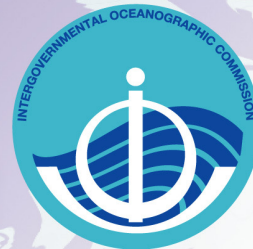


Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System



# TSUNAMI NEWSLETTER



International Tsunami Information Centre

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### Exercise Pacific Wave '06 — Philippine Drill Observed by Indian Ocean Countries

*Exercise Pacific Wave '06*, 16-17 May 2006 was the first Pacific-wide tsunami warning test ever conducted. Its foremost goal was to evaluate communication links for message dissemination. The Exercise provided scenarios for countries to choose from, to decide how they would test their systems' responsiveness in the case of a trans-Pacific tsunami. At the national levels, Tsunami Warning Focal Points were encouraged to work with local authorities and other responsible agencies, and the public, if they desired. Of the forty countries involved in the exercise, five of them chose to include the public to plan and perform evacuation drills. These were France (Papete, Tahiti), United States (American Samoa), Malaysia, Thailand, and the Philippines (Albay Province).

For example, in the Philippines, the Albay Provincial Disaster Coordinating Council (Albay-PDCC) oversaw evacuations of three *barangay* (local villages) in Albay Province, located in the southeast section of Luzon. The Philippine Institute of Volcanology and Seismology (PHIVOLCS) issued the incoming 'mock' warning messages to the National Disaster Coordinating Council (NDCC), who in turn contacted the Office of Civil Defense (OCD), which provides vital information on impending disasters to the local government units (LGUs) and regional OCD offices (RDCCs). The RDCCs relay information to the provincial (PDCC), then to the



Left: International observers were welcomed to Albay, where the exercise included evacuation of three villages. Right: Evacuation includes all members of society.

municipal or city (M/CDCC) and finally to the *barangay* (BDCC) for appropriate action.

Among those taking part in the exercise, were international observers, invited by the United Nations Development Programme (UNDP) and the IOC. The international observers were from Indonesia, the Maldives and Sri Lanka.

Because Albay Province has a high level of preparedness for frequent hurricanes and volcanic activity, it was selected as ready for a drill involving evacuation. Drill planning activities included developing local tsunami communication plans, deciding on evacuation routes, and developing community maps.

## SUMMARY OF EARTHQUAKES

Occuring May-June 2006

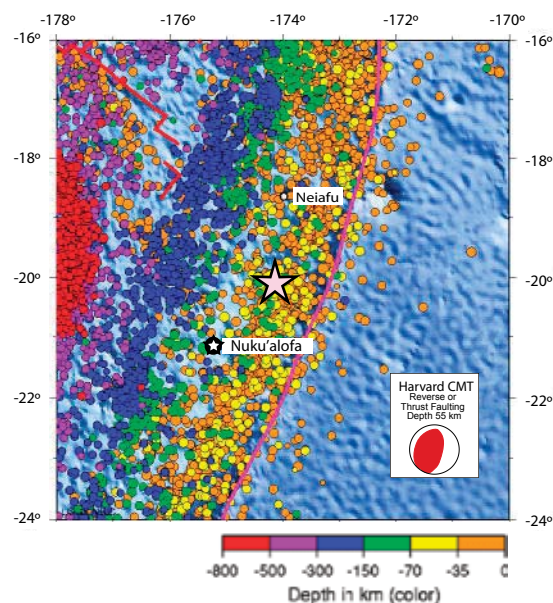
*With surface wave or moment magnitude ( $M_w$ ) greater than or equal to 6.5 and a depth no greater than 100 km, or an event for which a Tsunami Information Bulletin (TIB) or Regional Watch Warning (RWW) was issued. Epicenter, and  $M_w$  from USGS National Earthquake Information Center (NEIC, G); 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

DATE	TIME (UTC)	LOCATION	EPICENTER	DEPTH (km)	$M_w$	PTWC ACTION	ACTION TIME	TSUNAMI? DAMAGING?	Maximum height and place
3 May	15:27	Tonga	20.130° S 174.164° W	55	8.1(P1) 7.9 (G) 7.8 (P2,P3)	001 RWW 002 RWW 003 Cancel	15:42 16:33 17:39	Yes No	0.54 m Pago Pago, American Samoa and Crescent City, California
10 May	02:43	Fox Islands, Aleutian Islands, Alaska	52.515 N 169.257 W	18	6.5 (P) 6.4 (H) 6.3 (G)	TIB	02:52	No	
16 May	10:39	Kermadec Islands	31.782° S 179.307° W	152	7.5 (P) 7.4 (G,H)	TIB	10:59	No	
16 May	15:28	Nias Region, Indonesia	0.103° N 97.049° E	16	6.9 (P) 6.8 (G,H)	TIB	15:42	No	
22 May	11:12	Near East Coast of Koryakia, Russia	60.776 N 165.712 E	17	6.7 (P) 6.6 (H) 6.5 (G)	TIB	11:22	No	
28 May	03:12	New Britain Region, Papua New Guinea	5.727 S 151.139 E	34	6.7 (P) 6.5 (G, H)	TIB	03:26	No	

### TONGA 3 MAY 2006, 15:37 UTC, $M_w=7.9$

A major earthquake occurred in Tonga, about 160 km NE of Nuku'Alofa and equally far south of Neiafu. The earthquake, which happened at 4:26 AM (4 May) local time, measured 7.9 ( $M_w$ , USGS) and was felt throughout the surrounding islands. Although some damage was reported, few injuries and no deaths resulted. Steps were taken to escape a possible tsunami in Fiji and Gisborne, New Zealand.

A summary provided by the USGS National Earthquake Information Center (NEIC) lists recorded wave heights in meters (peak-to-trough) at the following selected tide stations: 0.54 m at Pago Pago, American Samoa; 0.10m at Tofino, British Columbia, Canada; 0.13 m at Raratonga, Cook Islands; 0.07 m at Suva, Fiji; 0.15 at Hanasaki, Japan; 0.48 m at Noumea, New Caledonia; 0.15 m at Jackson Bay, New Zealand; 0.42 m on Niue; 0.42 m at Apia, Samoa; 0.42 m at Nuku'alofa, Tonga; 0.13 m at King Cove, Alaska, 0.54 m at Crescent City, California, 0.35 m at Santa Barbara, California, 0.10 m at San Francisco, California, 0.49 m at Kahului, Hawaii,



*Historical seismicity with Harvard Centroid Moment Tensor Solution (CMT). The recent earthquake location is marked by a star. Map courtesy of USGS National Earthquake Information Center (NEIC).*

**Tonga, continued**

0.12 m at Portland, Oregon, 0.11 m at La Push, Washington, U.S.A; and 0.45 m at Port Vila, Vanuatu.

**US Tsunami Warning Centers Response Chronology  
May 3, 2006  
Tonga Earthquake and Tsunami**

A major earthquake occurred in the Tonga Islands (450 miles southwest of American Samoa) at 11:27 AM EDT (1527 UTC) on May 3rd, 2006. The quake was felt by the staff at the National Weather Service Office in Pago Pago and as far away as New Zealand, according to media reports. Initial magnitude was reported as 8.1, later revised to 7.8 moment, 7.7 Richter scale.

A non-destructive tsunami was detected by tide gauges in Fiji, Niue, Tonga, American Samoa, and Hawaii (including Midway). The maximum detected peak-to-peak height was 0.54 meters (21.26 inches) in American Samoa. There was no reported damage from the tsunami.

The Pacific Tsunami Warning Center (PTWC) issued Bulletin #1 for the Pacific within 15 minutes at 11:42 am EDT declaring a Tsunami Warning for New Zealand and Fiji. At 11:43 am EDT, PTWC issued Bulletin #1 for Hawaii declaring a Tsunami Watch for the State of Hawaii.

Bulletin #2 for the Pacific issued at 12:31 pm EDT included Tonga, Niue, American Samoa, Samoa, Wallis-Futuna in the Tsunami. Bulletin #2 for Hawaii issued at 12:34 pm EDT changed the watch to an advisory and estimated "a small sea level rise" in Hawaii.

Bulletins #3 canceling the warning for the Pacific and the advisory for Hawaii were issued at 1:36 pm EDT and 1:39 pm EDT, respectively.

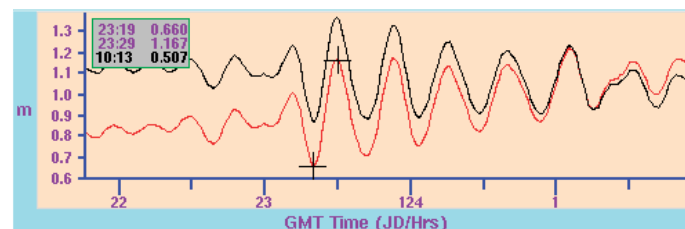
The West Coast/Alaska Tsunami Warning Center issued Tsunami Advisory Bulletins about the event at 11:43 am EDT, 12:48 pm EDT and 1:49 pm EDT. No watches or warnings were issued for their area of responsibility which included Alaska, Washington, Oregon, California and the west coast of Canada.

UTC	EDT*	Elapsed Time	Product/Event
15:27	11:27 am	0:00	Earthquake occurs
15:29	11:29 am	0:02	Samoa short period alarm alerted West Coast/Alaska Tsunami Warning Center (WC/ATWC) duty personnel
15:34	11:34 am	0:07	South Pacific regional alarm and autolocation of event in Tonga with initial magnitude 7.2 at the WC/ATWC in Alaska.
15:35	11:35 am	0:08	South Pacific regional alarm (stations CTAO and SNZO) and autolocation of event in Tonga with initial magnitude 8.2 at the Pacific Tsunami Warning Center (PTWC) in Hawaii

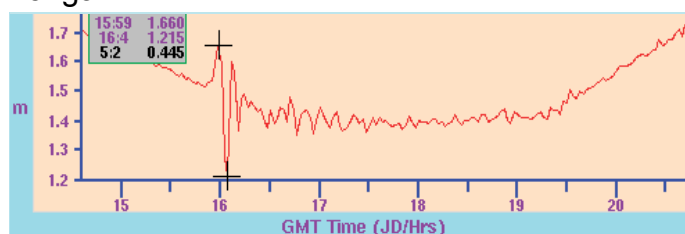
\*Eastern Daylight Time

## Water Level records from the Pacific Tsunami Warning Center (PTWC)

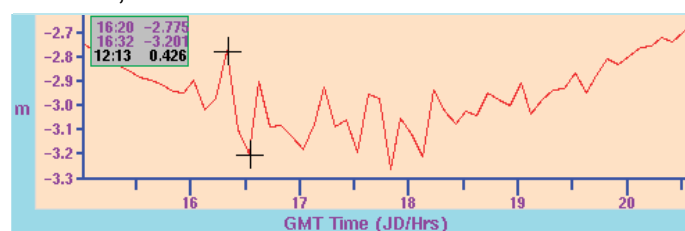
### Niue



### Tonga



### Kahului, Maui

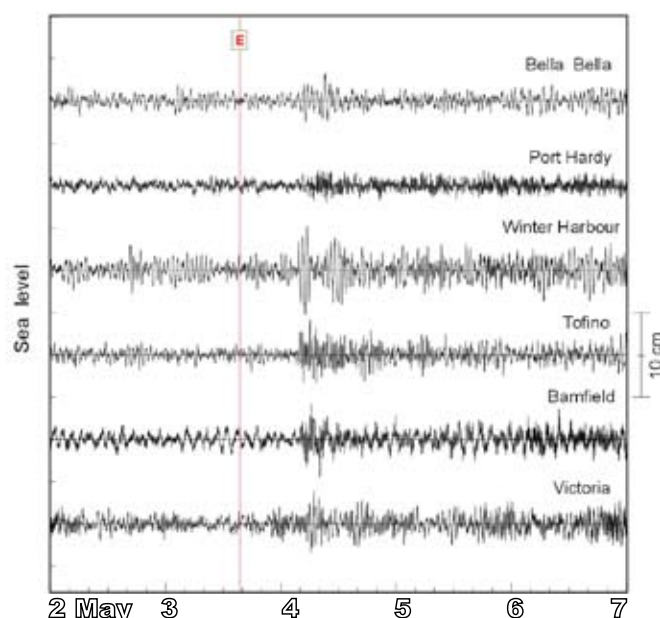


Above, Water level records provided by PTWC from Niue, Tonga, and Kahului, Maui, (Hawaii). Graphs indicate maximum peak-to-trough wave height (in metres) with elapsed time depicted.

## Water Level records from Canada

The Tonga tsunami of May 3, 2006 was clearly recorded near the coast of British Columbia as seen by the plot of the records to the right. These record the water level after high-pass filtering with 3-hour Kaiser-Bessel window and the red line indicates the time the earthquake occurred.

Stations (in British Columbia)	Arrival time UTC	Travel time	Max wave height
Bella Bella	04:16	12h 49m	5.7 cm
Port Hardy	04:15	12h 48m	3.7 cm
Winter Harbour	03:31	12h 04m	10.8 cm
Tofino	03:49	12h 22m	6.9 cm
Bamfield	04:00	12h 33m	5.6 cm
Victoria	05:17 UTC (4/05)	13h 50m	9.0 cm

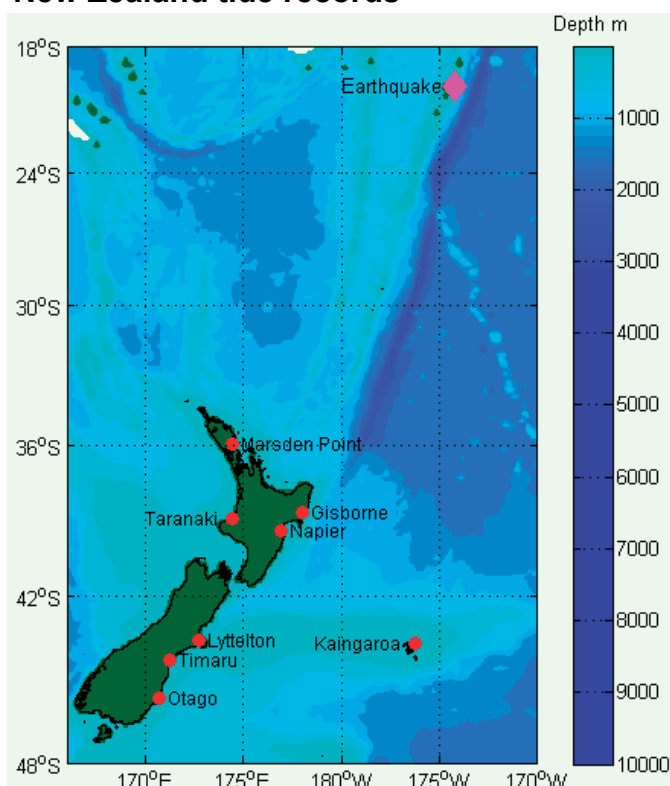


Tsunami travel time, maximum wave heights and sea level records courtesy of A. Rabinovich, Canada.



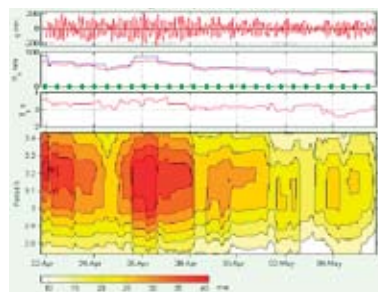
## Tonga, continued

## New Zealand tide records



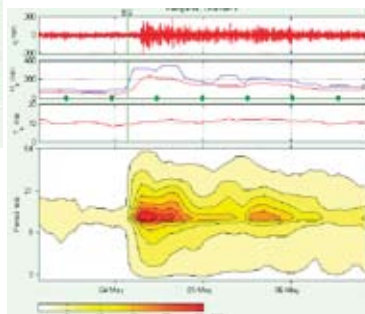
From 'Tsunami records in New Zealand' by Derek Goring, Mulgor Consulting Ltd., 24 Brockworth Place, Christchurch, New Zealand at <http://www.mulgor.co.nz>: "The direct path from the earthquake to the nearest port (Marsden Point) is only 2090 km, so we would expect the waves to arrive about 4 hours after the earthquake (07:30 NZST). In fact, the waves that arrived at Marsden Point were so small, they can hardly be distinguished from the background meteorologically generated waves (called Far Infra Gravity or FIG waves). However, the tsunami was felt at other east coast ports, though the main waves did not arrive until 12 or more hours after the earthquake, so they must have taken a roundabout route.

Subsequently, NIWA has kindly supplied data from their sea-level recorder at Kaingaroa, on the northeast tip of Chatham Island, almost due south from the earthquake location, and 900 km east of mainland New Zealand. Unlike the NZ coast sites, there is almost no continental shelf off Kaingaroa, so it receives waves from the Pacific first. In the deep ocean, the waves are travelling at up to 800 kph, but on the continental shelf, they slow to less than 250 kph."

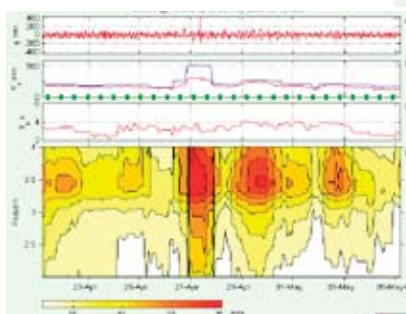


Kaingaroa  
up to  
06-May-2006 07:02  
NZST

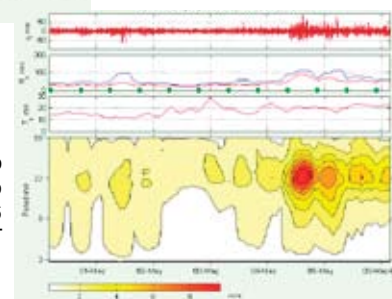
Seiche at Lyttelton  
up to 06-May-2006  
07:16 NZST



Seiche at  
Timaru  
up to  
05-May-2006  
16:15 NZST



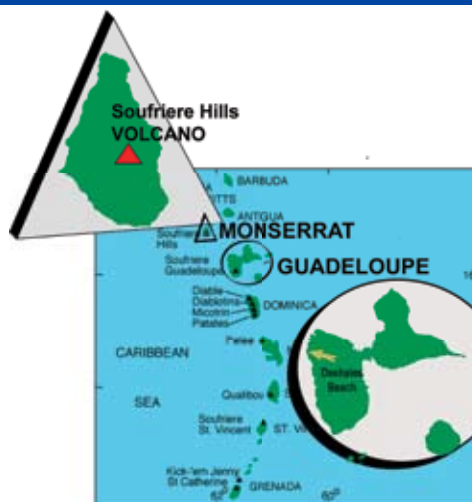
Spit Port Otago  
up to  
06-May-2006  
07:02 NZST



## DESHAIES, GUADELOUPE TSUNAMI, 20 MAY 2006, MONTserrat, LESSER ANTILLES, SOUFRIERE VOLCANO TSUNAMI

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A major lava dome collapse took place at the Soufriere Hills Volcano on the morning of 20 May 2006. A helicopter flight in the afternoon confirmed that most of the lava dome has gone, together with some remnants of the 2003 lava dome, leaving a broad, deep, eastward sloping crater at the summit of the volcano. The volume of the lava dome was believed to be about 90 million cubic meters and most of this collapsed over a period of less than three hours. Views of the western part of the crater where ash venting is continuing were not possible but it is unlikely that there is significant dome



Maps showing partial arc of the Caribbean Island chain, with enlargement of Montserrat (left) and Guadeloupe (right) where survey was made. (Base map courtesy of University of Texas Austin, Perry-Castaneda Digital Map Collection; <http://www.lib.utexas.edu/maps/>).

**Montserrat, continued**

material remaining there. The heavy rain was causing mudflows in Belham River valley at this time. By 06:32, a 1-meter high tsunami was reported from Deshaies Beach in Guadeloupe and swells were detected in Little Bay, Montserrat and at Jolly Harbour and English Harbour, Antigua.

I made a field survey the next day at Deshaies, Guadeloupe and collected information from witnesses. According to the testimonies of a fisherman who was at the beach, the effects of the tsunami were felt in the harbour of Deshaies at 7 am. He had been in calf-deep



Left: Eyewitness in his boat. Right: Deshaies Beach near the mouth of the river where eyewitness made his observations (marina in background).

water near his boat when he felt the water rising gradually to thigh-level. He saw great swirls of water at the mouth of the river and in the marina. The level of the river rose quickly to a height of approximately 60-70 cm. A strong current flowed between the river and the marina, through drainage pipes. These exchanges between the marina and the river sometimes caused drawdown in the marina roughly 1 m from the usual



Views of the lava dome as seen from a helicopter in the days prior to the collapse. Photos courtesy of the Montserrat Volcano Observatory, <http://www.mvo.ms/>.

depth of the marina at 4.5 – 5 m. This phenomenon lasted nearly an hour. Two small fishing boats moored in the mouth were slightly damaged. One sank at the river bed. The boats located in the marina were not damaged. The fishermen who were out to sea did not observe anything, nor were any of the structures damaged. Other testimonies confirmed the same observations, but none include observing the withdrawal of the sea. The height of this tsunami in this harbour is less than one meter. During this time, low-level ash clouds were drifting to the northwest of the volcano from the crater area and a steam-rich plume was rising to 6,000 ft. Unconfirmed reports suggest that pyroclastic flows first reached the sea at about 06:45. Regular pulses of pyroclastic flows were reaching the sea down the Tar River valley by 07:20 with major pulses recorded in seismic amplitude at 07:36, 07:43 and between 08:01 and 08:04. From 07:30 and 08:10 a number of long-period seismic events were detected. At 07:40, an ash cloud was reported with height at nearly 17km (55,000 ft), the highest reported ash cloud during the last ten years of volcanic activity. At 07:43, pyroclastic surges were observed spreading across the northeastern flanks of the volcano reaching the Spanish Point area.

## CIUTADELLA HARBOUR, MENORCA, SPAIN 15 JUNE 2006, RISSAGA

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On 15 June 2006 at 20:50 local time (18:50 UTC), Ciutadella Harbour, located at the end of a natural elongated inlet on the west coast of Menorca Island, the Balearic Islands, Western Mediterranean (Figure 1), was affected by the most dramatic 'rissaga' event of the last 20 years. A sudden first negative (ebb) wave of more than 4 meters was reported by local witnesses causing the catastrophic drying of a significant part

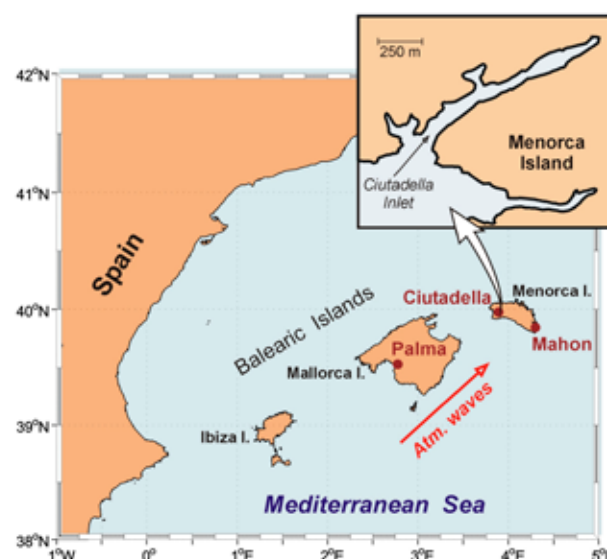


Figure 1. Map showing location of the Balearic Islands in the Mediterranean Sea with a detail of the Ciutadella Inlet on the island of Menorca.



Rissaga, *continued*

Figure 2. Series of photographs showing the wave moving through the waterway and impacting vessels; a) water retreats, stranding boats aground, b) water visually returns, c) and d) water currents toss boats in Ciutadella Harbour.

of the harbour. As a result, most of the boats in the harbour broke free from their moorings on the harbour walls and were freely dragged by the current when the water re-entered the harbour only a few minutes later. More than 40 boats were sunk or severely damaged (Figure 2) with the total economic loss estimated to be in order of tens of millions of Euros. This tsunami-like event was not produced by any reported earthquake in the Mediterranean but was undoubtedly associated with an abrupt atmospheric pressure jump passing over the Balearic Islands (Figure 3). The phenomenon could be referred to as a 'meteorological tsunami' and has repeatedly occurred in the Mediterranean (Rabinovich and Monserrat, 1996, 1998; Vilibić et al., 2004).



Figure 3. An abrupt change in atmospheric pressure recorded at Ciutadella 15 June 2006 ca.18:00 in Mahon (red line) and Palma (blue line).

'Rissaga' is a local name traditionally used by the Ciutadella citizens to refer to large amplitude seiches regularly observed in this Spanish harbour. The meaning of this Catalan word is 'drying' (similar to a Spanish word 'resaca'). Rissaga waves commonly occur in several inlets and harbours of the Mediterranean coast of Spain, however, they are most pronounced specifically in Ciutadella Harbour (Rabinovich and Monserrat, 1996). Recently, the term 'rissaga' has been internationalized and is used by some specialists to describe similar phenomena in other areas of the World

Ocean, in particular, in New Zealand (<http://www.tide-man.co.nz/DGGLWTimaru.htm>).

Ciutadella Inlet is about 1 km long, 100 m wide and 5 m deep. The natural fundamental period of the inlet (Helmholtz mode) is approximately 10.5–10.6 min. At other bays of the coast of the Balearic Islands the natural periods and the corresponding dominant periods of rissaga waves differ from 5 to 30 min. Due to the particular geometry of Ciutadella Inlet, it has a large Q-factor, which results in significant resonant amplification of longwave oscillations arriving at its mouth. Another important factor is the shape and the depth of the southeastern shelf of the Balearic Islands (Figure 1) which is conducive to the generation of intensive long ocean waves by travelling atmospheric disturbances due to 'Proudman resonance' (matching of oceanic and atmospheric wave phase speeds). Thus, the rissaga waves in Ciutadella Harbour are produced by the combination of these two resonant effects: (1) resonantly induced strong long waves propagating over the shelf and arriving at the mouth of Ciutadella Inlet; and (2) the resonant amplification of the arriving waves in the inlet itself.

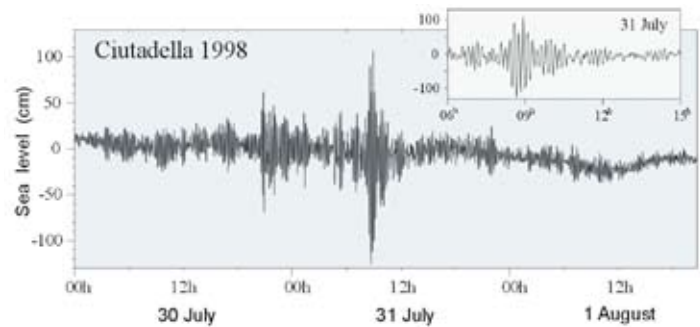


Figure 4. Recording of the 1998 seiche showing size comparative to normal tide.

Tides in Ciutadella, as is typical for the western Mediterranean, are relatively small: approximately 20 cm; consequently, the harbour structures and ropes tying the boats to the harbour walls are not designed to accommodate large sea level changes. In fact, most of the time seiches in Ciutadella are even larger than the tide (Figure 4). Significant rissaga waves (~1m) normally occur a few times per year (always in summer time); these events normally produce only some small floods in the area without additional negative consequences (Rabinovich and Monserrat, 1996). Destructive rissaga (>2 m) occur every 4–5 years. The rissaga of 21 June 1984, with wave heights of more than 4 m, was the most catastrophic event ever reported; more than 300 boats and yachts were badly damaged (Figure 5). A very similar catastrophic seiche phenomenon associated with atmospheric waves, called 'abiki' waves, is well known in Nagasaki Bay, Japan. In particular, on 31 March 1979 abiki waves with a dominant period of 35 min and wave heights up to 4.8 m killed three people and caused severe damage in this bay (Hibiya and Kajiura, 1981).

**Rissaga, continued**

The atmospheric origin of rissaga and similar waves in some other parts of the Mediterranean (for example, in the Adriatic, cf. *Vilibić et al., 2004*) is well established (cf. *Tintoré et al., 1988; Monserrat et al., 1991, 1998*). During late spring and summer the meteorological conditions in the western Mediterranean are favourable for the formation of high frequency atmospheric pressure disturbances with parameters promoting the generation of rissaga waves. These conditions include the entrance of warm air from the Sahara at near-surface levels, and relatively strong middle level winds from the SW. When this synoptic meteorological situation exists, trains of atmospheric pressure gravity waves (with periodicities in the range of minutes) are reported travelling from SW to NE (*Monserrat et al., 1991*). If these atmospheric pressure disturbances travel with a phase speed of about 22-30 m/s and a direction from SW to NE, resonant conditions are in place on the southeastern shelf of Mallorca Island and dynamic energy is efficiently transferred from the atmosphere into the ocean. This results in the generation of long ocean waves which resemble with tsunami waves. When these long waves reach the coast, they may significantly increase seiche oscillations inside the inlet/bay due to harbour resonance.

On 15 June 2006 an abnormal atmospheric pressure change was recorded on the Balearic Islands. The atmospheric pressure dramatically increased in Palma de Mallorca for almost 7 mbar in only half an hour, and more impressively, the last 5 mbar increase occurred in less than 10 minutes (*Figure 3*). This pressure jump travelled in the direction from the SW to NE, first being recorded at Palma de Mallorca (Mallorca Island) and then about 77 minutes later at Mahon (Menorca Island). Assuming the distance along the supposed wave track between these two sites is about 115 km, we get a rough estimate of wave speed as 25 m/s. As was mentioned above, this direction and propagation speed are conducive to producing the resonance response on the Mallorca shelf and the following observed extreme seiches (rissaga waves) in Ciutadella Inlet. Unfortunately, there were no working instruments (tide gauges) in this in-

let during the event, however, a typical example of the record of rissaga waves from this inlet (an event 31 July 1998) is shown in *Figure 4*. This record (as well as all other rissaga records obtained in the inlet – cf. *Rabinovich and Monserrat, 1996, 1998; Monserrat et al., 1998*) indicates almost monochromatic oscillations with a period of 10.5-10.6 minutes.

*Figure 5. View of the harbour following the rissaga of 21 June 1984, when waves higher than 4 meters damaged over 300 vessels.*

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**IOC NEWS**

**The Second Session of the Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and Connected Seas (ICG/NEAMTWS), Nice, France, 22-24 May 2006**

The Meeting, hosted by the Conseil Général des Alpes-Maritimes, was attended by about 70 participants from 17 countries, five partner organizations and observers.

At the meeting, the urgent need to establish a tsunami warning system for the NEAM region was reiterated and emphasis placed on the necessity to ensure full and active participation of all the Member States of the NEAM region and relevant organizations to establish the tsunami warning system. Member States were urged to provide continuous support to the activities of the intersessional working groups and to the Secretariat for coordinating the process.

The ICG nominated or confirmed the following Chairs



**NEAMTWS**, *continued*

and Co-chairs of the intersessional Working Groups:

1. Working Group 1—Hazard Assessment, Risk and Modelling: France and Spain;
2. Working Group 2—Seismic and Geophysical Measurements: Italy and Germany;
3. Working Group 3—Sea Level Data Collection and Exchange, including Offshore Tsunami Detection and Instruments: Spain and Algeria;
4. Working Group 4—Advisory, Mitigation and Public Awareness: Portugal and the United Kingdom.

The ICG adopted amended terms of references for the working groups and recommendations for the plan of action based on their deliberations as well the proposed three levels of functions for the architecture of the tsunami warning system, taking into account the experience of the PTWS and open for review at the Third Session.

These recommendations form the basis for a complete ICG/NEAMTWS plan of action, to be presented at the Third Session of the ICG, to be held in Bonn, Germany, in January 2007.

The Meeting also stressed the need for the ICG/NEAMTWS to further explore opportunities of funding from the European Commission, as well as modalities of cooperation with relevant global and regional organizations. Further details about the meeting can be found at <http://ioc3.unesco.org/neamtws/neamtws-ii/index.htm>.

The IOC Executive Council at its 39th Session was invited to endorse the recommendations for the plan of actions formulated by the ICG and to provide further advice, support and resources for its implementation. (*see next article*).

**IOC Executive Council (EC) Resolutions**

The Thirty-Ninth Session of the IOC Executive Council convened in Paris, 21-28 June 2006. The EC reviewed and adopted several resolutions pertaining to tsunami mitigation including the following:

**Resolution EC-XXXIX.8****INTERGOVERNMENTAL COORDINATION GROUP FOR THE PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM**

The Executive Council,

**Noting:**

- (i) Resolution XXIII-12, Resolution XXIII-13 and Resolution XXIII-14, establishing respectively the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS), the Intergovernmental Coordination Group for Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions, and the Intergovernmental

Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and Connecting Seas;

- (ii) The report of the 20th Session of the International Coordination Group for the Tsunami Warning System in the Pacific (ITSU-XX) Viña del Mar, Chile, October 2005), IOC/ITSU-XX/3;

**Recalling that:**

- (i) the Tsunami Warning System in the Pacific (ITSU) provides a comprehensive tsunami warning and mitigation service which covers the Pacific Ocean and all adjacent seas,
- ii) the ITSU is a coordinated network of regional, sub-regional and national systems and capacities,
- (iii) the International Tsunami Information Centre (ITIC) was established by the IOC through Resolution IV-6 (1965) and hosted by the United States of America in Honolulu, Hawaii,
- (iv) the North West Pacific Tsunami Advisory Centre (NWPTAC), hosted by Japan in Tokyo was established in 2005,

**Recognizing:**

- (i) the long experience of the ITIC as the primary provider of information and expertise for technology transfer, training and capacity building for the Tsunami Warning System in the Pacific in conjunction with the IOC Secretariat,
- (ii) the long experience of the Richard H. Hagemeyer Pacific Tsunami Warning Centre (PTWC) in Hawaii as the primary operational centre for the Tsunami Warning and Mitigation System in the Pacific,

**Acknowledging** with appreciation the continuing strong support of Chile, Japan and the United States of America for the operation of NWPTAC, the PTWC, the West Coast/Alaska Tsunami Warning Centre (WC/ATWC) and ITIC,

**Recalling** the IOC commitment to an open, free and unrestricted sharing of tsunami-relevant real-time observational data in accordance with the UNESCO/IOC Oceanographic Data Exchange Policy and without prejudice to the sovereignty of Member States,

**Stressing** that all Member States should make every endeavour to exchange with other Member States:

- (i) *seismic, sea-level and other data relevant to tsunamigenic events at or near real-time,*
- (ii) *national assessments and warnings of tsunamigenic events and of tsunami in a timely manner,*

**Emphasizing** the importance of the role of the communication media in reporting this information responsibly,

**Expressing** appreciation to the Secretariat of the UN International Strategy for Disaster Reduction (ISDR) for its guidance and support, and to the World Meteorological Organization (WMO) for contributing its



**Resolutions**, *continued*

infrastructure and technical support,

**Decides:**

- (i) to rename ITSU to be the Pacific Tsunami Warning and Mitigation System (PTWS);
- (ii) to establish an Intergovernmental Coordination Group for the PTWS, with terms of reference as given in the Annex to this resolution;
- (iii) that the IOC shall provide the Secretariat of the ICG/PTWS;
- (iv) that ITIC will continue to act as the primary provider of information and expertise for technology transfer, training and capacity building for the PTWS;

**Requests** that NWPTAC and PTWC continue to provide interim tsunami advisory information for the South China Sea region, at least until the next meeting of PTWS;

**Reaffirms** that PTWS should be part of a global network of warning and mitigation systems for tsunami and other ocean-related hazards;

**Welcomes** and **accepts** the generous offer of the United States of America to continue to support the ITIC and instructs the IOC Executive Secretary to establish ITIC as a programme office of IOC;

**Agrees** that, to facilitate durability, the Pacific Tsunami Warning and Mitigation System should continue to utilize or build on, where possible, existing organizations and institutions and complement existing warning frameworks, within a multi-hazard framework where appropriate;

**Invites** all Member States and other countries, international and regional organizations to provide financial, technical and other kinds of assistance for the PTWS, including voluntary contributions to the IOC Tsunami Trust Fund, in order to assist the Commission in the effective provision of Secretariat services for the ICG/PTWS;

**Further invites** Member States, including Member States of the PTWS, to encourage countries in the Pacific that are not already participating in the PTWS, to join the IOC and PTWS, and that in doing so, Member States should clarify to them the benefits that accrue from membership of the PTWS, which does not require any set annual financial contribution;

**Invites** WMO and ISDR to coordinate appropriately with IOC, to ensure that tsunami warning and mitigation activities are mutually consistent.

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**Annex to Resolution EC-XXXIX.8**

**Terms of Reference of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS)**

The ICG will be established as a subsidiary body of the IOC and will report to, and seek guidance from the IOC Assembly.

**Objectives:**

1. To identify the needs and coordinate the activities of the PTWS;
2. To organize and facilitate as appropriate the exchange of seismic, sea-level and other data at or near real-time and information required for the interoperability of the PTWS;
3. To support the national tsunami warning and mitigation services;
4. To promote the sharing of experience and expertise related to tsunami warning and mitigation for the Pacific Ocean and adjacent seas;
5. To promote tsunami research;
6. To promote the establishment and further development of national tsunami warning and mitigation capacities in accordance with standard protocols and methods;
7. To develop, adopt and monitor implementation of work plans of the PTWS, and to identify required resources;
8. To promote implementation of relevant capacity-building, resilience building and emergency management, including high levels of public awareness;
9. To liaise and coordinate with the ICGs for other tsunami warning and mitigation systems and to facilitate best practices;
10. To liaise with other relevant organizations, programmes and projects;
11. To promote the implementation of the PTWS within a multi-hazard framework;
12. To develop and promote best practices in tsunami warning and mitigation;
13. To keep under constant scrutiny the status of the system and how it satisfies the needs;
14. To arrange for liaison among the various national contact points and tsunami warning centres;
15. To maintain a current list of operational focal points and facilities for the PTWS and make it available on request to all Member States;
16. To maintain a list of those countries that are members of PTWS and a list of those countries that are not members, and make this available on the IOC PTWS website;
17. To initiate and support training activities to enhance and enrich tsunami warning and mitigation in the Pacific Ocean and adjacent seas.

**Membership of the ICG/PTWS:**

- Member States of the IOC within and bordering the Pacific Ocean and adjacent seas;
- Observers from other IOC Member States.

**Resolutions**, *continued*

- Invited observers from other organizations (including NGOs), programmes and projects, in accordance with the IOC rules and procedures.

**Officers of the ICG/PTWS**

- A Chair and two Vice-Chairs, who will be elected in accordance with the Statutes and Rules of Procedure of the IOC,
- Past Chair,
- Director of PTWC,
- Director and Associate Director of the ITIC.

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**Resolution EC-XXXIX.9**

**FOLLOW-UP TO THE TWENTIETH AND TWENTY-FIRST SESSIONS OF THE INTERGOVERNMENTAL COORDINATION GROUP FOR THE PACIFIC TSUNAMI WARNING AND MITIGATION SYSTEM (ICG/PTWS)**

The Executive Council,

**Noting** the summary report of the International Coordination Group for the Tsunami Warning

System in the Pacific (ITSU-XX) (Viña del Mar, Chile, October 2005), and the Executive Summary Report of the Twenty-First Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS-XXI) (Melbourne, May 2006),

**Expresses** its appreciation to Chile and Australia, respectively, for hosting the meetings;

**Endorses** the reports, resolutions and recommendations of ITSU-XX and ICG/PTWS-XXI;

**Decides** to postpone the planned ITSU Programme review, originally focussed solely on the Pacific, until such time as a full review of the IOC tsunami programme is carried out;

**Notes** with satisfaction the successful conduct of the Exercise Pacific Wave 06;

**Expresses** its appreciation to Australia, Japan and the USA for their leadership in the organization and conduct of Exercise Pacific Wave '06.

The full-text of the EC Meeting Report can be found at: <http://ioc.unesco.org/iocms/contents.php?id=39>.

## ICG/PTWS NEWS

**ICG/PTWS XXI****Melbourne, Australia, 3-5 May 2006**

The Twenty-first Session of the Intergovernmental Coordination Group for the Tsunami Warning and Mitigation System in the Pacific (ICG/PTWS) was held in Melbourne, Australia, 3–5 May 2006 under the Chairmanship of Captain Rodrigo Nuñez. It was attended by 45 participants from sixteen ICG/PTWS Member States, ten participants from non-PTWS Member States, representatives from six organizations, and twelve observers. The Session reviewed progress made during the intersessional period from October 2005 to April 2006 and drafted its work plan for the period 2006–2007. This work plan will focus on: (i) continued support for the International Tsunami Information Centre (ITIC); (ii) the conduct and assessment of Exercise Pacific Wave '06 on 16–17 May 2006; (iii) support for the continued work of the intersessional working groups, and the development of a Medium Term Strategy; (iv) complete analysis of the assessment questionnaires for ICG/ITSU Member States in support of PTWS capacity building; (v) completion of the Integrated Tsunami Data Base (ITDB); (vi) support for development of the TsunamiTeacher, and for its translation into French and Spanish; (vii) support for working groups on the Central America Pacific Coast Tsunami Warning System (CAPC-TWS) and the Southwest Pacific and; (viii) support for enhanced TWS capacity in the South China Sea region.

The five intersessional working groups met immediately prior to the Twenty-first Session and provided the Session with a summary of activities to date and recommendations for further work. (*Summary reports follow in the next article*). Working Group 2 (WG2) on sea-level measurements, data collection and exchange, met jointly with its counterpart in the ICG/IOTWS, to synergize and coordinate activities across adjacent ocean basins.

The Coordination Group requested a budget of US\$168,000 for the biennium 2006–2007 to accomplish the work plan; noting that only US\$58,000



*Current officers of the ICG/PTWS, left to right, Past Chair François Schindelé (France), PTWC Director, Charles McCreery, ITIC Director, Laura Kong, Chair, Rodrigo Nuñez (Chile) and Vice-Chair, Fred Stephenson (Canada).*



**ICG/PTWS-XXI**, *continued*

is presently funded, and that Member States will provide approximately US\$1,290,000 in extra-budgetary support. The Group also decided to form an intersessional Task Team to review language changes proposed by the Pacific Tsunami Warning Center (PTWC) to their tsunami messages, consider additional changes, and solicit input from all Member States on the potential impact of the bulletin amendments in accordance with USA NWS standards. Moreover, as a consequence of the Tonga earthquake 4 May 2006 the Coordination Group acknowledged the need for continued improvements to the timeliness and clarity of messages and other communications. Exercise Pacific Wave '06 will be the first Pacific-wide exercise and the post-event feedback received from Member States will guide the ICG/PTWS in the planning and format of future exercises. The Group urged the small island nations in the Pacific and Caribbean regions to exchange experiences on hazard warning and mitigation, and encouraged participation in future ICG meetings. Furthermore, the Group encouraged Pacific Island Countries to join IOC and ICG/PTWS if they haven't already done so. The Group expressed its support for the establishment of a framework for a

Group further accepted the offer of Samoa to host the Twenty-third Session in 2009. The Group again recommended that on the occasion of the next election of officers, to elect two Vice-Chairs, following the example of ICG/IOTWS. More on the meeting can be found at <http://ioc3.unesco.org/ptws/>.

### **ICG/PTWS-XXI INTER-SESSIONAL WORKING GROUP SUMMARY REPORTS:**

#### **Working Group 1 (WG1): Seismic Measurements, Data Collection and Exchange**

ICG/PTWS Intersessional Working Group 1 (WG1) met on 2 May 2006 at the Melbourne offices of the Australia Bureau of Meteorology to discuss and formulate recommendations concerning measurement of seismic parameters, seismic data collection and exchange for ICG/PTWS-XXI. The meeting was led by the Chair, Stuart A. Weinstein (USA), with eleven other members in attendance.

One of the most important discussions concerned the existence of new tsunami warning systems (Nicaragua) and those currently under development (El Salvador). It was quickly realized that more Member States had some capability for local tsunami warning than thought.



*Participants of ICG/PTWS XXI in Melbourne (Telstra Dome), May 2006, hosted by Australia's Bureau of Meteorology.*

global tsunami and other ocean-related hazards early warning system, and acknowledged the importance of the partnerships ICG/PTWS presently has with the IUGG Tsunami Commission, the World Data Center-A, GLOSS, WMO, JCOMM, ISDR and SOPAC. In this regard, the ICG/PTWS will continue to look for opportunities to improve the effectiveness of the Tsunami Warning System through existing or new partnerships. In support of other newly established Tsunami Warning Systems the ICG/PTWS will request the IOC Tsunami Unit in Paris to produce a tsunami newsletter covering global tsunami issues and news. The Group decided to organize its Twenty-second Session in October 2007 and accepted the offer of Ecuador to host the Twenty-second Session. The

Clearly, WG1 needs to take into account existing tsunami warning seismic networks before it can make informed decisions as to how best to leverage existing assets and determining the best adding additional assets that are needed. Further discussions brought to light that the development of analysis software based on an open-source and platform independent model by existing warning centers can help kick-start national tsunami warning centers.

Another issue that generated much discussion was the use of technologies such as GPS or strong motion sensor arrays in the context of tsunami warning. Much discussion regarded new cabled geo-ocean observing systems being installed around the world [Neptune (~2000-km cable), Japan Tokai (~200-km cable)].



**Working group reports, *continued***

Following on the twenty recommendations made at the intersessional meeting of 15–16 March 2006 in Honolulu, the WG made 26 recommendations in Melbourne, which fall into the same five basic categories. These categories are:

- Infrastructure of seismic networks/data access,
- Filling in the gaps of PTWS coverage (including instrumentation),
- New technologies for tsunami warning,
- Sharing operational techniques & procedures,
- Other recommendations.

Specific Recommendations of WG1 to ICG/PTWS-XXI follow, listed by the categories above.

**Infrastructure of seismic networks/data access**

1. The WG recognized that the international tsunami warning system depends largely upon the real-time seismic waveforms made available by the Global Seismographic Network (GSN), and noted that this scientific network is funded largely by the US National Science Foundation and the US Geological Survey. The WG also recognized the important contributions made by international and Member State organizations toward this Network. However, the WG noted that the function of these organizations is primarily for earthquake monitoring and research, and not tsunami warning. The WG thus strongly stated that it is essential that the GSN and other contributing networks should be sustained at high levels of operational reliability for tsunami warning.
2. The WG stated that open and unrestricted access to real-time data is essential for both research and operations. These data include seismic and sea level time series.
3. The CTBTO presently provides its primary station and hydro-acoustic data to tsunami warning centers. The WG noted its high value as presented by the JMA and PTWC, and recommended that this data flow be continued. The WG also recognized the importance of auxiliary station data for tsunami warning, and recommended that these be also made available in real time.
4. The CTBTO shares its Global Communications Infrastructure (GCI) with the GSN, and this telemetry is vital for tsunami warning systems. The WG recommended that the IOC recognize and encourage that this important cooperation with CTBTO continue.
5. The WG recognized the world wide coverage and open data availability of stations of the International Federation of Digital Seismograph Networks (FDSN), and recommended that global, regional, and local Tsunami Warning Systems work with FDSN and its member networks to incorporate real-time data from available FDSN stations.
6. The WG recognized that all seismic coverage is from land-based seismic stations, and that almost no coverage is available seaward from the major seismogenic zones around the Pacific. The WG noted that this is a fundamental gap in the PTWS ability and speed to characterize the earthquake source in near real-time. It was recognized that extensive deep-ocean tsunami infrastructure is being developed and deployed to monitor sea levels in real time. The WG recommended that enhancing these systems with seafloor seismic and acoustic sensors should be explored and developed.
7. The WG discussed the requirements for high-quality real-time seismic waveforms. For this, the concepts of waveform completeness and timeliness of receipt were agreed to be the most important metrics. Complete data must have little or no gaps. Latency should be as small as reasonable. The WG recommended definitions of 'completeness' and 'latency' to facilitate the discussion of seismic transmission standards. It was recognized that latency is comprised of several components; data record size (buffer), telemetry (including Internet latency), data reformatting and server latency. The WG recommended that transmission latency should be defined as the difference between current time and the time of the last datum received in the most recent packet, emphasizing the vertical 20sps channel. Networks should note the respective data record size for channels. Measures of latency should include median statistics to avoid effects of large outliers. Data servers should measure and note server latency due to data reformatting or internal buffers. The amount of tolerable latency depends on need. It is recommended that for teleseismic processing, buffer latency of twenty seconds is desirable and a buffer latency of second is desirable for local seismic processing.
8. As National systems develop their capabilities, their data should be shared in real time with the regional centers to simultaneously enhance the capabilities of the regional and basin-wide warning centers.
9. The WG recognized that the best seismometers for determining the tsunamigenic potential of an earthquake are Streckeisen STS-1. Therefore, the WG stated that is incumbent for Member States with STS-1 sensors to share the data in real time.

**Filling in the gaps of the PTWS**

10. The Pacific Tsunami Warning Center provides timely international tsunami warnings for tele- and regional tsunamis. However, given that the time elapsed before an initial bulletin is issued by the PTWC may range from 10 to 20 minutes, the WG recognized the limitations of the PTWC to provide local tsunami warnings (outside of Hawaii), and recommended each Member State consider

**Working group reports, *continued***

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

11. The WG recognized the high value of providing guidance on the establishment of local warning capabilities, and recommended this issue be addressed by the Working Group on the Medium-Term Strategy for the Pacific Tsunami Warning and Mitigation System.
12. The Southwest Pacific faces a significant threat from locally-generated tsunamis that is not currently addressed by any local warning system. The WG reaffirmed the Action Plan developed by eight SOPAC Member States during the South Pacific Tsunami Awareness Workshop in July 2004.
13. Countries along the Middle America Trench face a significant threat from locally-generated tsunamis and in some cases, this threat is not currently addressed by any local warning systems. The WG encouraged the WG for the Central America – Pacific Coast Tsunami Warning System to actively continue its activities to enable the timely dissemination of local warnings to coastal populations.
14. Produce, keep updated and distributed via a web based service a map showing the relevant instrumentation networks for all Member States. The IOC is to conduct a survey of the Member States to retrieve this information. GeoScience Australia has suggested a willingness to compile the information from this survey into a database. Member States should then send updates on their capabilities to GeoScience Australia.
15. The WG recognized that there currently are significant Internet and telemetry bandwidth limitations into PTWC which restricts bringing available, high-quality seismic, hydroacoustic, GPS and other relevant real-time continuous data for tsunami warning operations. The WG recommends that these limitations be reviewed and rectified at PTWC and at other TWS to assure adequate, dedicated bandwidth for available data flow.
16. The WG recognized and recommended that the GSN constitute the basis for the Pacific Core Network, encouraged the designation of additional real-time FDSN stations in the Core Network, and agreed that additional stations to densify the network, such as in the Southwest Pacific, South China Sea, and seaward of major seismogenic zones, will be very valuable.

**New technologies for tsunami warning**

17. The WG recognized GPS to be a promising technology for quickly measuring displacements

resulting from earthquakes in real time. Such technology is potentially very useful to address the local tsunami warning problem and great global earthquakes. The WG recommended that further research was needed to evaluate the use of GPS for tsunami warning methodologies.

18. The WG was concerned that STS-1 sensors are no longer being manufactured, and that no adequate replacement is in sight. Furthermore, existing deployed sensors are aging. The WG stated that it is necessary for the continued integrity of the tsunami warning system that a successor be developed as soon as possible.
19. Operational tsunami warning should take advantage of new cabled geo-ocean observing systems going in around the world. [Neptune (~2000-km cable), Japan Tokai (~200-km cable)]. To date the tsunami warning centers have not been involved in the planning of these systems. It is recommended that the IOC facilitate communication between the warning centers and the groups deploying these deep sea observing systems.
20. The tsunami warning system should explore the use of strong motion sensor arrays to rapidly determine the size and nature of the rupture of large earthquakes. Modeling should be conducted to establish criteria for assessing the appropriate thresholds for ground accelerations recorded by these arrays at which the genesis of a destructive tsunami is likely.
21. The tsunami warning system should explore the use of broadband sensor arrays to determine earthquake rupture characteristics.

**Sharing operational techniques and procedures**

22. The WG highly recommended that regular scientific symposia be convened to focus on improving tsunami warning systems and their operational procedures. The WG noted that the IUGG Tsunami Commission has convened such meetings on tsunami research, but not on operational systems, and further noted the need and high value for such symposia on real-time seismology.
23. The WG recognized that research plays a fundamental role in developing better ways of characterizing earthquakes and their potential for tsunamigenesis, and that it is critical that this research be developed into operational tools. The WG recommended that these tools should be openly shared with earthquake monitoring centres and tsunami warning centres.
24. Existing TWCs should make their operational software available to developing TWCs. TWCs should move towards more modular, portable, open-source, platform-independent software to help facilitate this type of exchange. The PTWC is beginning this process with some of its operational

**Working group reports, *continued***

software.

**Other recommendations**

25. The WG recognized that additional threats from tsunamis are generated by landslides, volcanic explosions, and meteorite impacts, but noted that current tsunami warning systems cannot adequately warn for these events. The WG recommended that further evaluation of these threats is merited.
26. The WG identified the strong need for synergy between other ICG Seismic Working Groups in the Indian Ocean, Caribbean and Adjacent Regions, and the North-eastern Atlantic, Mediterranean, and Connected Seas, and called for the IOC to take a leadership role in integrating and coordinating common activities.

The Specific Recommendations of WG1 to ICG/PTWS-XXI can be found in the full report posted at: [http://ioc3.unesco.org/ptws/working\\_groups\\_other\\_tsunami\\_meetings.htm](http://ioc3.unesco.org/ptws/working_groups_other_tsunami_meetings.htm).

**Working Group 2 (WG2): Sea Level Measurement, Data Collection & Exchange**

WG2 met 1-2 May 2006 at the Melbourne offices of the Australia Bureau of Meteorology to discuss sea level data issues and formulate recommendations for ICG/PTWS-XXI. Rick Bailey, WG2 Chair, opened the meeting. The meeting was held jointly with the ICG/IOTWS Working Group 2 on Sea Level Measurement, Data Collection & Exchange.

The meeting was attended by about 40 scientists and government officials representing PTWS and IOTWS Member States, organizations, and other agencies including universities.

Agenda sessions focused on;

- Sea level data requirements for tsunami monitoring and warning,
- Sea level network design principles,
- Sea level measurement technology and instrumentation,
- Sea level data exchange & archival needs,
- Intra- and inter-ocean basin coordination.

Each session consisted of informational presentations followed by discussion. ICG/PTWS and ICG/IOTWS breakout sessions were included to discuss basin specific requirements of the sea level network (coastal tide gauge and tsunami data buoy), review the sea level network design plan, and discuss the coordination and status of ongoing arrangements and enhancements.

Comments on this report were also received from attendees of ICG/PTWS-XXI including several delegates representing the Pacific Island Countries (PICs).

Recommendation: ICG/PTWS WG2 continue during

inter-sessional period and meet prior to next ICG/PTWS to ensure coordination and ongoing focus on Pacific Ocean issues by members in the region.

**Sea level data requirements for tsunami monitoring and warning,**

WG2 discussed the need for sea level data in tsunami monitoring and warning, and recommended that the highest priorities are a) operational tsunami detection and warning (verification of generation and 'all clear' notification); b) modeling & forecasting (use in warning, hazard & vulnerability assessments, historical data and metadata); c) post-tsunami analysis (defining terms: run-up, amplitude, arrival time (initial vs maximum), period, inundation distance, etc., (data archiving and access); and d) long-term scientific understanding and forecasting of tsunami. The group arrived at the following action and recommendation:

Action: Seek further input from modeling working groups on data requirements for warning and forecasting.

Recommendation: Include feedback from post event analyses into ongoing review of network design.

**Sea level network design principles**

WG2 discussed the various components of sea level networks, and identified the hinderances to an optimal monitoring network for tsunamis.

The WG acknowledged the high value of the GLOSS tide gauge network for providing regional sea level data coverage in support of tsunami warning, and recognized that the GLOSS network should comprise, at least, a subset of the Core Sea Level Network for tsunami detection.

The GLOSS representative, Bernie Kilonsky of the University of Hawaii Sea Level Center, provided further information about the programme, reporting that, in addition to offering *in-situ* sea level gauges, it also assists ICGs to set data standards, offers training courses, technical visits, technical manuals and other training materials, and holds workshops on special issues.

The GLOSS representative informed the Working Group on the activities of the Indian Ocean concerning the need for more densely spaced data networks to adequately monitor coastlines with significant tsunami hazards such as the western and southern parts of Indonesia and in the Makran source area of the Arabian Sea. He presented some proposed preliminary specifications for *in situ* sea level sites within 1 hour travel time and/or 100 km of tsunami generation areas. Important features of this new standard, which are proposed by the ICG/NEAMTWS and ICG/CARIBE-EWS where local tsunami hazards are a major concern.

The WG then considered the importance of how to maintain and sustain a tsunami sea level network for



**Working group reports, *continued***

infrequent hazards such as tsunamis. Members of the WG2 noted that the sea level gauge specifications for tsunami detection and monitoring were less than for climate change detection. Therefore tsunami gauges were cheaper to install, making it also possible for denser networks due to lower per unit costs.

Action: Joint WG to coordinate development of network design principles by ICG/IOTWS-III in Bali in July 2006 (Chair Jane Warne, Australia). They should consider the newly proposed standards for sea level sites within 1 hour tsunami travel time and/or 100 km of tsunami generation areas, and the implications of these standards in terms of network design for the Pacific.

Recommendation: Wherever possible and in the interim sea level stations should conform to GLOSS climate related standards, but the WG noted that requirements for tsunami detection are less stringent so that sea level stations could be installed at less cost where critically needed specifically for tsunami warning guidance.

Recommendation: Wherever possible, installation should be of multi-purpose observing sites to facilitate the long-term sustainability of the observing network.

Action: Bernie Kilonsky to advise by ICG/IOTWS-III in Bali July 2006 the additional cost of making a typical tide gauge, which is suitable for tsunami detection, also capable of monitoring sea level for climate change detection.

**Sea level measurement technology**

WG2 discussed the various present and future technologies available for measuring tsunami waves, and the plans of various Member States, including the USA, New Zealand, Australia, Russian Federation, Japan, and ASEAN countries (as presented by Malaysia) to enhance the monitoring networks in the Pacific.

Action: Need to coordinate and communicate outcomes from evaluations of existing and new technologies (e.g. radar)

**Data exchange, display & archival needs**

WG2 was informed of the various data formats of national and international networks, transmission processes, data archiving, decode and display capabilities (in operation), and discussed the feasibility and desirability for standardization of different operational schemes. The noted actions and recommendation are:

Action: ICG/IOTWS WG2 and ICG/PTWS WG2 coordinate efforts within basins to provide data to WDC (Chairs).

Recommendation: WG2 recommended the global adoption of the CREX Code for the transmission of sea level data over the WMO GTS.

Action: Joint ICG/IOTWS WG2 and ICG/PTWS WG2 Sub-WG to review tables, metadata and draft revisions by the end of June for joint review, then table at ICG/IOTWS-III in Bali at the end of July.

**Intra- and Inter-Ocean Basin coordination**

WG2 noted several activities happening which further enhance sea level networks to support tsunami warnings, but decided on no action items or recommendations in that regard.

**Sea Level Network implementation coordination**

WG2 noted the following Actions and Recommendations;

Action: Develop template by end of May 2006 for Pacific Ocean nations to provide status information and national plans for deployments by end of July 2006 to facilitate status monitoring, maintenance and development of sea level network programs (Jane Warne, Australia and National Representatives).

Action: Coordinate this activity with ITIC with view to ongoing maintenance and access to database (ICG/PTWS Chair, Rick Bailey).

Recommendation: ICG/PTWS WG Chairs participate on Medium Term Strategy WG to ensure coordination on status and developments in respective areas.

Recommendation: ICG/PTWS WG2 reviewed the ToR's of the International DART partnership (Annex II), and recommended that the ICG/PTWS endorse the concept of an International Tsunameter Partnership to ensure the interoperability of deep-ocean measurements and coordination of deployment opportunities.

**Inter-Ocean implementation coordination**

Recommendation: Chair of ICG/IOTWS WG2 and Chair of ICG/PTWS WG2 to help coordinate between basins and identify joint issues.

Recommendation: Respective ICG/PTWS and IOTWS WG2 chairs (or their representatives) to participate in GLOSS meetings to facilitate coordination of requirements.

**Working Group 3 (WG3): Tsunami hazard identification and characterization, including modeling, prediction and scenario development**

The group met early on 2 May 2006, at the Melbourne offices of the Australia Bureau of Meteorology to discuss tsunami hazard identification and characterisation issues and formulate recommendations for ICG/PTWS-XXI. Leading the meeting was the Chair, François Schindelé (France).

After having reviewed and discussed the relevant topics, WG3 made the following specific four recommendations to ICG/PTWS-XXI:

### Working group reports, *continued*

1. Working Group Three (WG3) on Tsunami Hazard should continue through at least the next intersessional period. Greater participation from Member States is needed.
2. Member States will provide information to ITIC on the type of tsunami modeling software used in their country, along with related documentation, manuals and references. ITIC will collect this information and provide to IUGG/Tsunami Commission for review.
3. Member States will complete questionnaires on credible seismic scenarios. (ITIC will transfer questionnaire provided by Chair WG3).
4. Member States are requested to provide in their National Reports an annex containing descriptive information on their tsunami hazard and risk activities.

### Working Group 4 (WG4): Resilience building and emergency management

This was the first meeting of the working group and much of the discussion centered on identifying and discussing present best practices, or activities which are likely to support improvement. The meeting was led by the Chair, Fred Stephenson, (Canada). Items discussed included:

1. Assessments – the IOC was an active participant in assessing the requirements and capacity for effective and durable tsunami warning and mitigation systems carried out for most Indian Ocean countries following the December 2004 Tsunami. Some ICG/PTWS Member States have also completed this questionnaire, but a comprehensive set of assessments (all countries) is required to identify baselines and gaps in capabilities. As part of the PTWS Exercise Pacific Wave '06, Member States were requested to complete this questionnaire to support pre-exercise evaluation.
2. Signage – The ICG/PTWS established a working group several years ago to recommend a set of signs for international use. Two approved signs were submitted to the International Standards Association (ISO), but the approval process has not been satisfactory or conclusive. The ICG/PTWS needs to move ahead (if need be, unilaterally) to promote one or more sign formats to other Tsunami Warning Systems.
3. Educational materials – for many years the ITIC has been responsible for the development of a broad range of tsunami educational material. Tsunami Teacher will provide more information than ever before and this information will be directed to a broad range of client groups.



*Participants and trainers for the IOC/USGS training course on seismology and tsunami warnings, held in Bangkok, Thailand, 15-22 May 2006. (story p. 21).*

4. Information sharing – in addition to developing and publicizing educational material, TWS groups need to do a better job of sharing operational information (e.g. national emergency response manuals and hazard assessments) and linking to all-hazards and capacity building (resilience) information.
5. Communication methods – many attendees, particularly those from SOPAC, indicated that present communication methods do not meet the needs of small or isolated communities. An effective TWS must have communication systems that are reliable, and capable of providing a timely warning to communities. In support of that goal communication redundancy is an important consideration, as is a Communication Plan which is up-dated on a regular basis.
6. Following Exercise Pacific Wave '06 it will be important for all Member States to complete the post exercise evaluation forms. These assessments will help us to identify and promote best practices.
7. Having identified a practice that supports improvement, there needs to be a process for keeping this information up-to-date (i.e., continuous improvement.) It is also important to recognize that best practices may be regionally or culturally specific.
8. Promote high level advocacy that ensures a sustained commitment to prepare for infrequent, high fatality hazards such as tsunami and earthquakes (e.g. promote community initiatives such as TsunamiReady [TsunamiResilient]).
9. The PTWS needs to develop a structure for information "inter-operability," i.e., making the considerable amount of information that is not data (water level, seismic) or educational material available to all the Tsunami Warning Systems and their Member States. The WG envisions that this information would be available through the global portal.

**Working group reports, *continued***

10. The 36th Pacific Islands Leaders Forum (Madang, October 2005) endorsed, for national implementation, the regional disaster risk management framework, "An Investment for Sustainable Development in the Pacific Island Countries Disaster Risk Reduction and Disaster Management, A Framework for Action 2005-2015 Building the Resilience of Nations and Communities to Disasters". Pacific Island Countries (PICs) are committed to develop Strategic National Action Plans guided from the six themes of the Framework. These themes promote capacity building on an all-hazards approach, and in particular, the enabling of communities to be well informed and motivated towards a culture of prevention and resilience. The WG and PTWS should look for opportunities to both support and learn from this initiative.

### **Working Group 5 (WG5): Interoperability and regional, sub-regional and national tsunami warning and mitigation systems in the Pacific**

WG5 met on 1 May 2006 at the Melbourne offices of the Australia Bureau of Meteorology to discuss interoperability issues and formulate recommendations for ICG/PTWS-XXI. Leading the meeting was the Chair, Charles McCreery, (USA).

Comments on this report were also received from some attendees of ICG/PTWS-XXI including several delegates representing the Pacific Island Countries (PICs).

WG5 identified key motivations for carrying out its work:

1. The global tsunami warning system that includes the PTWS is currently operating and will continue to operate with multiple tsunami warning centers (TWCs) having adjacent or overlapping areas of responsibility and simultaneous responsibilities for the same events. Information disseminated from multiple centers during events should be coordinated in form and content to avoid confusion or inaction that could in some circumstances result in the unnecessary loss of life.
2. Although each TWC has unique responsibilities and challenges, they also have many similarities. They should work towards a common underlying concept of operations (CONOPS) that will allow them to more efficiently and effectively exchange data, methodologies, technologies, and procedures with each other as well as with their partners in a multi-hazard framework, and provide backup services for each other, thereby enhancing their reliability and sustainability.

A large number of general issues were identified as

being related to interoperability. Most were not discussed in detail nor specific recommendations made. It was agreed, however, to recommend a few issues identified as being of high priority and sufficiently achievable to be recommended to ICG/PTWS-XXI for consideration. These specific recommendations are as follows:

1. WG5 should continue through at least the next intersessional period. Greater participation from Pacific Island Countries (PICs) is needed.
2. All TWCs should rapidly exchange their earthquake parameters, tsunami observations, and other operational tsunami information. A coordination tool should be developed to enable the (near) real-time internet exchange and display of this information.
3. Practice events such as Exercise Pacific Wave '06, and other regional or local exercises should continue to be carried out to maintain a level of readiness required during an actual event.
4. Areas of responsibility of each TWC should be identified, including the type of coverage provided (local, regional, or teletsunami). Areas in the vicinity of the Pacific without coverage for their threat (e.g., the Banda Sea for local and regional tsunamis) should be identified and existing TWCs should consider providing some type of coverage.
5. Work should continue to improve tsunami preparedness and warning coverage in the SW Pacific, including getting more countries to join the IOC-ICG/PTWS, advising them on setting up their national focal points and national TWCs, and developing end-to-end tsunami warning capacity.
6. PTWS country assessments, initiated prior to ICG/ITSU-XX, should be completed and evaluated.
7. Regional TWCs should develop abbreviated text messages and Short Message Service (SMS) dissemination capabilities. Member States should provide SMS contact points.
8. Funding should be provided by the IOC or by Member States for WG5 to meet at least once during the Intersessional Period, as well as to facilitate carrying out any WG5 recommendations adopted by ICG-PTWS-XXI.
9. The PTWS Communication Plan procedural information needs to be kept up-to-date by PTWC and focal point information kept up-to-date by ITIC. The current plan should be made available on the Internet by the IOC and made available in hardcopy as requested. Focal point information should be kept secure by password or otherwise for distribution only to ICG/PTWS National Contacts and their designated focal points.



## The Outcome of Pacific Wave '06

*This preliminary report provides feedback on the design and conduct of the exercise to assist members as they begin to apply some of the lessons learned to improve the direction of future exercises. The full report will be finalized by the end of the year [2006]. This report was compiled by Mark Sullivan (Australia), Task Team Chair, PTWS Officers: Rodrigo Nuñez (Chair, Chile), Fred Stephenson (Vice-Chair, Canada), François Schindelé (Past-Chair, France), Charles McCreery (PTWC), Laura Kong (ITIC Director), Emilio Lorca (ITIC Associate Director) and Brian Yanagi (ITIC), and can be found at [http://ioc3.unesco.org/ptws/exercise\\_pacific\\_wave\\_06\\_info.htm](http://ioc3.unesco.org/ptws/exercise_pacific_wave_06_info.htm).*

The objective of the Exercise Pacific Wave '06 was to test, evaluate and review the operational lines of communication within the Pacific Tsunami Warning System's area of responsibility. These include the Philippine Sea, East China Sea, Yellow Sea, Sea of Okhotsk, Bering Sea, South China Sea and Eastern Archipelagic Seas such as the Singapore and Sunda Straits, Java Sea, Bali Sea, Flores Sea, Timor Sea, Arafura Sea, Banda Sea, Ceram Sea, Halmhera Sea, Molucca Sea, Sulawesi Sea, Mindanao Sea, Sulu Sea, and Celebes Sea, and those of the South Pacific Ocean, such as the Bismarck Sea, Solomon Sea, Coral Sea, and Tasman Sea.

Altogether, 40 Pacific Basin countries and island states agreed to participate in one or both of the two scenarios. In total, PTWC operational warning contacts include more than 60 countries or island states, with some having more than one Tsunami Warning Focal Point for the receipt of official messages from the regional and sub-regional tsunami warning centres (TWCs). During the exercise, PTWC called or confirmed that their messages were received from a total of 48 Tsunami Warning Focal Point countries. The Communication Plan for the PTWS describes the operational components, services, and products of the warning system, and includes 24/7 Tsunami Warning Focal Point information for every point of dissemination. The ITIC works with the PTWC and other sub-regional warning centres and national contacts to keep the Com Plan up-to-date.

The Exercise was coordinated from the Pacific Tsunami Warning Centre (PTWC) in Hawaii 16–17 May 2006. Messages were sent by the PTWC, WC/ATWC, and NWPTAC of Japan Meteorological Agency. Messages were sent out via the normal operational mediums and countries were encouraged to make critical and timely decisions and disseminate information and warnings through their standardised channels to relevant jurisdictions, agencies and organisations. Individual countries could elect to extend the Exercise down to the level of actually warning the public. (see cover story).

A set of six questions was sent to all participating countries. Responses were received from 30 countries; Australia, Canada, Chile, China (Hong Kong),

Colombia, Costa Rica, El Salvador, Ecuador, Fiji, French Polynesia, Guatemala, Japan, Federated States of Micronesia (FSM, Kosrae), New Zealand, Nicaragua, Malaysia, Papua New Guinea, Peru, Philippines, Republic of Palau, Republic of Korea, Russian Federation, Samoa, Singapore, Solomon Islands, Thailand, Tonga, USA, Vanuatu, and Vietnam.

Six questions were asked with preliminary summaries and comments as follows:

### 1. Did you receive the relevant exercise bulletins?

Summary: Responses to this question indicated that most participating countries received the exercise bulletins. Some of the comments highlighted the need to regularly confirm points of contact and details. One responder stated that there was some disparity between bulletin timings with some agencies running ahead of the PTWC and this has the potential to cause confusion. Another relevant suggestion was that a final bulletin could be sent to clearly state the end of the Exercise.

### 2. Was the information clearly disseminated?

Summary: The responses emphasise the importance of delivering messages by a variety of means including email, fax and phone as in some areas a single mode cannot be relied on 100% of the time. Some comments also highlighted the need to clarify internal communication channels within countries. Some participants noted that as it was an exercise they were able to refer to the manual, however concerns exist that in a real event countries will be totally reliant on information disseminated in bulletins. Some countries expressed a desire for the manual to be interpreted into other languages, however a greater lead-time may allow this to be completed within individual countries.

### 3. Did you find the exercise useful in confirming contact details and communication plans?

Summary Generally the responses indicated that the exercise was a useful tool to confirm and validate relevant contacts and communication arrangements. A number of responders stated that the exercise identified the need to investigate a variety of modes of message delivery within countries. It also identified key players who needed to be contacted but were not on original contact lists. The exercise also highlighted the time it takes to separately fax or phone individuals, and as such, countries need sufficient staff on call to facilitate the dissemination of messages.

*ICG/PTWS Secretariat (ITIC) Comment: The PTWC, WC/ATWC and NWPTAC used this Exercise to confirm their Tsunami Warning Focal Point emergency contact information. Contact information from the Exercise, the ICG/PTWS-XXI National Reports, the 24/7 Tsunami Warning Focal Point forms submitted by countries, and other recent communications are being compiled to update the Communications Plan for the Pacific Tsunami*

**Pacific drill, continued****Warning and Mitigation System.****4. Did the bulletins provide sufficient realistic information for rapid decision-making?**

Summary: A number of responders stated the bulletins did not provide the detail that countries would require if they were to make critical decisions such as the need to evacuate areas of the population, however it was stated that most used the Exercise as a communications test and did not engage at the strategic decision-making level. It was suggested that the next exercise run in real time and provide more information on predicted wave heights. It was also suggested that bulletins could include more interpretive information on estimated wave heights at certain locations and that they be delivered using less technical and scientific terms i.e., a plain English version for non-scientists.



*Evacuation Drill, Albay Province, Philippines.*

**ICG/PTWS Secretariat (ITIC) Comment:** *Exercise participants should become familiar with the definitions of various tsunami bulletins (i.e., tsunami information; advisory; watch; warning bulletins). The different types of bulletins express degrees of earthquake and tsunami severity and threat, as well as wave arrival time estimations. It should be emphasised that Tsunami Warning Centres and Tsunami Bulletins do not order evacuations. According to the PTWS system, it is the responsibility of national and local authorities to interpret the threat evaluations issued by the TWCs for applicability to their country as a whole, or to specific localities along their coasts with potential for tsunami damage, and then, if necessary, to issue public evacuation orders. Additionally, participants must be aware of the limitations of the TWC's capacity to detect earthquakes and tsunamis, and the possibility of "false warnings" or warnings being issued for non-destructive tsunamis.*

**PTWS Officer's Comment:** *Additionally, exercise participants should be aware that currently TWC cannot predict tsunami wave heights for most events except for a few historical events that are well documented, such as the 1960 Chile tsunami. To be able*

*to provide accurate wave forecasts for the Pacific, all other sources must be studied, numerical modelling conducted and calibrated with actual tsunami data for all sources, operational wave forecasting software must be implemented in the warning centres, and inundation maps or estimates of run-up calculated. Any predictions of wave heights will need to also provide information of the accuracy of the estimates. Operational wave forecasting is being developed, but much work still needs to be done with techniques continually improved by researchers.*

**5. Do you have any comments on the planning of the exercise?**

Summary: Responders commented that to plan an exercise of this size involving so many participating countries takes a significant amount of time and greater lead-time could also increase the amount of internal involvement within countries. This would allow a more comprehensive run through of the system from receipt of the bulletin, through the decision making process down to notifying agencies, warning the public and managing an evacuation. Exercising in real time [as opposed to condensed time] is preferred as it allows a more realistic response.

**6. What other initial points would you like to make?**

Summary: Some very positive comments were received supporting the concept of multi-national exercises on a regular basis. A number of participants used this as an opportunity to raise awareness of tsunami risk to a variety of agencies and organisations reinforcing the need to improve planning arrangements. Most participants noted that there were positive lessons from the exercise and it enabled them to identify areas requiring improvement. A number of participants stated that they look forward to future exercises allowing a full activation of their systems.

**General Conclusions**

The Exercise confirmed the dissemination and receipt process of warning messages from the PTWC, WC/ATWC, and NWPTAC to the involved countries and highlighted some opportunities for improvement.

Responses from participants confirmed that the exercise provided an excellent opportunity to clarify and confirm the 24-hour-a-day points of contact (24/7 Tsunami Warning Focal Points) for all involved countries. It also clarified the need to have sufficient staff on call in all countries to ensure bulletins can be actioned appropriately. Both the development and conduct of the exercise provided a valuable opportunity for countries, agencies and individuals to network and share information and initiatives. This dialog should be encouraged and fostered as a tsunami event has the potential to impact across a wide region and effective networks would greatly assist during a real event.

Future Exercises and Planning--Responses indicate

### Pacific drill, *continued*

strong support for future exercises, but consideration should be given to increasing the lead-time and keeping countries updated on the development and aims and objectives of the exercise. Thought should also be given to adding value to bulletins to assist countries in making informed decisions about actions and this should also be done in plain English avoiding the use of technical jargon. Running an exercise in real time versus using compressed time would also assist in engaging the planning and decision-making process. Serious consideration of conducting an exercise on a yearly basis, and to alternate the location of the earthquake/tsunami from east to west to be able to have all areas regularly experience a feasible scenario. Finally, it would be useful to enable some mechanism for media involvement since they are key communicators for information dissemination.

#### Recommendations from this report

A number of relevant suggestions were received from the feedback. Below is a consolidation of recommendations from the major themes:

- *Future exercises be developed and conducted building on the achievements of Exercise Pacific Wave 2006. Development of these exercises will consider broadening the objectives to include allowing sufficient time for strategic and critical decision-making. Consideration should also be given to running the exercise in real time;*
- *Countries are encouraged to develop and conduct individual tsunami exercises to regularly exercise their national arrangements and these could be conducted prior to International exercises to maximize their benefit;*
- *Participants ensure that their points of contact are regularly reviewed and updates circulated. Consideration should be given to the development of a regularly updated contacts register;*
- *Consideration be given to the inclusion of additional information into the bulletins to provide a simple English word-picture of the threat faced by the tsunami; and*
- *Networking between the agencies and the media continue, to enhance the profile of the critical work being conducted.*

*Closing ICG/PTWS Secretariat (ITIC) Comment: The Indian Ocean Tsunami of 24 December 2004 graphically demonstrated the potential threat faced by a tsunami. Exercise Pacific Wave '06 provided the first opportunity for many participating countries to exercise their communication arrangements in such a regional activity. Many issues have been identified and some are being addressed. Hopefully we can seize the opportunity and continue to work together, network and share information to improve our capacity as a region to deal with tsunamis.*

### Recommendations of the Tsunami Warnings for Indonesia Roundtable

**17 May 2006, Media Sheraton Hotel, Jakarta**

To inform on the progress and prepare for stronger coordinated activity in the implementation on an effective end-to-end tsunami warning system for Indonesia, the Meteorological and Geophysical Agency (BMG), in coordination with the IOC International Tsunami Information Centre (ITIC), organized a 1-day Roundtable involving Indonesia government and non-government agencies, and universities involved in the detection and threat evaluation of earthquakes and tsunamis, dissemination of warnings to provincial, district and community levels, and the conduct of education, outreach, and other preparedness measures to reduce the impact of tsunamis on life and property.

Over the course of the day, roundtable attendees from BMG Jakarta and its Regional Center Directors, BAKOSURTANAL, LAPAN, BPPT, BAKORNAS, KOMINFO, Indonesian Institute of Sciences (LIPI), RISTEK, ITP, Mabes POLRI, French Red Cross, Pusat Vulkanologi dan Mitigasi Bencana Geologi, Ditjen PUM Depdagri, Air Putih, ORARI Pusat, RAPI Pusat, PRSSN/Trijaya, Malaysia Meteorological Department, and PTWC, US Embassy, UNESCO Jakarta, and ITIC shared information in support of activities to enhance tsunami warning and mitigation.

Having discussed a wide range of topics and actions, and their implications and requirements for achieving tsunami preparedness in the most responsible manner for Indonesia, Roundtable attendees endorsed the following Recommendations for immediate action:

#### **Recommendation I —Disaster Operational Center; 24-hour Operation; Telecommunication**

Noting that Indonesia is on the way of establishing the TWS which will involve many institutions, including BMG, LIPI, KOMINFO, BAKORNAS, and others under the coordination of the Ministry of RISTEK;

Recognizing that for the TWS, what is still missing is the warning dissemination system to coastal communities, and considering that a tsunami disaster could happen any time;

Further recognizing recent developments to support the delivery of time-critical national tsunami warnings through the WMO Global Telecommunications Systems in cooperation with the RANET project;

Recommend to the Government (BAKORNAS, Ministry of Home Affairs, Provincial and District Government) to establish 24/7 disaster operation centers at the district level;

Recommend to Ministry of Communication and Information Technology to facilitate the appropriate communications and dissemination system for disaster



**Roundtable, continued**

reduction purposes;

Recommend to BMG to evaluate methods of communication and dissemination of tsunami warnings, including RANET and other means of reaching Provincial and District tsunami disaster operations centers and coastal communities, and implement the most advantageous method as a pilot project.

**Recommendation II —Public preparedness & awareness.**

Noting that public awareness and preparedness are the most important components to reduce the degree of the disaster;

Recognizing that the knowledge and experience to face the disaster will enhance the capability of the people to escape from the disaster;

Recommend to LIPI, Ministry of Home Affairs, Provincial and District Government, non-governmental organizations (NGOs), and other related institutions to prepare disaster risk reduction modules and conduct training of trainers on regular basis.

**Recommendation III —Tsunami Exercise**

Noting that the Tsunami Warning Center should issue the warning in a timely manner to the right addresses;

Considering that the system should be capable of trans-

*Dr. Fauzi, Head Indonesia  
BMG Tsunami Division*



mitting the warning to the public appropriately and in a timely manner;

Learning from the experience of the Philippines and other communities conducting community-based, end-to-end national tsunami drills during the Tsunami Exercise Pacific Wave '06 held May 16-17, 2006;

Recommend to all involved governmental institutions, including BMG, BAKOSURTANAL, BPPT, LIPI, KOMINFO, Ministry of Home Affairs, and other agencies under the coordination of Ministry of Research and Technology, Red Cross, NGOs, provincial and district governments, to start immediately mobilizing resources to prepare and plan a drill and exercise on the simulation of tsunami warning on the occasion of second commemoration of the Aceh earthquake-tsunami on 26 December 2006;

Recommend the next site for the simulation would take place, by priority, in: a) Bali, b) Banten, or c) NTT;

Recommend that 26 December be designated as "Disaster Reduction Day" in Indonesia;

Invite the international community to observe the drill in Indonesia on 26 December.

**Recommendation IV—Legal Framework**

Noting the importance of designating clear authorities responsible for ensuring public safety during tsunamis and other disasters;

Recommend with urgency to finalize the Disaster Management Law and related decrees to include clear responsibilities and institutional arrangements for an end-to-end TWS;

Provide for the necessary capacities for each agency or institution to carry out their responsibilities.

**ITIC-PTWC NEWS****IOC-USGS Seismology & Tsunami Warning Training**

**Jakarta, Indonesia, 8-17 May 2006**

**Bangkok, Thailand, 15-22 May 2006**

A 7-day training course in seismology and tsunami warnings was held in Jakarta and Bangkok during the month of May 2006. The goal of the trainings was to develop a scientific baseline for recently hired staff that will support tsunami warning operations in each country. Topics covered included general seismology, including seismic waves, earthquake location and source characterization and tsunami science, warning operations and mitigation. A collaboration between the IOC and USGS, the training was funded by IOC and USAID, and organized by ITIC and USGS-IOTWS Coordinator Dr. Walter Mooney. International lecturers were invited from India, Indonesia, Canada, IOC, PTWC, JMA, and the USGS. Held at the Department of Mineral Resources,



*Participants in the training session held in Jakarta, May 2006.*

Bangkok, the training was attended by five meteorologists from the Thai Met Office, five geologists from the Department of Mineral Resources, and twelve employees of the National Disaster Warning Center (NDWC). It was one of four training sessions in seismology and tsunami

**Training, continued**

warning systems co-sponsored by the IOC and USGS.

The training was also held in Sri Lanka 4-7 April 2006 and planned for Malaysia and the Maldives in August 2006. At the end of each training, a Roundtable discussion was held with senior high-level officials from different national agencies to discuss progress with the goal of cooperatively recommending actions for implementation of an effective warning system.

### **UNESCO-IOC International Training Course on Tsunami Numerical Modeling:**

#### **Course I: Tsunami Sources & Tsunami Propagation**

**Kuala Lumpur, Malaysia, 8-19 May 2006**

**Oostende, Belgium, 5-16 June 2006**

In order to address the immediate need to develop the capability for conducting tsunami modeling, training is being funded by the UNESCO Intergovernmental Oceanographic Commission (IOC). Training Courses on Tsunami Numerical Modeling. Organized by its International Tsunami Information Centre (ITIC) and coordinated with the IUGG/TC. The ITIC has engaged a Group of Experts to design, build, and teach the courses. These include, Dr. Emile Okal (Northwestern University, Illinois), Dr. Costas Synolakis (University of Southern California and Technical University of Crete), Dr. Vasily Titov (NOAA PMEL, Seattle), Dr. Kenji Satake (IUGG TC Chair), Dr. Andrey Zaytsev (Nizhny Novgorod State Technical University, Russian Federation) and Dr. Ahmet Yalciner (Middle East Technical University, Turkey). The courses use software developed by Dr. Efim Pelinovsky (Russian Academy of Sciences, Russian Federation).

The first session of Course I was conducted in Malaysia and was hosted by the Malaysia Centre for Remote Sensing (MACRES) and Malaysia's National Oceanography Directorate (NOD) and Astronautic Technology Sdn Bhd (ATSB). Similarly, the courses was held in

Belgium, where it was hosted by the IOC IODE Project Office. Participants were nominated by the governments from the Indian Ocean region and included PTWS Australia, Indonesia, Japan, Malaysia, Singapore and Thailand.

The two-part training course builds upon the advanced International Training Workshop on Numerical Modeling of Tsunami for Developing Countries in Southeast Asia, the Pacific, and the Indian Ocean, held 9-19 November 2005 in the Philippines and hosted by The Philippine Institute of Volcanology and Seismology (PHIVOLCS). The course included instruction by Dr. Modesto Ortiz (Mexico) and Dr. Yuichiro Tanioka (Hokkaido University). Following these three sessions, Course I has been taught to 75 individuals from 31 countries.

The course concentrates on providing the background in geology and geophysics, seismology, oceanography and tsunami science to understand the problem to be solved, and training in the numerical propagation of tsunami waves from a number of different source configurations to understand the effects of initial boundary conditions on the different models used for computation. The training includes hands-on computer work to calculate the tsunami wave effect from a number of different plausible sources with the goal of contributing to the creation of regional tsunami hazard maps for the Indian Ocean based on several worst-case scenario earthquakes and tsunamis generated off of Indonesia and Pakistan.

Course II, Tsunami Inundation/Evaluation, concentrates on tsunami inundation modeling in which the result will be an inundation map, using the propagation of the tsunami wave from the source to offshore using linearized, deep-water numerical methods, followed by the propagation onshore to calculate inundation and runup using non-linear shallow-water numerical methods. Course II: is planned to be conducted between the end of 2006 and into 2007.

*Left, One of the expert lecturers, PTWC's Stuart Weinstein makes a presentation during the Indonesia training session, Right, Participants of the modeling training session in Malaysia.*



*Left: Participants attending the modeling training course in Belgium. Right: Visit to Malaysia National Tsunami Warning Centre during training session in Kuala Lumpur.*



## WORKSHOP AND MEETING SUMMARIES

### Great Earthquake Tsunami Sources: Empiricism & Beyond Menlo Park, California, USA, 21-22 April 2006

A tsunami sources working group at the USGS Menlo Park (led by Stephen Kirby, Eric Geist, and Willie Lee) held a workshop on April 21-22, 2006 that was co-sponsored by the Coastal & Marine Geology and Earthquake Hazards Programs of the USGS. The theme of the workshop was Great Earthquake Tsunami Sources: Empiricism & Beyond Empiricism. In support of efforts to upgrade tsunami warning capabilities, the main objective of the workshop was to determine whether or not there are geologic or tectonic controls on the

occurrence of  $M > 8.5$  earthquakes along the world's subduction zones. This workshop was well attended by over 90 scientists from around the world, including Australia, Canada, Germany, Japan, New Zealand, Puerto Rico, Taiwan, and Thailand. Results from this workshop provided guidance on new directions for future tsunami research.

Workshop details, including presentation abstracts, can be found at: <http://walrus.wr.usgs.gov/tsunami/workshop/index.html>.

### Pacific Island Countries Workshop Melbourne, Australia, 1-2 May 2006

A workshop was held prior to PTWS XXI in Melbourne to acquaint Pacific Island Countries (PICs) with tsunami warning in the Pacific. Supported by Geoscience Australia, Emergency Management Australia and the Australian Department of Foreign Affairs and Trade, the workshop was sponsored by Ray Canterford, the ICG/PTWS National Contact for Australia and convened by Rick Bailey, both from Australia's Bureau of Meteorology (BOM).

Participants from nine island nations (Cook Islands, Fiji, Nauru, Niue, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu) were brought together for two days to be briefed on tsunami hazards and tsunami warning system messages and procedures. Guidelines on tools available were provided. Countries reported on their response capabilities in order to share information on capabilities and capacity building need in the region. Participants were briefed on all aspects of tsunami



*Pacific Island Country Workshop participants meet at Australia BOM offices in Melbourne, 1-2 May 2006.*

mitigation programmes and encouraged to participate in the ICG/PTWS meeting and working groups.

### Third Tsunami Symposium of the Tsunami Society Honolulu Hawaii, USA, 23-25 May 2006

*George Pararas-Carayannis, former ITIC Director, PO Box 8523, Honolulu HI 96815 USA, [itmc@pixi.com](mailto:itmc@pixi.com).*

The Third Tsunami Symposium of the Tsunami Society took place 23-25 May 2006 at the East-West Center at the University of Hawaii (UH), in Honolulu. Dr. Gary Ostrander, UH Vice Chancellor for Research, gave the welcoming address. Other welcoming addresses were given by Dr. Barbara Keating, Symposium Chairperson and Tsunami Society President, and by Dr. Charles Mader, Symposium Program Chairman and editor of *The Science of Tsunami Hazards*. The Symposium included several theme sessions over a three-day period, poster presentations, a banquet and awards

ceremony, and a field trip after its conclusion. The Third Tsunami Symposium was a very successful conference attended by many scientists from several countries.

Emphasis in the Third Tsunami Symposium program was given to the Indian Ocean Tsunami of 26 December 2004 and what was learned from it. Several members of the Tsunami Society had participated in extensive surveys of nations affected by the disaster and reported on their findings. Papers were presented on the US response to the Indian Ocean Tsunami, field observations, numerical modeling and tsunami risk management.

The 2006 Tsunami Symposium program, abstracts and



### TS meeting, *continued*

complete presentations were published in a special Tsunami Symposium issue of the *Science of Tsunami Hazards*, which can be found at: <http://www.sthjourn.org/tsabst/prog.htm>.

The symposium banquet and awards ceremony took place at Treetops Restaurant in Manoa. Dr. Zygmunt Kowalik, was the after-dinner-speaker. His presentation on the numerical modeling of the Great 2004 Indian Ocean Tsunami, entitled "Around the World in 200 Million Cells" was followed by the Third Tsunami Symposium awards ceremony. The 2006 awards of the Tsunami Society were given to Dr. Zygmunt Kowalik, Dr. Eddie Bernard, Mrs. Karen O'Loughlin and Dr. Barbara Keating, in recognition of outstanding and original contributions to *The Science of Tsunami Hazards*.

The Tsunami Society held a business meeting to elect officers and to discuss future plans and the organization of the Fourth Tsunami Symposium to be held on 26-28 May 2009 at the East-West Center, at the University of Hawaii, in Honolulu, Hawaii. Abstracts of presentations at this symposium are due on 1 February 2009 and papers are due on 1 March 2009.

Following the symposium, a field trip led by Dr. Charles Helsley, Dr. Barbara Keating and Dr. Dan Walker took participants to sites on the southeastern side of the island of Oahu, to view the geology of Honolulu Series Volcanics and see deposits of tsunami and storm activity, including those of the 1946 Tsunami.



*Top: Tsunami Society Symposium participants in Tsunami Science Investigators (TSI) safety vests, presented as part of the programme. Bottom: 2006 Tsunami Award recipients honored at the banquet, pictured with spouses. from left, Dr. Barbara Keating of the University of Hawaii with her husband to the left, Karen O'Laughlin of Boulder, Colorado, with her husband to her right and Dr. and Mrs. Zygmunt Kowalik of the University of Alaska. Missing: Dr. Eddie Bernard of NOAA's Pacific Marine Environmental Laboratory (PMEL). Photos courtesy of Lori Nottingham.*

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

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

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