretary, Peter Pissierssens, ITSU Chair Dr. François Schindelé, and ITIC Director Dr. Laura Kong convened a special informational session on tsunamis on 24 May 2005 at the IOC WESTPAC-VI. In addressing Member States, Dr. Bernal noted the increasing level and scope of intersectorality and interdisciplinarity needed in the design and implementation of UNESCO's programmes, and noted as an example the essential contribution of the IOC GLOSS and GOOS programme to help build the Indian Ocean Tsunami Warning System (IOTWS).

Member States were informed on the IOC's tsunami initiatives in the Indian Ocean, including the provision on interim advisory information by the PTWC and JMA, and in southwest Pacific where a Tsunami Awareness Workshop was convened in cooperation with SOPAC in July 2004 to identify needs and priorities. The Southeast Asian Member States and organizations made presentations on their tsunami warning, preparedness and hazard assessment activities; these included Malaysia, Philippines, SOPAC, Asian Disaster Preparedness Center, and WAPMERR.

Dr. Patricio Bernal addressed Member States during the opening ceremonies of WESTPAC-VI, thanking the Government of Viet Nam and the Institute of Oceanography for the local hosting of the meeting.

The JMA Tsunami Warning System Director Masahiro Yamamoto informed Member States on the activities of Japan in the Indian Ocean since 26 December 2004, and its present role and future plans as a regional center providing tsunami information for the northwest Pacific. The ITSU Chair introduced discussion on tsunami preparedness in Southeast Asia and in particular noted the possible need to organize a tsunami warning system for the South China Sea. Toward these ends, Dr. Schindelé encouraged Member States to actively participate in ITSU, welcomed Malaysia and Vietnam as new members of ITSU, informed the group on the provisional agenda for ITSU-XX 3-7 October 2005, and invited all Member States to attend the meeting where southeast Asia tsunami warning and mitigation needs can be fully discussed.

TSUNAMI DEPOSITS AND THEIR ROLE IN HAZARD MITIGATION Seattle, Washington, USA, 12-15 June 2005

Convenors: Joanne Bourgeois, Dept. of Earth and Space Sciences, Univ. of Washington, 310 Condon Hall, Box 351310, Seattle, WA 98195, jbourgeo@u.washington.edu; Harry Yeh, Dept. of Civil Engineering, Oregon State University, Corvallis, OR 97331-2302, harry@engr.orst.edu; Brian F. Atwater, U.S. Geological Survey at Dept. of Earth and Space Sciences, Univ. of Washington, Box 351310, Seattle, WA 98195-1310, atwater@u.washington.edu

This workshop brought together almost 100 scientific researchers and educators, as well as government and community representatives, from 15 countries in order to advance understanding of tsunami behavior as reflected in coastal erosion and deposition—an understanding needed to define earthquake and tsunami hazards. The workshop also aimed to improve the communication of tsunami research results to potentially affected communities, for example, through conducting tsunami hazard assessments that would help to quantify recurrence intervals and size estimates of past events, and tsunami-deposit studies. Tsunami-deposit studies can also help in generating public education and awareness—an important aspect of mitigation efforts. Outcomes of the workshop included recommendations on tsunami research priorities and a brochure summary of conclusions to be distributed to policymakers. The workshop was funded primarily by the U.S. National Science Foundation, and hosted by the Department of Earth and Space Sciences at the University of Washington.

At the meeting, the ITIC Director gave a presentation on the activities of the IOC in coordinating the implementation of the IOTWS, and in particular focused on the importance of scientists freely sharing their data and post tsunami survey results with national governmental agencies. The ITIC Director further encouraged scientists to submit their data set to the ITIC who would forward the information and recommendations to the proper national authorities. Further information can be found at *http://earthweb.ess.washington.edu/tsunami2/deposits/workshop.htm*.

22nd IUGG INTERNATIONAL TSUNAMI SYMPOSIUM
Chania, Crete, 27-29 June 2005

Dr. Gerassimos A. Papadopoulos, Research Director, Institute of Geodynamics National Observatory of Athens, Institute of Geodynamics, PO Box 20048, 118 10 Athens, Greece, g.papad@gein.noa.gr

The 22nd International Tsunami Symposium, organized by the IUGG Tsunami Commission in association with the National Observatory of Athens, Greece, was a great success with the participation of 90 scientists from more than 20 countries. More than 15 participants from India, Sri Lanka and developing countries received financial support from the IUGG and the local organizing committee. A total of 86 papers were presented, 73 oral and 13 posters, covering all aspects of tsunami science, technology and risk mitigation. Four major sessions were convened, with each introduced by a keynote speaker; (a) Mediterranean Sea Tsunamis, (b) The Indian Ocean Earthquakes and Tsunamis, (c) Tsunami Technology and Society, (d) On 29 June, a Symposium field-trip was organized to the coastal site of Phalasarna, northwest Crete, where archaeological and geological evidence exists about the large historical earthquake and tsunami of 21 July 365 AD. A pre-Symposium tour on 26 June visited the famous Minoan (2nd millennium BC) palace of Knossos, the archaeological museum, and the coastal Minoan settlement of Amnissos, to understand better the archaeological and geological evidence about the large pre-historical (~1630 BC) Minoan tsunami, its generation from the collapse of the volcanic cone of Santorini, and its possible link with the decline of the Minoan civilization. Symposium papers will appear in two special issues of international journals of *Annales of Geophysics* for papers about European tsunamis, and *Pure and Applied Geophysics* for Indian Ocean Tsunami and other topics. Further information can be found at *http://www.gein.noa.gr/English/tsunamis.htm*.

IUGG TSUNAMI COMMISSION BUSINESS MEETING
Chania, Crete, 28 June 2005

Dr. Kenji Satake, Chairman, IUGG Tsunami Commission, Active Fault Research Center, GSJ/AIST, National Institute of Advanced Industrial Science & Technology, Site C7 1-1-1 Higashi, Tsukuba 305-8567 JAPAN, kenji.satake@aist.go.jp

The IUGG Tsunami Commission (TC) convened on 28 June 2005 with 18 members present in addition to observers from the 22nd International Tsunami Symposium; five new members were welcomed. The Chair reported on activities since the last meeting in 2003, noting that the IUGG has sponsored tsunami-related meeting, conferences, and workshops, published its proceedings, coordinated tsunami-related projects, interaction with the IOC and other IUGG official bodies, and support information and data exchange.

Specifically, the IUGG jointly organized the Joint IUGG/TC-ICG/ITSU Workshop, *Tsunamis in the South-West and Central Pacific - Research Towards Preparedness and Mitigation*, 26-27 September 2003 in Wellington, and published in June 2005 through Springer publishers a book entitled “Tsunamis: Case studies and recent developments” containing 20 papers from the 2003 IUGG Tsunami Symposium. IUGG funding then supported the purchase of 73 copies of the book for distribution to various tsunami warning centers at the ITSU-XX; ITIC received the remaining copies for further distribution to national governments. In 2005, the IUGG sponsored the 2005 Tsunami Symposium (*see related article*), and will publish proceedings.

The IUGG/TC has organized three Working Groups to compile information on the 2004 Indian Ocean Tsunami. Drs. Viacheslav Gusiakov, Ahmet Yalciner, Koji Fujima, and Jose Borrero will work to compile tsunami measurements. Drs. Alexander Rabinobich, S.I. Iwasaki, and Frank Gonzalez will work to compile tsunami instrumental data from sea level gauges, and Drs. Emile Okal and Vasily Titov will work to compile tsunami satellite data. Data formats will be jointly agreed upon, and data requests will be asked for through the Tsunami Bulletin Board. The collected data will be compiled and made available to the community, and available for archive at the World Data Center/National Geophysical Data Center. Collaborative data collection is being pursued with by the San Diego Supercomputer and Oregon State University (*see related article)*.

Structural damage to due to scour (Harry Yeh, Oregon State Univ.)

JAPAN & HAWAII STUDY TOURS ON NATIONAL TSUNAMI WARNING AND MITIGATION SYSTEMS, Japan, Hawaii, July 2005

Two study tours on national tsunami warning systems were conducted in Japan (11-14 July 2005) and Hawaii (26-29 July 2005) for high level administrators responsible for tsunami warning activities. The study tours presented information on the Japan and Hawaii systems, and complemented information received by participants of the JICA training held 7-18 March 2005 and the Japan *Mission on Policy Dialogue for High Level Administrative Policy Makers* held 22-24 February 2005 in Tokyo, Japan. Altogether experts from 22 of the 26 Indian Ocean countries participated in the tours organized jointly by the Intergovernmental Oceanographic Commission (IOC/UNESCO) and the International Strategy for Disaster Reduction (UN/ISDR). In Hawaii, the IOC ITIC organized and hosted the meeting, and in Japan, the Cabinet Office of Japan (CAO) and Asian Disaster Reduction Center (ADRC) organized and hosted the meeting. Additionally, the World Meteorological Organization (WMO) contributed their expertise to the Study Tours. Funding was provided through the UN/ISDR Flash Appeal project *Evaluation and Strengthening of Early Warning Systems in Countries Affected by the 26 December 2004 Tsunami in South East and South Asia* (UN Flash Appeal Project TSU-REG-05/CS06-REGION). ITSU Members Australia, Indonesia, Malaysia, Singapore, and Thailand participated.

Tsunami Center Director Masahiro Yamamoto describes operations. Seismic and tsunami data are projected onto large screens allowing staff to see all the information that is available at once.

The main purpose of the study tours was for high level administrators responsible for tsunami warning activities in Indian Ocean rim countries to acquire, through the comparison of different types of systems in Hawaii and Japan, the necessary judgment and methods of assessment to identify the components of the national tsunami warning and mitigation system that need to be built or strengthened; these include the following:

- *Establishment of a tsunami early warning mechanism in each country that includes an effective communication system for the warning announcement and coordination and response mechanisms for ensuring understandable risk*

Participants of the Japan Study Tour taken during the visit to JMA. ITSU Member States of Australia, Indonesia, Malaysia, Singapore, and Thailand participated. Not shown-- ITIC Director and Deputy Director.

STUDY TOURS, *continued.*

communication;

- *Identification and publicizing of high risk areas, and the development of national tsunami response plans;*
- *Promotion of knowledge about tsunami to achieve a prepared public.*

Japan and the USA, and specifically the state of Hawaii, have mature operational tsunami warning and mitigation systems along with experts that can share their knowledge and guidance gathered from decades of practice.

The study of the two systems provided participants with examples of two types of systems implemented to meet different tsunami warning requirements. Japan's system can be viewed as appropriate for nations with a high level of national tsunami hazard, where a large monitoring system comprised of densely-spaced, real-time instrumentation to determine exactly earthquake parameters is required, or for nations with long coastlines which require additional local warning centers. In contrast, the study of Hawaii's system may be a good example for small island nations, for nations wanting 'small' systems to provide baseline national monitoring, or for nations that must respond to distant tsunamis. Knowledge on and an understanding of why the solutions (instrumentation, analysis methods, message dissemination) were implemented is essential for the proper design of national systems that provide the greatest safety to its citizens.

Both study tours were coordinated to cover the same materials and topics while focusing on the specific national implementation depending on the Tour location. In this regard, the Hawaii system was covered during the Japan Tour, and the Japan system was covered during the Hawaii Tour. At the close of each Study Tour, each Indian Ocean country delegation prepared and presented a Summary of what they learned and what ideas they would take back with them for implementation.

Japan Study Tour

The Japan Study Tour highlighted Japan's long destructive history of tsunamis dating back to the 7th century. The elements of Japan's Tsunami Early Warning System include national and local government disaster management systems, coastal countermeasures against tsunamis, creation of tsunami and storm surge hazard maps, land, infrastructure and transportation mitigation practices, and community- and school-based disaster reduction programs. The Study Tour venues were the Cabinet Office of Japan (CAO) and the Japan Meteorological Agency (JMA) in Tokyo.

In Numazu, participants walked up a tsunami evacuation route to higher ground.

The Tour was opened by Mr. Takahiro Shibata of CAO, Mr, Kiyoshi Koinuma of Minstry of Foreign Affairs (MOFA), and ISDR's Reid Basher, and followed by orientation by Mr.Satoru Nishikawa of CAO and information on the international activities undertaken by the ISDR (Basher), IOC (Dr. Laura Kong), and WMO (Haleh Kootval). Japan provided a comprehensive overview of their tsunami disaster mitigation system and activities that covered its administrative system, transmission of tsunami warnings and system of evacuation, tsunami mitigation and hazard mapping, education in schools, and community-based disaster reduction. Japanese agencies making presentations were CAO, Japan Fire and Disaster Management Agency, Ministry of Land, Infrastructure and Transport, Ministry of Education, Culture, Sports, Science and Technology, and the Asian Disaster Reduction Center. Information on the Hawaii System was provided by Dr. Kong (ITIC), Brian Yanagi (ITIC), and Dr. Chip McCreery (PTWC).

On Day 2, JMA Director General Koichi Nagasaka welcomed the participants to JMA where Director Masahiro Yamamoto provided information on JMA's national tsunami, earthquake, and volcano monitoring operations center. Discussions with participants on the techniques and operations of a tsunami warning system, and the interim provision of Tsunami Watch Information for the Indian Ocean countries, involved the JMA's Noritake Nishide, Yamamoto, and Yasuo Sekita, and PTWC's McCreery.

A Field trip was taken to Numazu City in Shizuoka Prefecture to learn about community-based tsunami countermeasures, including tsunami hazard and evacuation maps, signage, routes, and shelters, warning sirens, and large water gate built to protect the Port of Numazu from tsunami waves. Specific visits were made to a Tidal Observatory, the Numazu Fire Department Headquarters and Public Works Office, and a community disaster reduction prevention center. The field trip illustrated the close coordination between agencies at all levels of government and the community that is essential for effective mitigation. On the last day,

STUDY TOURS, *continued.*

participants visited the Japan Broadcasting Corporation (NHK) to learn about the important role that the media plays in immediately disseminating earthquake and tsunami information to the public.

Hawaii Study Tour

The Hawaii Study Tour focused on tsunami warning and mitigation programs created in the United States and in particular the State of Hawaii which has a long history of impact from distant and local tsunamis. The ISDR Dr. Yuichi Ono opened the meeting reading remarks from ISDR Director Salvano Briceno and IOC Peter Pissierssens welcomed participants on behalf of IOC Executive Secretary Dr. Patricio Bernal.

Presentations were made by the U.S. National Tsunami Hazard Mitigation Program Manager Jeff LaDouce (National Oceanic and Atmospheric Administration, National Weather Service (NOAA/NWS)), NOAA Pacific Marine Environmental Laboratory Director Dr. Eddie Bernard on NOAA's deep-ocean tsunami detection systems (DART) and its Tsunami Inundation Modeling Effort project (TIME), Drs. Chip McCreery and Stuart Weinstein on NOAA/NWS Pacific Tsunami Warning Center (PTWC) operations, Dr. Walter Mooney on the U. S. Geological Survey's network and real-time analysis improvements, Bernie Kilonsky of the University of Hawaii Sea Level Center on the IOC's Global Sea Level Observing System (GLOSS), George Crawford of the Washington State Division of Emergency Management on the NOAA/NWS TsunamiReady community-based preparedness program and Washington State's All-Hazards Alert Broadcasting (AHAB) radio and siren warning system.

PTWC Geophysicist Barry Hirshorn gives a tour of the PTWC Operations Center. From left to right, Hirshorn, Sri Woro Harijono (Indonesia), Yadowsun Boodhoo and Suresh Chundre Seeballuck (Mauritius), Wills Agricole (Seychelles), Sahondrarilala Raveloarisoa (Madagascar), Prih Harjadi (Indonesia).

Haleh Kootval gave information on the activities and initiatives of the WMO. Information on Japan's system was provided by Tomoaki Ozaki (Deputy Director, Earthquake and Volcanic Disaster Management, the Cabinet Office of Japan), Akiko Nakamura (Asian Disaster Reduction Center), and Yasuo Sekita, (Japan Meteorological Agency). The ITIC Director also announced the availability of several services and products that can help national institutions immediately access tsunami monitoring data streams. (*See related article*).

Visits were made to the PTWC, the Hawaii State Civil Defense Agency where Director Ed Teixeira and his staff briefed participants on the coordinating role of the State in tsunami emergency response and the implementation of post tsunami survey plans, and the Oahu Civil Defense Agency where Plans and Operations Officer John Cummings briefed participants on the County responsibilities for evacuating people from tsunami inundation zones. On the last day, a field trip to Hawaii island was organized to visit tsunami memorials and the Pacific Tsunami Museum where Director Donna Saiki described the activities which include the collection of substantial oral histories

Hawaii Study Tour. 56 participants from 21 countries, the ADRC, IOC, the ISDR, and the WMO participated.

STUDY TOURS, *continued.*

and photos from tsunami histories and ongoing tsunami public safety and awareness programmes. The Tour ended at the Hawaii County Civil Defense where the Mayor Harry Kim, previously the County Civil Defense Director for nearly 25 years, recalled his experiences in building a system from nearly nothing and provided heartfelt encouragement to all of participants to continue to work together for success. In Hawaii, close partnerships and coordination were demonstrated at all levels of government.

Left: Participants visited the Pacific Tsunami Museum where Director Donna Saiki (right, PTM Staff Jill Sommers to left) briefed them on the Museum's history, its dedication to collect and memorialize the stories of Hawaii's tsunami survivors, and its public programs and activities to increase tsunami awareness and teach tsunami safety. Above: Oahu Civil Defense Emergency Operations Center. Government officials sitting at consoles can access the County's GIS-based multi-hazard, multi-disciplinary information system, and enter up-to-date reconnaissance reports which are immediately displayed on a large projection screen at the front. Television screens show broadcasts from a number media sources simultaneously

GLOBAL SEISMOLOGY WORKSHOP: A VISION AND PARTNERSHIP WITH GEOSS AN INTERNATIONAL WORKSHOP ON THE UTILIZATION OF SEISMOGRAPHIC NETWORKS WITHIN THE GLOBAL EARTH OBSERVATION SYSTEM OF SYSTEMS, Washington, DC, USA, 23-24 August 2005

Dr. Rhett Butler, Program Manager, Global Seismic Network, The IRIS Consortium, rhett@iris.edu, and Dr. William Leith, Coordinator, Advanced National Seismic System, Associate Coordinator for Earthquake Hazards, Geomagnetic Hazards and Global Seismograph Network, U.S. Geological Survey, wleith@usgs.gov

In February 2005, the Third Earth Observation Summit established the Group on Earth Observations (GEO), whose membership is open to all Member States of the United Nations and to the European Commission. The Group on Earth Observations has resolved that understanding the Earth system—its weather, climate, ocean, atmosphere, water, land, geodynamics, natural resources, ecosystems, and natural and human-induced hazards—is crucial to enhance human health, safety and welfare, to alleviate human suffering and to reduce disaster losses (*http://earthobservations.org/*). In a series of international meetings held since the first Summit in July 2003, GEO has defined the concept of a Global Earth Observation System of Systems (GEOSS) to provide the critical Earth observations and coordinated delivery of information from which decisions and actions for the benefit of humankind can be made. The Global Seismographic Network (GSN) and Japanese seismic networks have already been put forth by U.S. and Japan, respectively, as Observing Systems within GEOSS.

On August 23-24, 2005, the USGS, IRIS and NSF held "An International Workshop on the Utilization of Seismographic Networks within The Global Earth Observation System Of Systems". Over 50 scientists from 14 countries gathered at the American Association for the Advancement of Science in Washington, D.C., for talks and discussions on policy, in-situ networks, data managements, data products, capacity building, synergy, and science for the societal benefits encompassing the GEOSS plans.

Global seismic monitoring networks, exemplified by the Global Seismographic Network (GSN) and the member networks of the Federation of Digital Seismic Networks, offer data and infrastructure that broadly meet the goals and requirements of GEOSS, including those for standards, interoperability and open data access. The global seismological community, with over 100 years of practical service in international cooperation for global observing and data sharing, serves as a useful model for a GEOSS "community of practice". Moreover, the scientific desire to collect seismic data in remote areas often coincides with opportunities for capacity-building in less-developed nations.

Workshop participants also included representatives of other geophysical disciplines, including global geodesy, geomagnetism and infrasound. Each of these

GEOSS, *continued.*

communities has a strong potential for contributing to societal concerns and for capacity building, as well as providing essential data for scientific investigations. To varying degrees, the observing networks of these allied disciplines complement and augment seismological networks. Good opportunities for sharing infrastructure and cross-disciplinary science were recognized.

The workshop participants endorse the Federation of Digital Seismic Networks (FDSN, a Commission of the International Association of Seismology and the Physics of Earth's Interior), to represent the seismological community to the Group on Earth Observations. The FDSN is already a GEO *Participating Organization*, and represents the Global Seismographic Network and those national and regional seismographic networks that are FDSN members.

Vice Admiral (ret.) Conrad Lautenbacher, Undersecretary of Commerce for Oceans and Atmosphere and Administrator of NOAA, presents the Keynote Address on "The GEO Initiative" at the August 23-24 GEOSS Workshop in Washington, D.C. (Photo courtesy of Lew Thompson, USGS)

The workshop participants recommend that the FDSN appoint representatives of the seismological community to serve on each of the five GEOSS Working Groups (Tsunami, Capacity Building & Outreach, Architecture & Data, Science & Technology, User Interface), and encourage the FDSN to work to broaden its advocacy for the community to encompass other seismic monitoring efforts, such as strong motion monitoring and ocean-based seismic monitoring, and to collaborate with other in-situ networks in GEOSS. Other geophysical communities should make contact with GEOSS through the FDSN where appropriate, or to develop formal relations with GEOSS independently. The existing GEOSS targets in the areas of Disaster, Architecture, Data & Users, and Capacity Building that pertain to seismic networks and their products were endorsed, and prospective tasks under these targets were encouraged to be submitted to the GEO Secretariat, either via FDSN or through respective National delegations to GEO.

The GEOSS structure is largely focused on societal benefits, and there was recognition of the need to improve and expand the societal benefits derived from seismic networks—including those that come from earthquake monitoring, hazard and risk assessments, tsunami warning, and rapid damage estimation—through capacity building, research, product sharing, and product development. Discussion focused on specific tasks to further global and regional seismology within GEOSS: for example, sustaining GSN/FDSN operations and maintenance; expanding real-time telemetry capabilities and robustness for the GSN/FDSN stations; improving operational uptime and data availability of GSN/FDSN; advocating free, open access to real-time seismic data from GEOSS in-situ observing systems, facilitating data-sharing among GEOSS members; and facilitating data management coordination within GEOSS for seismological data, metadata, and products.

In addition to establishing the GSN/FDSN as existing baseline sites for global in-situ networks, and reviewing GSN/FDSN as a logistical framework for other GEOSS in-situ measurements, representatives of geophysical disciplines outside seismology were encouraged to develop similar goals and tasks within the GEOSS targets. Two additional targets were suggested to advance seismology within GEOSS: development of new, very-broadband seismometers for seismology and tsunami warning; and extending global seismological coverage into the oceans through synergy and shared logistical infrastructure with GEOSS in-situ ocean observing systems.

Dr. Patrick Leahy, Acting Director of the U.S. Geological Survey, presents the Keynote Address on "In Situ Observing Systems within GEOSS" at the August 23-24 GEOSS Workshop in Washington, D.C. (Photo courtesy of Lew Thompson, USGS)

The workshop participants expressed interest in GEO-sponsored workshops on sharing in-situ ocean observing infrastructure with seismology, and for coordinating the implementation of the Indian Ocean Tsunami Warning System. Interest and encouragement was expressed for the newly developing seismological networks in the Indian Ocean region, with hope that those not already participating in FDSN would join and adhere to its standards.

In many ways, the global seismological community, through its seismic networks, leads other sciences in developing common practices and standards, establishing worldwide real-time communications, promoting open data exchange with rapid data availability, and building integrated, multi-sensor Earth observatories. Now, independently and through collaboration with scientists from many disciplines, these vital *network characteristics* have become in large part the vision of GEOSS. It is therefore only natural that we engage with GEOSS and GEO and further that vision, with benefits to be accrued before and upon the next great earthquake.

ENHANCING EARLY WARNING FOR PACIFIC ISLAND COUNTRIES, SOPAC REGIONAL PLANNING WORKSHOP, Suva, Fiji, 5-6 September 2005

The South Pacific Applied Geoscience Commission (SOPAC) *Regional Planning Workshop on Enhancing Early Warning for Pacific Island Countries* (PIC's) sought to strengthen "all hazards" early warning systems for geological, tsunami, and hydro-meteorological hazards. The workshop was attended by technical and emergency management representatives from over ten Pacific Island Countries (PIC), including Australia, Cook Islands, Federated States of Micronesia, Fiji Islands, Marshall Islands, New Zealand, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu. The Council of the Regional Organizations of the Pacific was represented by the Pacific Islands Forum Secretariat, Fiji School of Medicine, and Secretariat of the Pacific Community. Support organizations included the Australia Marine Science & Technology, European Union, Federal Republic of Germany, International Federal of Red Cross and Red Crescent, Japan International Cooperation Agency, Pacific Disaster Centre, Pacific Tsunami Warning Centre (PTWC), UNESCO/IOC International Tsunami Information Centre, International Strategy for Disaster Reduction (UN/ISDR), Pacific Emergency Management Associates, and The Asia Foundation.

Following the Mauritius International Meeting on Small Island Developing States and the Second World Disaster Conference in Kobe, Japan in January 2005, *A Framework for Action 2005 – 2015: Building the Resilience of Nations and Communities to Disaster*, was agreed to at official levels. This Framework was comprised of six themes, one of which was to address "Effective, Integrated and People-Focused Early Warning Systems." This Framework states that effective measures for disaster preparedness should include well-functioning early warning systems that deliver accurate and understandable information in a timely manner. It also recognized the need to strengthen its early warning systems to respond to urgent needs and to respond in a manner takes into account the circumstances in PIC's and communities. This includes the need to communicate over vast ocean distances both within and between countries, and of the generally isolated populations. These systems need to be integrated into the global network supporting early warning, and vice-versa, but must also be tailored so that information remains "community-focused" and addresses all hazards.

The workshop prepared a Draft Strategy (Key National and Regional Actions) for early warning systems in which nations were encouraged to establish sustainable and effective all hazards warning systems. Significant highlights related to tsunami warning and mitigation are bold-faced. The Draft Strategy has been referred to all stakeholders for consideration and further input. The workshop requested that the SOPAC Secretariat bring the Draft Strategy to the SOPAC Governing Council meeting in September 2005 in Samoa for their consideration and support. The Secretariat would then coordinate the finalization of the Draft Strategy and its subsequent coordination and implementation.

A Draft Strategy For Enhancing Early Warning For Pacific Island Countries

(Highlights related to tsunami warning and mitigation are in bold)

45. Key National Activities
a. Established and/or strengthened institutional capacities ensuring early warning systems are integrated into governmental policies, decision-making processes and emergency management systems at both national and community levels.
Strengthen access to 'common interest' data and promote information sharing via MOUs supported by legislation, policy, regulations, as necessary, and the adoption of regional and international best practices where available.
Emergency response plans supported by Standard Operating Procedures for all hazards developed and integrated into national development plans, and with provisions for regular testing and exercising.
Develop and adopt national symbology, signage and terminology including map scales consistent with International standards.
Develop risk maps through the completion of hazard and vulnerability assessments using the collection of bathymetry, coastline, historical and population data and ensure the NDMOs and other stakeholders have the capacity to use these information products.
Develop and strengthen where necessary national technical services to support early warning systems.
Develop and strengthen initiatives to extend communications to remote and rural areas including supporting initiatives that are exploring new means of extending communications to remote isolated areas, focusing on approaches that use common commercially available systems where possible.

SOPAC PICs, *continued*

Develop and strengthen co-ordination with Hydrographic Offices, Transport and other relevant government, NGOs, and Red Cross.
Strengthen National and Local level response to optimise disaster preparedness, mitigation, and especially targeting the most vulnerable communities as well as new residents and development sectors (tourism, local businesses).
Identify, develop and strengthen agencies responsible for flood warnings and management, including revision of development planning policies to encourage better floodplain and integrated catchment management, and acquiring necessary baseline data and instigate/improve ongoing hydrological monitoring to assist flood warning.
Recommend that PICs, who have not already done so, join IOC and WMO in order to gain benefits from hazard mitigation frameworks operating in the region.
b. Completed inventories and needs analyses of national early warning systems ensuring inputs from all stakeholders, including traditional knowledge and community needs are addressed.
Complete assessments of formal and informal national warning systems, identify gaps and prepare capacity building activities where appropriate for stakeholders at all levels.
Strengthen partnerships to monitor health, crop and animal pests and diseases, including feedback from community to extension offices of all relevant agencies and, inclusion of both technological and traditional practices, instrumental and sensory systems.
Document all forms of indigenous knowledge, skills and coping mechanisms on hazards and early warning, and integrate these into national planning.
Ensure an understanding of risk, and the use of risk assessments to refine and target warnings at all levels.
Ensure planning processes take into consideration the fact that for local tsunamis in coastal areas backed by lagoons, rivers and cliffs only tradition knowledge (+ perhaps some technology, sirens) can minimise impact.
Identify potential risk areas and create landslide susceptibility maps.
Identify needs for national river flooding EWS across region.
c. Upgraded or redesigned existing national forecasting or early warning systems to cater for major hazards.
Where relevant and applicable adopt a multi-hazard focus, for warning systems, using a dissemination system that is easily accessible, understandable and frequently used, such as traditional methods e.g. lali/drum, conch shells/horns, church bells.
Assist in the development of indicators that will identify and trigger responses to slow onset disasters, including those caused by biological, environmental, technological and other hazards.
Improve the use of appropriate, existing and new technologies such as RANET, Internet, E-mail, txt-messaging and satellites systems, in order to build redundancy in dissemination routes at all levels.
Develop and strengthen the relationship between the media, NDMOs and other response agencies.
Install basic, low-cost instrumental systems on a restricted number of the highest risk volcanoes, bearing in mind the feasibility of on-going maintenance costs and system sustainability.
Develop and strengthen agencies with responsibility for Marine Safety at national level, including the strengthening of communications between vessels in EEZs and the relevant national agency.
Improve predictions and applications of climate variability, including ENSO events, in order to mitigate their effects of changing the frequency and intensity of related hazard events.
Strengthen national seismic and sea-level observation systems as well as communication systems to facilitate the exchange of data between national and regional observatories, and enhance early warning capabilities.
d. Developed and implemented a comprehensive programme for community awareness and preparedness.
Engage all relevant organisations to develop and strengthen a coordinated public awareness programme.
Engage and support communities in the identification of their disaster related vulnerabilities and associated capacity needs.
Identify and/or work with partners to help implement hazard awareness campaigns such as the Tsunami Awareness Kit to reach diverse audiences.

SOPAC PICs, *continued*

Develop volcano-aware communities through education and awareness-raising so that they become 'front line' observers of precursory signs of impending volcanic eruptions.
Conduct regular community based disaster risk management training and workshops using an "all-hazards approach" which will include Training of Trainers for emergency response and disaster risk management.
Develop and strengthen annual national disaster awareness programmes in PICs to include multi-hazard awareness.
Improve formal and informal multidisciplinary education programmes that integrate sustainable development and hazard mitigation.
Through educational curricula and public awareness campaigns enhance awareness of coastal processes including the impacts of storms, tides, wind waves, and river floods.

46. Key Regional Activities
a. Completed inventories and needs analyses of regional early warning systems and identify priorities for improved regional early warning systems that will better support national needs.
SOPAC Council to consider its Secretariat to be strengthened as a regional Centre of Expertise and resources to support PICs in developing their early warning capacities.
Complete regional hazard/risk analysis of active volcanoes of the SOPAC region, resulting in identification of the highest risk volcanoes, including any that are not monitored currently and bearing in mind their potential for different kinds of eruptions, cone collapses, caldera formation, etc.
b. Supported the provision of regional forecasting, and early warning and monitoring systems of hazards such as tropical cyclones, droughts, flooding, storm surges, tsunamis, earthquakes and volcanic activity.
Improve the preparedness of quarantine services in PICs to respond to human, crops and animal pest and disease incursions by putting in place surveillance systems and emergency response plans.
Develop and adopt regional symbology, signage and terminology including map scales consistent with International standards.
Rather than establish a regional tsunami warning centre for PICs, existing data as well as data from new or improved observation systems should be made available to existing and developing warning centres such as PTWC to improve the performance of their operations for events in the region.
Invite PTWC and other warning centres send messages with P-wave arrival times and preliminary earthquake parameters to regional and national observatories for events in the region, from about Mw=5.7 to Mw=6.4, that are below PTWC's Mw=6.5 Tsunami Information Bulletin threshold.
PICs that do not currently receive PTWC bulletins contact PTWC and make suitable arrangements to receive and interpret these bulletins and be prepared to act on a 24/7 basis.
Create a mobile instrumental monitoring system for deployment at restless volcanoes in the SOPAC region, to be managed by the SOPAC Secretariat and maintained by an existing selected and funded national technical agency.
Enhance relationships between the volcanological agencies in the SOPAC region and the two regional Volcanic Ash Advisory Centres (Darwin and Wellington), in order to enhance volcanic eruption warnings throughout the region through the joint use of satellite data and ground observations.
Integrate the development of EWS with PI-GOOS, PI-GCOS and PI-HYCOS.
Identify the need, develop and provide storm surge/wave models where applicable in the region.
Investigate the potential of a "Coastwatch Facility" for example, NOAA's Coastwatch service on the web.
c. Integrated national and regional early warning systems into the global networks and vice-versa.
SOPAC Secretariat support regional participation in the Global Earth Observing System of Systems (GEOSS).
To continue to support and develop the Regional system for tropical cyclone monitoring and prediction that operates under the auspices of the WMO, and extends it to countries that need it.
Carry out a feasibility study on the possible use of Regional Specialised Meteorological Centre as a communications node for multi-hazard EWS service provision for the region.

TSUNAMI RECONNAISSANCE DATA PRESERVATION WORKSHOP
San Diego, California, USA, 21-22 September 2005

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The ITIC Director participated in a Tsunami Reconnaissance Data Preservation Workshop 21-22 September 2005 sponsored by the US National Science Foundation. The workshop was hosted by the San Diego Supercomputer (SDSC) and Oregon State University (OSU) to discuss the development of centralized tsunami reconnaissance data repository. Participants were from a broad range of disciplines, including the private sector, and had conducted post-tsunami surveys after the December 2004 tsunami. Project funding is being provided by the U.S. National Science Foundation through the NEES Program (Network for Earthquake Engineering Simulation) to the SDSC and OSU for implementation. The central repository will be hosted by the SDSC, and will include not only data management capabilities, but also tools for searching, exploring, analyzing and extracting data. The Information will be curated by experts, with special functions allowing the broader community to add commentary about the usefulness of data and its application in studying tsunamis and other hazards.

The objectives of the Tsunami Reconnaissance Data Repository are to:

- *Preserve key data about the Dec. 26th tsunami that would otherwise be scattered or even lost.*
- *Make data widely accessible via Web interfaces and tools. New methods will be developed for searching and presenting data in ways that make sense to non-scientists as well as specialists.*
- *Create methods and tools compatible with emerging standards, so that tsunami reconnaissance data can be linked and cross analyzed with related information from other sources.*

The site will be mirrored by the IOC at its IODE (International Oceanographic Data and Information Exchange) Project Office in Ostend, Belgium. The ITIC and the World Data Center/National Geophysical Data Center are encouraging broad usage of this facility for the archiving of tsunami data from the 26 December 2004 tsunami. Data being compiled by the IUGG Working Groups can be digitally archived by this facility. While the repository is being initially developed to archive the Indian Ocean data, it is being designed so that it can support the multi-media tsunami data preservation needs of all historical and future tsunami events. Further information can be found at *http//:www.tsunami.nees.org/workshop.php*.

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

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

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