

## Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System



# TSUNAMI NEWSLETTER



## International Tsunami Information Centre

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### Twenty-fourth Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS)



Fifty-one (51) participants from 16 Member States gathered for the twenty fourth session of the ICG/PTWS. Photo courtesy of IOC.

## SUMMARY OF EARTHQUAKES

1 APRIL - 30 JUNE 2011

Reported by: International Tsunami Warning Centres  
 Compiled by: International Tsunami Information Centre, ITIC

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

DATE	TIME (UTC)	LOCATION	EPICENTRE	DEPTH (km)	$M_w$	PTWC (P), JMA (J) or WC/ATWC (A) ACTION	ACTION TIME (UTC)	TSUNAMI? DAMAGING?	MAXIMUM MEASUREMENT and LOCATION
3-Apr	20:07	South of Java Indonesia	9.786° S 107.749° E	18	6.7 (G, P)	(P) 01 TIB	20:15	NO	
7-Apr	13:11	Chiapas Mexico	17.431° N 93.978° W	152	6.5 (G) 6.7 (P)	(P) 01 TIB	13:19	NO	
7-Apr	14:32	Near East Coast of Honshu Japan	38.253° N 141.640° E	53	7.1 (G) 7.4 (J, P)	(J) 01 NWPTA (P) 01 TIB	14:38 14:39	YES NO	8 cm (amp) (g) Ofunato, Japan
11-Apr	08:16	Near East Coast of Honshu Japan	37.007° N 140.477° E	12	6.6 (G) 7.1 (A, J, P)	(J) 01 NWPTA (P) 01 TIB (A) 01 TIS	08:24 08:25 08:26	NO	
18-Apr	13:03	South of Kermadec Islands	34.34° N 179.87° E	98	6.7 (A, P) 6.6 (G)	(P) 01 TIB (A) 01 TIS	13:11 13:13	NO	
23-Apr	04:17	Solomon Islands	10.349° S 161.233° E	78	6.9 (A, G, J, P)	(P) 01 TIB (A) 01 TIS (J) 01 NWPTA	04:25 04:26 04:31	NO	
10-May	08:55	Loyalty Islands	20.252° S 168.273° E	14	7.1 (A, P) 6.8 (G)	(P) 01 TIB (A) 01 TIS	09:02 09:03	NO	
15-May	18:37	Solomon Islands	6.12° S 154.40° E	54	6.6 (A, P) 6.5 (G)	(P) 01 TIB (A) 01 TIS	18:52 20:40	NO	
21-May	00:16	South Sandwich Islands Region	56.066° S 27.165° W	45	5.9 (G) 6.5 (P)	(P) 01 TIB	00:28	NO	
2-Jun	11:51	West of Macquarie Island	55.944° S 146.588° E	12	6.3 (G) 6.5 (P)	(P) 01 TIB	12:03	NO	
16-Jun	00:04	New Britain Region P.N.G.	5.994° S 151.095° E	21	6.6 (A, G, J, P)	(P) 01 TIB (J) 01 NWPTA (A) 01 TIS	00:11 00:20 00:47	NO	
20-Jun	16:36	Chile-Bolivia Border Region	21.898° S 68.299° W	135	6.5 (G) 6.6 (A, P)	(P) 01 TIB (A) 01 TIS	16:46 16:48	NO	
22-Jun	21:50	Near East Coast of Honshu Japan	39.980° N 142.247° E	43	6.7 (A, G, J, P)	(J) 01 NWPTA (P) 01 TIB (A) 01 TIS	21:57 21:59 22:00	NO	
24-Jun	03:10	Fox Islands, Aleutian Islands	52.008° N 171.859° W	70	7.3 (A, P) 7.2 (G)	(A) 01 TWW (P) 01 TIB (A) 02 TWW (A) 03 TWW	03:15 03:20 03:42 04:19	YES NO	10 cm (amp) (g) Nikoski, Alaska, USA

## Executive Summary

The Twenty-fourth Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS-XXIV) was held in Beijing, China, from 24-27 May 2011 under the Session Chairmanship of Lt Giorgio de La Torre, Chair of the ICG/PTWS. It was attended by 51 participants from 16 ICG/PTWS Member States and representatives from one organization (WDC/NGDC). The main outcomes of PTWS-XXIV were 1) agreement on Exercise Pacific Wave 2011 (PacWave11) date, format (10 scenarios), and 2) acceptance of Pacific Tsunami Warning Center (PTWC) proposal for new products, which will include forecasts and move away from watch/warnings to threat levels based on forecasted wave amplitudes.

The **ICG decided** to continue Working Group (WG) 1 on Tsunami Risk Assessment and Reduction with Dr François Schindelé (France) as Chair, and established a Task Team on Tsunami Modelling Hazard Assessment (Chair: Dr V Titov–USA) and a Task Team on Tsunami Risk Assessment (Chair: Dr Nguyen Hong Phuong–Vietnam).

The **ICG agreed** to continue Working Group 2 on Tsunami Detection, Warning and Dissemination with Dr Chip McCreery (USA) as Chair and Mr Daniel Jaksa (Australia) as Vice-Chair, and continued WG2 Task Team on Warning Dissemination (formerly Emergency Communications), WG2 Task Team on PACWAVE 11 (formerly PTWS Exercises), WG2 Task Team on Enhancing Products (formerly Enhancing Tsunami Warning Products), WG2 Task Team on Seismic Data Sharing in the South West Pacific, and **established** a WG2 Task Team on Sea Level Monitoring with Mr Chris Ryan (Australia) as Chair.

The **ICG agreed** that Member States should regularly review the information on Tsunami Warning Focal Points (TWFPs) and Tsunami National Contacts (TNCs) at the IOC password protected website for accuracy and advise the IOC Secretariat regarding any errors or changes.

The **ICG agreed** that the PTWC should disseminate a communication test message once a month on the same day and at the same time to the PTWS Member States TWFPs. Member States should ensure they receive these regular tests by all designated means and troubleshoot with PTWC or other appropriate organizations only if any message is not received by the designated method. In addition, PTWC will conduct twice yearly unannounced communication tests. Member States should respond to these tests within an hour, indicating the methods by which

the message was received and the time at which it was received. Testing will begin in October of 2011. Member States' TWFPs and TNCs will be informed in advance regarding details on the conduct of these tests by an IOC circular letter.

The **ICG requested** the Secretariat to inquire by October 2011 of PTWS Member State TWFPs regarding their need to receive PTWC message products by fax.

The **ICG agreed** that all PTWS Member States having offshore sea level data, such as that from undersea cabled observatories, from differential GPS buoys, or from deep-ocean bottom pressure sensors connected to buoys, should share those data for tsunami detection and warning purposes.

The **ICG requested** the IOC Secretariat to seek funds for follow-up training in the configuration and use of seismic monitoring and analysis systems for Member States in the SW Pacific.

The **ICG decided** to continue Working Group 3 on Tsunami Awareness and Response with Mr David Coetzee (New Zealand) as Chair.

The **ICG decided** to continue the Regional Working Group on Tsunami Warning and Mitigation on the Central American Pacific Coast with Mr Alejandro Rodriguez (Nicaragua) as Chair.

The **ICG accepted** the offer of SHOA (Chile) of hosting in 2011 a seminar focused on numerical modelling of tsunami risk scenarios and requested the Secretariat and other regional organizations and donors (i.e. CPP, SOPAC, CEPREDENAC, and USAID) to seek/ contribute funding for this event.

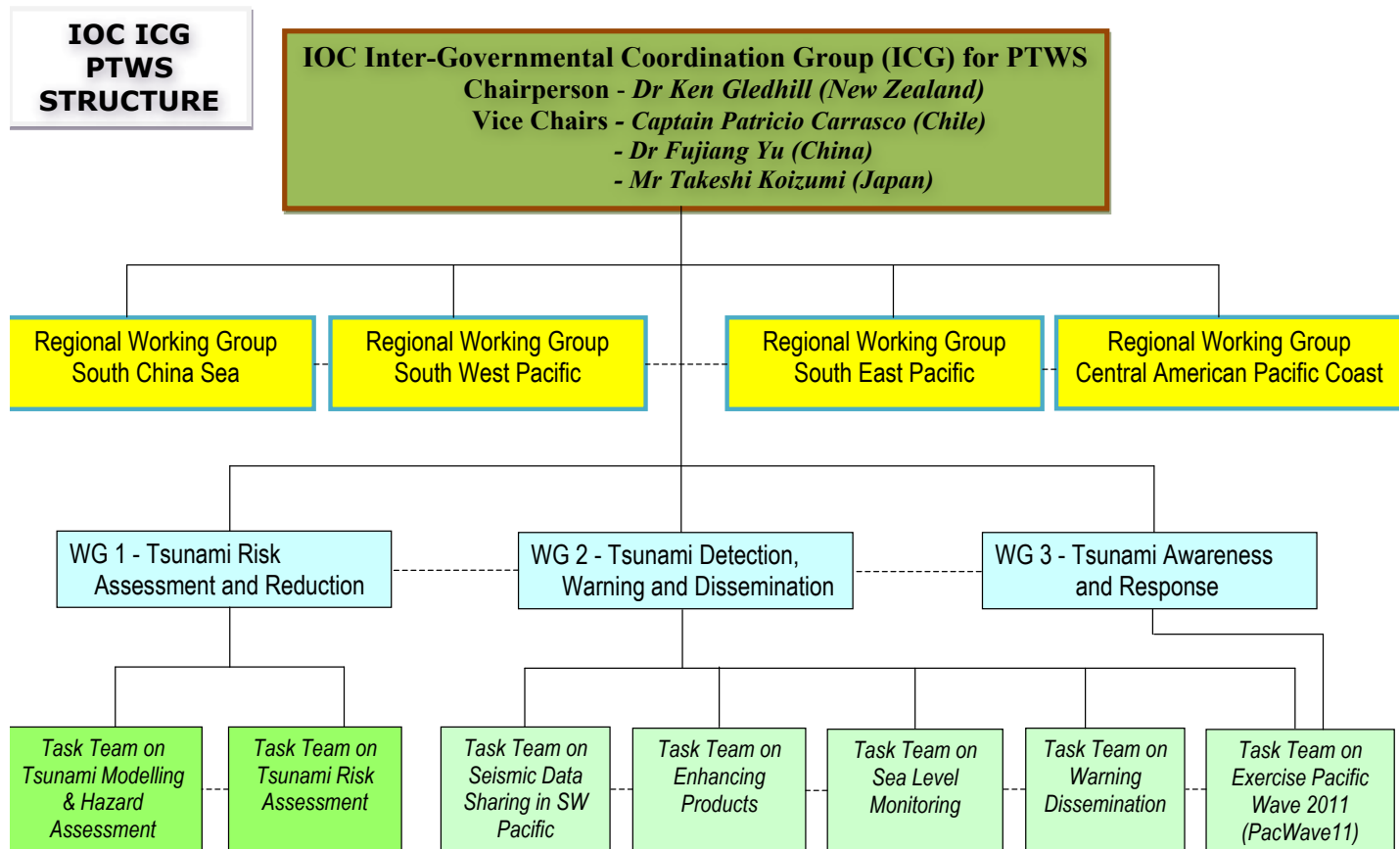
The **ICG decided** to continue the Regional Working Group on Tsunami Warning and Mitigation in the Southeast Pacific Region with Lt Cmdr Edwin Pinto (Ecuador) as Chair.

The **ICG decided** to continue the Regional Working Group on Tsunami Warning and Mitigation in the South China Sea Region with Dr Mohd. Rosaidi bin Che Abas (Malaysia) as Chair and Dr Fujiang Yu (China) as Vice-Chair.

The **ICG decided** to continue the Working Group on Tsunami Warning and Mitigation in the Southwest Pacific Region and elected Ms Filomena Nelson (Samoa) as the Chair and Mr Don Anderson (Australia) as Vice Chair.

The **ICG agreed** that PTWC should proceed with its development of improved tsunami procedures and products.



Executive Summary, *continued*

*Courtesy of IOC.*

The **ICG further agreed** to continue the Task Team on Enhancing Products (renamed) under WG2 to guide and provide feedback to PTWC regarding these changes and requested the Task Team Chair to provide a report on the recommendations and any implementations at ICG/PTWS-XXV.

The **ICG also agreed** that any new products and procedures only be exercised in an experimental mode as they are developed and until they are approved for official use later by the ICG.

The **ICG agreed** that the PACWAVE 11 exercise be conducted on 9 and 10 November 2011 and include several tsunami scenarios that can be independently selected by each Member State for their practice. Each scenario will be initiated by PTWC, NWPTAC, and or WC/ATWC with a message product announcing its start.

The **ICG agreed** to task the PTWS Steering Committee with finalising the PTWS Funding Strategy and complete the information about existing funding towards the three pillars of the PTWS Implementation Plan.

The **ICG encouraged** Member States to include

representation of National Disaster Management Organizations (NDMO's) in their delegations to the ICG and inter-sessional Working Groups.

The **ICG thanked** the Russian Federation and agreed to hold the ICG/PTWS-XXV in Vladivostok, Russian Federation, on August–September 2013.

The **ICG noted** the interest indicated by USA of hosting its Twenty-Sixth session in 2015.

The **ICG elected** Dr Ken Gledhill (New Zealand) as Chair and Captain Patricio Carrasco (Chile), Dr Fujiang Yu (China) and Mr Takeshi Koizumi (Japan) as Vice-Chairs for the ICG/PTWS for the period May 2011–May 2013.

## ICG/PTWS-XXIV Recommendations

### Recommendation ICG/PTWS-XXIV.1 PTWS Governance

The Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS),

**ICG/PTWS-XXIV Recommendations, *continued***

**Having met** for its 24th Session from 24 to 27 May 2011 in Beijing, China,

**Expresses** its deep condolences to the people of Samoa, Chile, Indonesia and Japan for the loss of many lives caused by the earthquakes and tsunamis in 2009, 2010 and 2011;

**Recalling** IOC Resolution IV–6 that established the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) and IOC Resolution XXXIX-8 that renamed ITSU to be the Pacific Tsunami Warning and Mitigation System (PTWS) and to provide continuity through the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS),

**Reaffirming** that the Pacific Tsunami Warning and Mitigation System (PTWS) will be a coordinated network of national systems and capacities, and will be part of a global network of early-warning systems for all ocean-related hazards,

**Reaffirming further** that each Member State has the responsibility to issue warnings within its respective territories,

**Noting** with appreciation the tsunami forecasting guidance materials provided for the Member States of the PTWS by the PTWC hosted by the USA and the NWPTAC hosted by Japan,

**Recalling** the Mauritius Declaration adopted at the Intergovernmental Coordination Meeting held at Grand Baie, 14–16 April 2005 to openly share and exchange tsunami-relevant realtime observational data in accordance with the UNESCO/IOC Oceanographic Data Exchange Policy,

**Having noted** IOC Resolution XXV-13 outlining the requirements for the future development of tsunami warnings, which established the TOWS-WG Inter-ICG Task Teams on Sea Level for Tsunami Purposes, Disaster Management and Preparedness, and Tsunami Watch Operations,

**Having reviewed** the progress made in the implementation of the PTWS since the 23rd Session of the ICG/PTWS,

**Having considered** the reports of:

- Working Group 1 on Tsunami Risk Assessment and Reduction

- Working Group 2 on Tsunami Detection, Warning and Dissemination and its Task Teams
- Working Group 3 on Tsunami Awareness and Response
- Regional Working Group on Tsunami Warning and Mitigation on the Central American Pacific Coast
- Regional Working Group on Tsunami Warning and Mitigation in the South East Pacific Region
- Regional Working Group on Tsunami Warning and Mitigation in the South West Pacific Region
- Regional Working Group on Tsunami Warning and Mitigation in the South China Sea
- 2nd Meeting of the PTWS Steering Committee held in Hawaii, USA, 17-20 August 2010
- Fourth Meeting of the TOWS-WG (Paris, 21–22 March 2011)
- North West Pacific Tsunami Advisory Center (NWPTAC)
- Pacific Tsunami Warning Center (PTWC)
- International Tsunami Information Centre (ITIC),

**Recognizing** the difficulty in providing effective near-field tsunami warning in the recent events in Japan, Chile, and Samoa,

**Acknowledging** that the PTWS is effective in saving lives and reducing the impacts to communities in both near-field and distant-tsunami events through the three pillars of risk assessment and reduction, detection, warning and dissemination, and awareness and preparedness,

**Noting** the recommendations of the TOWS-WG of the need by ICGs to evaluate the impact and value of real time observations for tsunami warning,

**Appreciates** the recent report of the JCOMM Data Buoy Cooperation Panel and endorses the recommendations to help decrease the incidence of data buoy vandalism and seek to better understand the causes of damage and promote the importance of these observing systems for critical tsunami warning systems;

**Encourages** voluntary contributions to support Budget

**ICG/PTWS-XXIV Recommendations**, *continued*

and Programme activities recommended by the ICG/PTWS either directly or through the IOC Special Account set up for the PTWS;

**Recognizing** the limited capacity of many Member States of the PTWS in hazard assessment and risk reduction;

**Requests** Member States to regularly review the list of Tsunami National Contacts (TNCs) and Tsunami Warning Focal Points (TWFPs) on the IOC website and inform the Secretariat of all changes;

**Requests** Member States to share any new forms of sea level data for tsunami warning purposes in accordance with the IOC Oceanographic Data Sharing Policy;

**Requests** PTWC not to use the terminology “warning” in its guidance to Member States in its new products on the tsunami threat across the region;

**Decides to:**

## 1. Continue existing Working Groups (WG):

WG1. Tsunami Risk Assessment and Reduction, with modified Terms of Reference as attached in Annex, Chair Dr François Schindelé (France);

WG2. Tsunami Detection, Warning and Dissemination, with modified Terms of Reference as attached in Annex, Chair Dr Charles McCreery (USA) and Vice-Chair Mr Daniel Jaksa (Australia);

- WG2 Task Team on Warning Dissemination
- WG2 Task Team on PACWAVE 11
- WG2 Task Team on Enhancing Products
- WG2 Task Team on Sea Level Monitoring
- WG2 Task Team on Seismic Data Sharing in the South West Pacific

WG3. Tsunami Awareness and Response, with Terms-of-Reference as attached in Annex, Chair Mr David Coetzee (New Zealand).

Sub-Regional Working Groups:

- Regional Working Group on Tsunami Warning and Mitigation on the Central American Pacific Coast, Chair Dr Alejandro Rodriguez (Nicaragua).

- Regional Working Group on Tsunami Warning and Mitigation in the South East Pacific Region, with modified Terms of Reference as attached in Annex, Chair Lt Edwin Pinto (Ecuador) and Vice-Chair to be nominated (Peru).
  - Regional Working Group on Tsunami Warning and Mitigation in the South West Pacific Region, Chair Ms Filomena Nelson (Samoa) and Vice-Chair Mr Don Anderson (Australia).
  - Regional Working Group on Tsunami Warning and Mitigation in the South China Sea with modified Terms of Reference as attached in Annex, Chair Dr Mohd Rosaidi bi Che Abas and Vice-Chair Dr Fujiang Yu (China).
2. Establish a WG1 Task Team on Tsunami Modelling Hazard Assessment with Terms of Reference as attached in Annex; Chair Dr Vasily Titov (USA);
  3. Establish a WG1 Task Team on Tsunami Risk Assessment with Terms of Reference as attached in Annex; Chair Dr Nguyen Hong Phuong (Vietnam);
  4. Continue the Steering Committee with modified Terms-of-Reference as attached in Annex;
  5. Disseminate a communication test message from the PTWC once a month on the same day and at the same time every month and two random unannounced tests annually to the PTWS Member State TWFPs starting October 2011;
  6. Conduct training workshops on hazard and risk assessment organised by WG1 in coordination with IUGG to enhance collaboration between the operational and research communities as recommended by the TOWS-WG, subject to extra-budgetary funding support being identified;
  7. Proceed with PTWC’s development of improved tsunami procedures and products with the Task Team on Enhancing Products guiding and providing feedback and related documentation to PTWC and the ICG/PTWS regarding these changes, in accordance with the timeline in Annex V. Any new products and procedures will only be exercised in an experimental mode as they are developed and until they are approved for official use later by the ICG/PTWS.

**ICG/PTWS-XXIV Recommendations, *continued***

**Requests** the Executive Secretary to:

1. Inform Member States of the timing and conduct of the PTWS communications tests by circular letter,
2. Survey the PTWS Member State TWFPs regarding their need to receive PTWC message products by fax by October 2011,
3. Inform the Member States about the website for TNC and TWFP contact details, provide them with passwords and advise them of the procedures for updating contact details,
4. Mobilise extra budgetary resources for follow up training in the configuration and use of seismic monitoring and analysis systems for Member States in the SW Pacific,
5. Also organize documentation on the IOC Tsunami website by discipline/topic to facilitate access and utility of reference material across Working Groups and ICGs,



*Dr. Vasily Titov (USA) and Dr. François Schindelé (France) confer on Working Group issues. Photo courtesy of L. Kong.*

**Encourages** Member States to include representation of National Disaster Management Organizations (NDMO's) in their delegations to the ICG and inter-sessional Working Groups;

**Instructs** the PTWS Steering Committee to finalise the summary of existing funding available to the PTWS from national, bilateral and multilateral sources to develop a strategy for funding ICG/PTWS activities, to be reported at ICG/PTWS-XXV;

**Expresses its gratitude** to the Government of China

for kindly hosting the 24th Session of the ICG/PTWS in Beijing;

**Accepts with appreciation** the kind offer of the Russian Federation to host the 25th Session of the ICG/PTWS in Vladivostok in the time frame August or September 2013 subject to the approval of the Government, and

**Accepts with appreciation** the interest of USA to host the 26th session of the ICG/PTWS in Honolulu in 2015, subject to the approval of the Government.

### **Annex to Recommendation ICG/PTWS-XXIV.1**

#### **Working Groups and Steering Group Terms of Reference (TOR)**

#### **Terms of Reference Working Group 1: Tsunami Risk Assessment and Reduction**

1. Review and report on existing arrangements with regard to tsunami hazard identification and characterization;
2. Advise on credible seismic scenarios that need to be captured for numerical tsunami modelling e.g., location, magnitude, rupture, orientation, dip, and probability of occurrence;
3. Review details on models that are currently used or in development and desirable standards of documentation (model inputs and outputs etc.);
4. Explore cooperation regarding coastal inundation models, including appropriate requirements for bathymetry;
5. Develop guidance on mandatory metadata including details of bathymetry, hydrography and topography;
6. Consider the issue of assessing hazard, vulnerability and risk, including the facilitation of access to models and mitigation measures;
7. Liaise with Working Groups from the other ocean basins, as well as other working groups within ICG/PTWS to coordinate and ensure efficient and effective information for tsunami warning and mitigation.

The Group will be composed of members nominated by Member States, with a Chair and a Vice-Chair to be elected.



**ICG/PTWS-XXIV Recommendations, *continued***WG1 Task Team on Tsunami Modelling Hazard Assessment

Chair Dr Vasily Titov (USA).

## Terms of Reference:

1. Develop relevant methodology and recommend standards for tsunami modelling for hazard assessment;
2. Define and recommend tsunami risk and hazard assessment products, for planning and/or real-time hazard assessment.

WG1 Task Team on Tsunami Risk Assessment Chair  
Dr Nguyen Hong Phuong (Vietnam).

## Terms of Reference:

1. Define relevant methodology and required data and products for tsunami risk assessment based on existing ones;
2. Establish links with the WG3 activities, in particular the required products.

**Terms of Reference Working Group 2: Tsunami Detection, Warning and Dissemination**

1. Review and report on existing arrangements with regard to seismic, sea level and other kind of measurements, data collection and exchange;
2. Advice on how best to ensure that all events likely to cause tsunami can be reliably located and sized in a timely manner;
3. Review and make recommendations regarding upgrades and enhancements to the PTWS seismic and sea level stations and networks, communications, processing and analysis, particularly those that are important for the rapid characterization of earthquakes capable of generating local tsunamis, to further reduce the time required for source characterization to meet desired warning responses;
4. Liaise with the appropriate organizations and relevant experts to ensure effective data representation and code forms are used for the exchange of data (standards, metadata requirements);
5. Review and report on various means of transmitting data to warning centres, and conduct

tests of latency (timeliness) of transmissions as required;

6. Coordinate the development and operational implementation of [the upstream part of] warning systems in the Pacific;
7. Liaise with Working Groups from the other ocean basins, as well as other working groups within ICG/PTWS to coordinate and ensure efficient and effective information for tsunami warning and mitigation;
8. Coordinate and ensure training on existing and new operational procedures and products;
9. Coordinate regular exercises to test the end-to-end performance of the PTWS;
10. Review and report on various means of transmitting warning products end-to-end to improve their efficiency and effectiveness.
11. The Group will be composed of members nominated by Member States, with a Chair and a Vice-Chair to be elected.

WG2 Task Team on Warning Dissemination

Co-Chairs Ms Filomena Nelson (Samoa), and Mr Edward Young (USA).

## Terms of Reference:

1. To encourage Member States to develop arrangements for the transmission and receipts of tsunami warning alerts from international centres, and the dissemination of alerts and public safety actions within their countries;
2. To provide a forum to identify methods and systems currently available and planned for the future for alert dissemination within Member States, and internationally across the Pacific, and between oceanic basins;
3. To consult with National Tsunami Warning Focal Points to determine appropriate requirements for the dissemination of alerts from the Tsunami Warning Centres and exchange of information for the confirmation of reception.

WG2 Task Team on PACWAVE 11

Co-Chairs Ms Jo Guard (New Zealand) and Dr Laura Kong (ITIC, USA).



**ICG/PTWS-XXIV Recommendations, *continued*****Terms of Reference:**

1. Identify lessons learned and develop recommendations based on the PACWAVE 08 evaluation and submit recommendations to the PTWS Steering Committee;
2. Design and carry out a third end-to-end Pacific-wide exercise with the following characteristics:
  - The exercise will take place preferably in the fourth quarter of 2011.
  - The exercise scenarios will be major tsunamis originating in various seismic zones of the Pacific to complement previous scenarios in other places.
  - The exercise date be finalized by the Task Team and the exercise announced to Member States at least 180 days in advance of the exercise date.
  - The exercise manual including instructions to Member States regarding their participation and the evaluation instrument be prepared with content and structure similar to what was prepared for the previous two Pacific-wide exercises, but taking into account lessons learned and any need to collect additional information.
  - The exercise manual be distributed to Member

States at least 90 days in advance of the exercise date.

- Participating Member States be asked to complete and return the evaluation instrument no more than 90 days following the exercise.
- The exercise be played out in real time.
- The exercise be considered as a way to test new products from the international TWCs including graphical products.

**WG2 Task Team on Enhancing Products**

Chair Dr Chip McCreery (USA).

**Terms of Reference:**

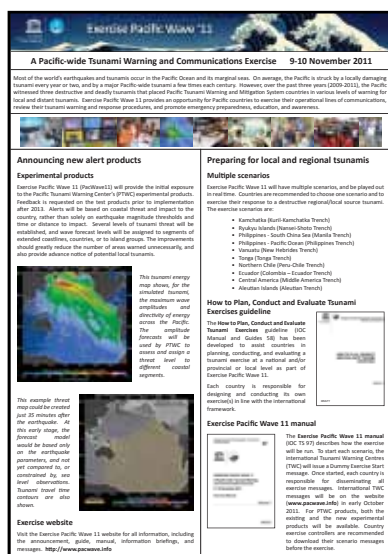
1. Review the capabilities and plans of the international TWCs with respect to their operational products and product dissemination for the PTWS;
2. Gather feedback from Member States regarding international TWC current and planned product content, format, and dissemination;
3. Consider best practices based on social science as well as the experiences of the Member States;
4. Consider the global harmonization of tsunami warning products and terminology;
5. Develop recommendations to improve current products and /or develop new products.

**WG2 Task Team on Sea Level Monitoring**

Chair Mr Chris Ryan (Australia).

**Terms of Reference:**

1. Review the PTWS Medium Term Strategy and make recommendations for upgrading and improvements relating to sea-level measurements, in coordination with GLOSS and the Data Buoy Cooperation Panel (DBCP) International Tsunami Partnership (ITP);
2. Review and recommend changes to the ICG/PTWS Implementation Plan in relation to sea-level monitoring;
3. Review and suggest changes to the procedures for assigning transmission slots for sea-level station data to meteorological geostationary satellites;



*PacWave11 will be conducted on 9-10 November 2011 to encourage countries to focus on responding to local and regional tsunamis. For more information, visit <http://www.pacwave.info>.*

**ICG/PTWS-XXIV Recommendations, *continued***

4. Review existing training documents and coordinate the organisation of a training workshop for sea-level instrument operators and users in 2011.

**WG2 Task Team on Seismic Data Sharing in the South West Pacific**

Chair Dr Ken Gledhill (New Zealand).

**Terms of Reference:**

1. To advocate seismic data sharing in the region;
2. To advise South West Pacific countries on data sharing protocols, techniques and technologies;
3. To work with SWP Countries and donors to ensure a common data sharing policy;
4. To ensure the recommendations of the ICG/PTWS-XXIII Sessional Working Group on Data Exchange in the South West Pacific are achieved.

**Terms of Reference Working Group 3: Tsunami Awareness and Response**

1. Promote good practice examples of capacity and resilience building and emergency management to improve the management of tsunami risk through mitigation, preparedness and response activities. Such measures include the following:
  - Preparedness: capacity assessments, education for public awareness, training, response and evacuation planning and exercising
2. Develop and codify good practices in emergency operations and evacuation plans and procedures through consistent Standard Operating Procedures (SOPs) and drills;
3. Liaise with Working Groups from the other ocean basins, as well as other working groups within ICG/PTWS to coordinate and ensure efficient and effective information for tsunami warning and mitigation.

The Group will be composed of members nominated by Member States, with a Chair and a Vice-Chair to be elected.

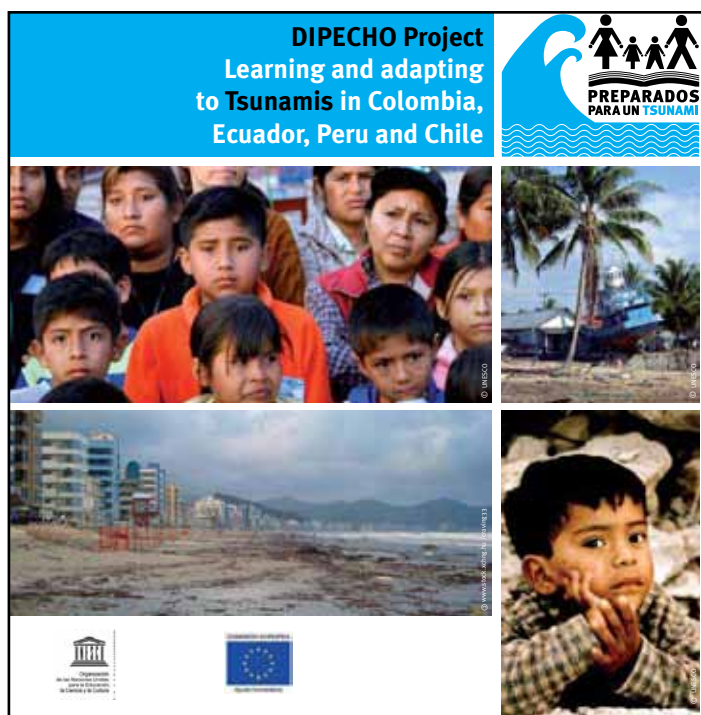
**Terms of Reference Working Group for the Central American Pacific Coast**

1. To assist the Central American countries in the development, improvement and implementation of their National Tsunami Warning and Mitigation Systems, and the countries which are becoming new members of ICG/PTWS in their integration into the ICG/PTWS;
2. To recommend Centro de Coordinación para la Prevención de los Desastres Naturales en América Central (CEPREDENAC) to determine whether the National Tsunami Warning Centres of Nicaragua or El Salvador (or of both countries cooperating) could act as interim Regional Tsunami Warning Centre disseminating warnings to all Central American countries;
3. To invite CEPREDENAC to consider the implementation of a Technical Committee for the Development of Regional Tsunami Warning and Mitigation Systems;
4. To implement a regional communications and warning plan;
5. To facilitate Tsunami Hazard and Risk studies in the Central American Region.

The Group will be composed of member from Member States Nicaragua, El Salvador, Guatemala, Costa Rica, Honduras and Panama (as soon as they finalized the formal procedure of joining ICG/PTWS), with a Chair and a Vice-Chair to be elected.

**Terms of Reference Working Group for the South East Pacific Region**

1. To identify current gaps on the warning and mitigation capabilities of countries in the South East Pacific Region based upon the lessons learned from the last tsunami events. Understand and prioritize the new requirements from countries in the Southeast Pacific Region for the tsunami warning and mitigation services, and group them under the three central pillars of the Medium Term Strategy 2009-2013;
2. To organize the working plan and structure of the South East Pacific Region taking into account the three central pillars of the Medium Term Strategy 2009-2013;

ICG/PTWS-XXIV Recommendations, *continued*

*The project, Adaptive Learning Mechanism on Tsunami Preparedness in Coastal Communities of Colombia, Ecuador, Peru and Chile (2009-2010), is being implemented by the Regional Office of Education for Latin America and the Caribbean, and the Intergovernmental Oceanographic Commission (IOC) of UNESCO within the framework of the Sixth DIPECHO Action Plan for South America.*

3. To promote and facilitate tsunami hazard and risk studies in the region, through the active participation of appropriate national delegates from Member States, in the Working Group 1: Tsunami Risk Assessment and Reduction;
4. To facilitate cooperation in the establishment and upgrading of seismic and sea level stations and networks and communication systems in the region, and their interoperability in accordance with ICG/PTWS requirements, through the active participation of appropriate national delegates from Member States, in the Working Group 2: Tsunami Detection, Warning and Dissemination;
5. To improve the education programs with a regional criteria based on the regional social, cultural and economical reality, through the active participation of appropriate national delegates from Member States, in the Working Group 3: Tsunami Awareness and Response;
6. To facilitate capacity building and the sharing of

tsunami information in the region, including the free and open exchange of data;

7. To promote and facilitate the creation of in-region trainers in order to meet the regional needs of training.

The Group will be composed of representatives nominated by the Member States of Colombia, Ecuador, Peru and Chile, with a Chair from Ecuador.

### Terms of Reference Working Group for the South West Pacific Region

1. To continually review and evaluate capabilities of and make recommendations for improvements to countries in the Southwest Pacific Region for providing end-to-end tsunami warning and mitigation services;
2. To support the involvement and contribution of SWP countries in the activities of the ICG/PTWS;
3. To promote and facilitate the tsunami hazard and risk studies in the SWP region;
4. To facilitate cooperation in the establishment and upgrading of seismic and sea level stations and networks in the region, and the interoperability of these systems in accordance with ICG/PTWS requirements;
5. To facilitate training and capacity building in the end to end tsunami warning and mitigation system in the region;
6. To encourage the sharing of tsunami information in the region, including but not limited to the free and open exchange of data, and
7. To facilitate tsunami awareness in school curricula, and development and dissemination of public educational materials;
8. To work in cooperation with PTWS Working Group 3, especially on activities which strengthen country capacity in tsunami emergency response.

The Group to be comprised of representatives from Member States and territories of the Secretariat of the Pacific Community (SPC) as members and observers with Chair and Vice Chair to be elected by the members of the Working Group and endorsed by the ICG/PTWS.



**ICG/PTWS-XXIV Recommendations, *continued*****Terms of Reference Working Group for the South China Sea**

1. To evaluate capabilities of countries in the South China Sea Region for providing end- to-end tsunami warning and mitigation services;
2. To ascertain requirements from countries in the South China Sea for the tsunami warning and mitigation services;
3. To promote and facilitate tsunami hazard and risk studies in the region;
4. To facilitate cooperation in the establishment and upgrading of seismic and sea level stations and networks and communication systems in the region;
5. To facilitate improvement of the education programs on tsunami mitigation in the region;
6. To facilitate capacity building and the sharing of tsunami information in the region, including the free and open exchange of data.

The Group will be composed of members nominated by Member States Brunei, Cambodia, China, Indonesia, Malaysia, Philippines, Singapore, Thailand, Vietnam and invited experts with a Chair and Vice-Chair to be elected.



*Tsunami Exercise conducted as part of IOC Vietnam Tsunami Standard Operating Procedures training, September 2009. NZ & ITIC led the training. Photo courtesy of N. Phuong.*

**Terms of Reference Steering Committee:**

1. The Steering Committee shall act in an advisory

capacity to the Chair of the ICG/PTWS during the inter-sessional period;

2. The Steering Committee shall coordinate and integrate the work of ICG/PTWS in the inter-sessional periods, as implemented through the various technical and regional working groups and task teams, including but not limited to:
  - Maintain the PTWS Medium Term Strategic Plan.
  - Monitor, maintain and update the PTWS Implementation Plan.
  - Develop a Strategy for funding PTWS activities.
  - Monitor the performance of the PTWS.
3. The Steering Group will be composed of the ICG/PTWS Officers (Chair and three Vice- Chairs), Chairs of the Technical and Regional Working Groups, Directors of PTWC, NWPTAC and ITIC or their representatives, other members' representatives by invitation of the Chair.

**Recommendation ICG/PTWS-XXIV.2****Enhancing Tsunami Awareness and Response**

The Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS),

**Recognizing** that tsunami 'Awareness and Response' is recognized as one of the Pillars of the PTWS Medium Term Strategy,

**Also recognizing** that efficient tsunami 'Awareness and Response' is critical in the 'last mile' of any end-to-end tsunami warning system,

**Re-confirms** the role of the ITIC as the central point for the collation of good practice and delivery of training, and in conjunction with the relevant Working Groups, and in particular recent work towards the development of guidelines on exercises, Standard Operating Procedures and post event assessments, and therefore;

**Encourages** Member States to utilize these materials and environments in the development of their own exercises, processes and programmes to foster consistency within the PTWS;



**ICG/PTWS-XXIV Recommendations**, *continued*

**Agrees** that technical Working Group 3 assigned with Awareness and Response continues its work in support of the ITIC and its partners with regards to the development and standardization of Awareness and Response material and the delivery of training in this regard;

**Recommends** that the experience of ITIC be utilized in the design and implementation of regionalized training programmes to train trainers;

**Encourages** Member States to take advantage of the availability of distance learning environments such as through the IOC/IODE Ocean Teacher and US NOAA COMET as a means of economical training;

**Notes** that ICG Member States contribution to and participation in PTWS Technical Working Group 3 assigned with 'Awareness and Response' has been limited and that this limited involvement is attributed to a low level of Disaster Management Organisations (DMOs) presence in the ICG;

**Agrees** to enhance the partnership between science and disaster management in the PTWS;

**Encourages** Member States to ensure strong institutional partnerships with clear responsibilities among all stakeholders, in particular between NTWCs and DMOs within their countries;

**Considers** that a wealth of good practice and experience with regards to Awareness and Response exists within the PTWS, and also noting the high value of shared good practices from recent events;

**Invites** UNESCO/IOC, other potential donor organizations or Member States to fund regional workshops in which to share best practices in community based warning and preparedness, an example of which was conducted between Central America and the Caribbean in 2008, and/or specific in-country programmes to enhance tsunami response capacity;

**Recommends** that technical Working Group 3 maintains its cooperation with similar working groups of other ocean basin systems, and in particular with TOWS Task Team 2, Disaster Management and Preparedness;

Also **notes** that Working Group 3 is conducting a

survey among the National Tsunami Warning Centres (NTWCs) and DMOs of Member States to assess the status of Awareness and Response in the PTWS;

**Requests** all Member States to participate in the survey and Working Group 3 to develop a work plan based on the findings of the survey;

**Further notes** the emphasis on disaster risk reduction in international development programmes and the experience in the PTWS based on the 2009 Samoa, 2010 Chile and 2011 Japan tsunami;

**Encourages** international organizations to include a tsunami-specific focus as a benchmark end-to-end warning system in their development of disaster risk reduction programmes;

**Further notes** that International Tsunami Survey Teams (ITST) have conducted extensive post event surveys following the 2009 Samoa, 2010 Chile, and 2011 Japan tsunami and that data from these surveys can be of value to the affected country;

**Urges** ITST scientists to coordinate their surveys with the UNESCO/IOC, utilise the IOC Post-Tsunami Field Survey Guide in planning and conducting their surveys and to share their preliminary data, findings, and outcomes of their analysis in a timely manner with the affected country;

**Requests** the Executive Secretary and ITIC to work through the governments of affected countries in order to facilitate coordination of the ITSTs, including calls for nominations and approval of national participation through Tsunami National Contacts.

**Financial implications:**

Extra budgetary funding is required for:

- Regional best practice workshops and/or in-country programmes, including travel costs for presenters and some delegates.
- Offering and attending (some Member States) regional 'Training of Trainers'.
- Working Group members to attend an inter-sessional Working Group meeting (could be held back-to-back with one of the above) and for a Working Group delegate to attend a meeting of the Inter-ICG Task Team 2.

**ICG/PTWS-XXIV Recommendations, *continued*****Recommendation ICG/PTWS-XXIV.3****PTWS Exercises**

The Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS),

**Recalling** Recommendation ICG/PTWS-XXIII.2,

**Emphasising** that 99% of deaths caused by tsunamis in the Pacific since the establishment of the PTWS is the result of local tsunamis,

**Noting** that during the inter-sessional period 2009–2011, three destructive and deadly tsunamis occurred in the Pacific, which placed PTWS countries in various levels of warning for distant tsunamis, and locally, five countries were impacted nearly immediately with people having only 10–30 minutes before the first large waves hit,

**Recognizing** all communities at risk need to be prepared for the next tsunami,

**Recognising further** that drills and exercises are an effective and important way to increase readiness and raise awareness,

**Noting** that the ICG/PTWS-XXIV agreed that PTWC should proceed with its development of improved tsunami procedures and products,

**Decides** to conduct Exercise Pacific Wave 2011 (PACWAVE 11) on 9 and 10 November 2011 and to continue with the PTWS Task Team on PACWAVE 11;

**Decides further** that:

1. The objectives of PACWAVE 11 will be to evaluate the readiness to respond to a local/regional source tsunami, and to also evaluate the understanding and use of new PTWC experimental products,
2. PACWAVE 11 will be conducted as a multi-scenario exercise with major tsunamis originating in various seismic zones of the Pacific to complement previous scenarios in other places,
3. The exercise manual including instructions to Member States regarding the exercise conduct and the evaluation instrument be prepared taking into account lessons learned and any

need to collect additional information, provide feedback on the PTWC new products, and the recommendations of TOWS-WG Inter-ICG Task Team 2,

4. The exercise manual be distributed to Member States at least 90 days in advance of the exercise date,
5. An exercise guideline, How to Plan, Conduct, and Evaluate Tsunami Exercises be prepared in order to assist countries in preparing for PACWAVE 11 in collaboration with TOWS-WG Inter-ICG Task Team 2,
6. Participating Member States be asked to complete and return the evaluation instrument no more than 90 days following the exercise,
7. The PTWS Task Team on PACWAVE 11 and PTWS Task Team on Enhancing Products to meet after the exercise evaluation to compile a list of actions from the findings for consideration by the ICG/PTWS XXV.

**Recommendation ICG/PTWS-XXIV.4****Sub-Regional Tsunami Warning and Mitigation System for the South China Sea Region**

The Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System (ICG/PTWS),

**Recognizing** that the South China Sea is a region adjacent to the Pacific seismic zone and facing potential tsunami risks,

**Noting with appreciation** that PTWC and NWPTAC are providing tsunami advisory services on an interim basis to the South China Sea region,

**Noting** the need to further promote the capacity within the South China Sea region to provide tsunami warning and mitigation services,

**Recalling** that the Intergovernmental Oceanographic Commission (IOC) adopted Resolution EC-XLI.6, which the Member States around the South China Sea and other regional seas, as appropriate, to actively promote the development, establishment and sustained operation of national and sub-regional

**ICG/PTWS-XXIV Recommendations, *continued***

Tsunami Warning and Mitigation Systems within the framework of ICGs,

**Recalling** further that the ICG/PTWS adopted the Recommendation ICG/PTWS-XXIII.5, which established the Working Group for the South China Sea,

**Having considered** the Outlook of Tsunami Warning and Mitigation System of South China Sea proposed by China,

**Decides** to establish a sub-regional Tsunami Warning and Mitigation System for the South China Sea region within the framework of ICG/PTWS;

**Decides further** that the Outlook of Tsunami Warning and Mitigation System of South China Sea could serve as a basis for the establishment of a sub-regional Tsunami Warning and Mitigation System within the framework of ICG/PTWS;

**Encourages** members of the Working Group of the South China Sea as well as all coastal countries of this region to review and comment on the Outlook

of Tsunami Warning and Mitigation System of South China Sea and actively participate in and contribute to the establishment of the sub-regional Tsunami Warning and Mitigation System within the framework of ICG/PTWS;

**Invites** countries outside of the South China Sea region to provide appropriate support to the establishment of the sub-regional Tsunami Warning and Mitigation System within the framework of ICG/PTWS;

**Decides** to organize an inter-sessional meeting of the Working Group for the South China Sea in the second half of 2011 to discuss future arrangements for the establishment of the sub-regional Tsunami Warning and Mitigation System within the framework of ICG/PTWS;

**Requests** the Secretariat of the ICG/PTWS to disseminate the Outlook of Tsunami Warning and Mitigation System of South China Sea and provide necessary service in organizing the inter-sessional meeting of the Working Group for the South China Sea.



*ICG/PTWS-XXIV Closing Ceremonies. From left to right: Bernardo Aliaga, IOC PTWS Technical Secretary; Lt. Giorgio de la Torre, Ecuador, Outgoing Chair; Dr. Ken Gledhill, New Zealand, Incoming Chair; Dr. Hai Wang, China, Director General, National Marine Environmental Forecast Center, Host Country. Photo courtesy of L. Kong.*



## ITIC-PTWC NEWS

**PTWC and ITIC visit Chile, 9-13 May 2011**

*by Dr. Laura Kong, Director, ITIC & Dr. Charles McCreery, Director, PTWC*

The following summarizes the visit of the PTWC & ITIC Directors to Chile from 9-13 May 2011. The mission was conducted at the invitation of the Servicio Hidrográfico y Oceanográfico de la Armada (SHOA). The focus of the mission was to learn and comment on the latest improvements of SHOA after the 27 February 2010 Chile tsunami, especially after the 11 March 2011 Japan tsunami, and to learn how their system had performed. The mission also met with other science stakeholders, including the University of Chile that operates their National Seismological Center.



*SHOA Tsunami Warning Center operations room. From left to right: Lt. Cmdr. Miguel Vasquez, Lt. Nicolás A. Guzmán, and Cecilia Zelaya. Photo courtesy of L. Kong.*

**Summary of Activities**

Since the February 2010 tsunami, SHOA has implemented many new improvements to strengthen their tsunami warning operations, including the hardening of the communications systems for notifying stakeholders Oficina Nacional de Emergencia del Ministerio del Interior (ONEMI), Navy, improving earthquake and sea level monitoring through network densification and faster transmission of critical data, reviewing and improving their standard operating procedures for analysis, criteria for messaging, and dissemination of alerts to stakeholders and the public, and addition of staff during events for warning operations and provision of public information. Many of the new components were used successfully

during the March 2011 Japan tsunami. Additionally, SHOA is updating its inundation maps developing operational tsunami forecast methodologies, and continues to actively engage in tsunami awareness and preparedness activities. SHOA has established a Tsunami Science Advisory Council to assist them in improving their tsunami warning operations, and to help their country improve their science knowledge and preparedness for the next tsunami.

**Trip activities were:**

- Met with SHOA Staff to discuss tsunami warning operations in Chile
- Met with Tsunami Science Advisory Council, sponsored by SHOA, to discuss and finalize their Terms of Reference, role and activities in support of tsunami warning, hazard risk assessment, and preparedness in Chile
- Met with Oficina Nacional de Emergencia del Ministerio del Interior (ONEMI), SHOA, and University of Chile (U/Chile) to discuss participation in Exercise Pacific Wave 2011 (PacWave11)
- Provided keynote lectures on PTWC and Lessons Learned from Recent Tsunami Events to Navy-sponsored Seminar (200 persons attended) covered by media
- Met with SHOA to discuss ICG/PTWS and ITIC activities, and potential contributions by Chile to assist Spanish-speaking countries to strengthen their systems.

**Outcomes:**

- Learned of the current status of the Chile Tsunami Warning System, including its tsunami warning operations (SHOA - standard operating procedures, communications and data redundancy, and sea level monitoring networks), coordination with the disaster management office (ONEMI) and the National Seismological Center (U/Chile).
- Provided best practice suggestions and recommendations to strengthen their national warning system, including enhancing the long-term geophysically and seismologically trained staff of SHOA, deploying an improved sea level



**Chile, continued**

network (coastal and DART gauges), developing forecasting capabilities, and improving its existing inundation maps. These were accomplished throughout the week by meetings with SHOA, ONEMI, and U/Chile.

- Learned of SHOA's tsunami warning response to the March 11, 2011 Japan tsunami. SHOA performed well providing an accurate assessment of the impacts that occurred resulted in no casualties.
- Provided briefings and obtained feedback for the proposed new PTWC procedures and products

that will be implemented for testing starting with PacWave11 in November 2011. Chile supports the improved PTWC products, and will participate in a full-scale exercise during PacWave11 by evacuating Easter Island.

- Learned of Chile's intent to share all new sea level and seismic data streams with the PTWS tsunami warning centres.
- Discussed and agreed on the potential contributions of Chile as the ITIC Associate Director. These will be incorporated into the ITIC work plan for 2011-2012.

**WORKSHOP AND MEETING SUMMARIES**

**Looking Back, Looking Forward: Scientific, Technical Operational, and Preparedness Aspects of the Samoa, 29 September 2009, Chile, 27 February 2010 and Japan, 11 March 2011 Tsunamis**

*PTWS-XXIV Summary Report, Annex IV*

**1. Introduction**

A Technical Workshop was conducted on 24 May 2011 at the Twenty-fourth Session of the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System. The Workshop provided an opportunity to share experiences and lessons learned from recent locally-destructive tsunamis and to discuss and elaborate on how effective the PTWS, both as a system and individually as countries, has been in providing early, timely warnings to communities at risk. The session was convened and organized by Workshop Organizing Committee Tanya Ivelskaya (Russian Federation), Dr. Laura Kong (ITIC), Dr. François Schindelé (France) and Angélica Muñoz (Nicaragua). Outcomes from the Workshop are intended to serve as a catalyst for improving the system. The PTWS Working Groups were requested take into account the Workshop discussions and outcomes when formulating their Working Group recommendations to the ICG/PTWS-XXIV.

This Report summarizes the Workshop presentations, plenary discussions and recommendations. During the Workshop, Speakers and Working Group chairs were asked to provide their interventions in the context of the PTWS Medium Term Strategy 2009-2013, and the following questions:

- How well prepared are countries for the next tsunami?
- Are risks known, warnings available, and awareness sufficient for effective response?
- What can be done better technically to strengthen national systems?
- What are warning centre and response operations gaps for local or distant tsunamis?
- Are there science research gaps that need to be addressed in order to improve warnings?
- Are communications systems adequate for alerting and responding?
- Is the current international system of a PTWC-centered Pacific system adequate for warning against tsunamis (both distant and local / regional), or would a regional approach (PTWS as a system of systems) be more effective?

The PTWS Medium Term Strategy (MTS), 2009-2013, envisions that the PTWS as an "An interoperable tsunami warning and mitigation system based on coordinated Member State contributions that uses best practices and operational technologies to provide timely and effective advice to National Tsunami Warning Centres. As a result, PTWS communities at risk are aware of the tsunami threat, reduce risk, and are prepared to act to save lives." The MTS builds from the ITSU (PTWS) Master Plan (1999, rev 2004) which summarizes the mitigation of tsunami hazards in the Pacific.

## Looking Back, Looking Forward, *continued*

The PTWS MTS is comprised of three Pillars supported by four foundational elements. The Pillars are:

- Risk Assessment and Reduction: hazard and risk identification and risk reduction
- Detection, Warning and Dissemination: rapid detection and warning dissemination down to the kilometer
- Awareness and Response: public education, emergency planning and response

The supporting foundational elements are:

- Interoperability: free, open and functional exchange of tsunami information
- Research: enhanced understanding and improved technologies and techniques
- Capacity Building: training and technology transfer
- Funding and Sustainability: resources to sustain an effective PTWS

Within each Pillar, prioritized activities, guided by the PTWS's foundational elements, should be undertaken with the aim of making populations at risk safer.

As the PTWS moves forward in the aftermath of the 2009-2011 events, careful and thoughtful thinking and review are again required to draw out and prioritise the critical, practical, and pro-active recommendations for countries and the PTWS to take action on.



*Vehicle caught in the turbulence of the receding wave, Pago Pago Harbor, American Samoa, 29 September 2009. Photo courtesy of R. Madsen.*

## 2. Summary Workshop Recommendations

Each PTWS Working Group Chair was asked to look forward and make recommendations for action to improve tsunami warning and mitigation of PTWS countries, considering the recent tsunamis in the context of the ITSU Master Plan (rev 2004) and PTWS Medium Term Strategy (2009-2013).

PTWS Working Group and the Task Teams should then align their work plan with the PTWS Medium Term Strategy and PTWS Implementation Plan priorities

### Governance

- A PTWS comprised of the entire Pacific Ocean needs to continue because of the cross-ocean nature of tsunamis; the PTWS was first started because an international system was identified as a requirement after the 1960 Chile tsunami.
- The international system of a PTWS is important. But, strengthening of the national and/or regional components are required as a country's first priority.
- In each country, Tsunami Warning Centre and Disaster Management Offices must work together in a coordinated and seamless manner for effective end-to-end tsunami warning and mitigation. Establishment of Tsunami Coordination Committees of stakeholders, comprising at a minimum scientists, warning centre, and disaster management, is an practical and important mechanism for building a strong and sustainable system.
- The PTWS should promote the enhancement of the partnerships between disaster management, warning centres, and science generally in countries, and specifically within PTWS Working Groups and as part of ICG delegations.
- Within the PTWS, Regional Working Groups are essential to address the end-to-end approach in the appropriate manner considering to the specificities of the region (in terms of geography, networks, communications, culture and language, capacities, and governance). Regional organizations can play an important role in facilitating work plans. Active Regional Working Groups are also essential since travel costs and distances often prevent all countries from attending every ICG/PTWS.

**Looking Back, Looking Forward, *continued***Awareness And Response (Working Group 3)

- Tsunami preparedness, through education and awareness and which is pertinent to communities, are the key elements and pillar for saving lives, especially for local tsunamis.
- Public awareness and education are required beforehand for quick response – and both must be maintained for decades or longer because of the infrequency of tsunamis.
- The development of community-based tsunami hazard maps, evacuation zones, safe places, and routes (with sign posting), based on historical data and numerical modeling of worst case scenarios, will greatly improve the effectiveness of tsunami response.
- Preparedness through exercise and drills helps to increase readiness and sustain awareness, and should be conducted regularly at the international to community levels. Within organizations, exercises and post-event reviews enable response plans, protocols, and procedures to be tested, reviewed, and where needed, corrected and improved.

Risk Assessment And Reduction (Working Group 1)

- There is an urgent priority to identify the largest potential tsunami sources and provide the best estimated parameters for inundation modeling. This is because the last three large tsunamigenic earthquakes were not expected in the short term. Research on historical and paleo-tectonic earthquakes and tsunamis is still needed.
- Internationally-coordinated and national post-tsunami field surveys are necessary in order to collect the data that will improve mitigation, e.g., understand impacts, assess hazard and risk, calibrate numerical models, and improve warning.
- Coordination of international tsunami survey teams, at the request of the affected country, is important especially to respect that response, saving lives, and public safety should take highest priority. Pre-event planning, such as through bi-lateral or regional agreements, is essential for success since the days immediately after a destructive tsunami are extremely hectic,

and logistics and communications will be less than ideal.

- Due to the many different modeling softwares being utilized, a report giving an overview of softwares available, their advantages and disadvantages (limitations), and applicability for different scenarios, is needed. Benchmarking standards should be endorsed globally.
- Development of building design standards for safe use of tall buildings for vertical evacuation is desirable. In places where there is no time to escape inland and to higher ground from a local tsunami, these buildings can serve as temporary vertical refuges. Coastal areas prone to tsunami flooding should be designated as non-build zones for critical infrastructure or schools, hospitals, and first responder facilities.

Detection, Warning, And Dissemination (Working Group 2)

- Detection, warning and dissemination all need to be improved, particularly for regional and local events. Sensitivity analyses should be conducted to identify network detection gaps. New geophysical and oceanographic data types and better and faster methods of earthquake source characterisation, along with tsunami wave forecast products, need to be implemented. More robust and affordable communication systems for rapid alert notification, especially in geographically remote locations, are needed.
- Improvement and expansion of the sea level and seismic networks is still needed. Denser networks result in faster detection, analysis, and threat assessment message issuance.
- For local tsunamis, faster warnings are required. Pre-calculating impacts for near-shore scenarios should be done for all vulnerable coasts.
- Warning Centres, supported by their national or regional/international agencies, should invest in efforts to use and understand forecast models to enable more effective alerting (e.g., implement warnings using terminology based on assessments of threat level by coastal zones). Training must be an important part of the process of moving to a threat level based system.
- Because forecasts will guide tsunami response,



**Looking Back, Looking Forward, *continued***

impact estimation, and public safety advice, the various forecast models in use need to be rigorously compared to give confidence in their validity. See Recommendation under Working Group 1.

- Member States are encouraged to collaborate on the development of inundation modeling tools for response and evacuation planning, and interoperable forecast tools and products for warning. The collaboration can be in the form of joint workshops and training, joint development of compatible forecast products, comparisons of forecast products, or other information sharing.
- PTWS post-event assessments after major tsunami events must be conducted in order to continue to monitor the effectiveness of the system in terms of accuracy, robustness, timeliness, and usefulness of the international, basin-wide system and its products.

**3. Looking Back: Lessons Learned From Recent Tsunamis****Samoa, 29 September 2009**

*Dr. Ken Gledhill, GeoNet Project Manager, IGNS, New Zealand  
Filomena Nelson, Principal Disaster Management Officer,  
NDMO, Meteorology Div, Samoa*

The earthquake (MW 8.1, 15.509°S, 172.034°W, USGS) was originally thought to be an outer rise normal event, but is now known to be complex and also involving subduction thrusting. The tsunami caused the loss of 192 lives (34 in American Samoa, 149 in Samoa, 9 in Tonga) and extensive damage (in Samoa, American Samoa, northern Tonga and Wallis & Futuna). In Samoa, about 18% of total population was affected, with 143 confirmed deaths, 6 missing, 600 injuries. And 824 families in 51 coastal villages impacted. Most of the casualties were the elderly and young children. There may have been some delay in response due to complacency or curiosity; additionally, it may not have been the advancing wave, but the receding wave that overtook some. The psychological effect was tremendous, and tourism was severely impacted. The total damage was \$262 million Tala (USD \$104 million). Maximum run up of 17 m in Samoa, American Samoa, and Tonga, and 4.5 m in Wallis & Futuna. There are lessons and positives from the Samoa-Tonga tsunami of 29 September 2009 for all three PTWS “pillars”:

**Pillar: Risk Assessment and Reduction**

An impressive international effort coordinated by UNESCO/IOC has provided a huge amount of information on tsunami impacts. The earthquake that caused the tsunami was a very complex event composed of two earthquakes – a subduction thrust sub-earthquake and an outer rise normal faulting earthquake. Which event came first is still the subject of debate (Lay et al., 2010; Beavan, et al. 2010). This is probably a very infrequent event.

**Summary:**

- Internationally coordinated post-tsunami surveys are effective in providing data to understand impacts and calibrate forecast models.
- There is still a lot to learn about large subduction zone earthquakes and their potential to generate tsunami. If the “slow” subduction thrust had not been accompanied by the normal faulting event, would any warning have been given?
- Forecast models are becoming very important to tsunami response and impact estimation. The usual methods of estimating tsunami travel times (e.g. TTT) can be a long way out because of the effects of deep ocean trenches and ridges.
- The various forecast models in use need to be rigorously compared to give confidence in their validity.
- Currently, risk estimates are based on too little history!

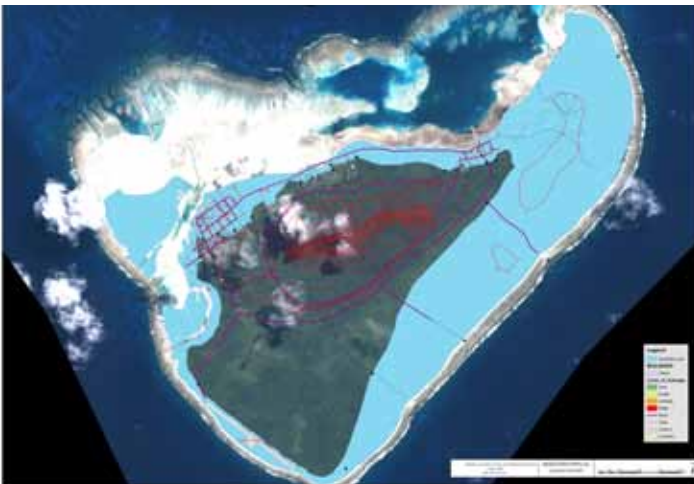


*The 29 September 2009 tsunami hit the southeastern coast of Upolu Island, Samoa within ~10-15 minutes. Shown is Lalomanu village, once a pristine, beautiful beach, where 53 persons died. Runups up to 17 m were measured. Lalomalulu was visited by ICG/PTWS-XXIII participants in February 2009, 7 months before the tsunami destroyed beachside fales. Photo provided by P. Lafale.*



**Looking Back, Looking Forward, *continued***

The Samoa-Tonga tsunami was mainly a local/regional event with high local and some regional impacts. PTWC took 16 minutes to issue the first message (average at the time was 10 minutes). This was largely due to the density of seismic sensors in the region. Global Positioning System (GPS) data, in combination with seismic data, provided important constraints on deformation; when combined with tsunami modeling and sea level observations to model the damage patterns and inundation, complexity of the event was shown (outer rise normal faulting earthquake triggering subduction thrust earthquake on descending plate interface, or vice versa in time) – but not until much later. GPS data were shown to be very useful in understanding rupture and slip for the Chile 2010 and Japan 2011 events, demonstrating the practical utility these data should have for improving tsunami threat assessments. In the two Samoas local warning systems (based initially on the intensity of shaking) worked well. In Tonga and Wallis & Futuna, no warnings were issued. For New Zealand forecast models were used for the first time and proved an effective method of estimating local impacts.



*The 29 September 2009 tsunami also attacked Tonga, reaching Nuiatoputapu Island ~15 minutes after the earthquake. 30% of the island was inundated (light blue), including the southeast where the airport and Meteorological Services (local warning center) are located. Two International Tsunami Survey Teams visited in November 2009. Map courtesy of Tonga Ministry of Lands, Survey, and Natural Resources.*

**Summary:**

- Detection, warning and dissemination all need to be improved, particularly for regional and local events to enable faster warnings. Installation of real-time GPS networks, which provide

instantaneous relative displacement, should be considered to complement seismic analysis.

- The SWP region needs more sensor sites. The PTWS Southwest Pacific Seismic Data Sharing Task Team (under WG2) is making progress on seismic sites. Do we need a similar effort for sea level?
- Warnings need to be faster and be based on forecast models (threat levels and coast zones). We need to both simplify and use newer technology for warning message content. This work is underway and progressing (PTWS Enhancing Tsunami Warning Products Task Team under WG2). Dissemination systems (particularly the last kilometre) remain a problem in the SWP region. The PTWS Emergency Communications Task Team (under WG2) is working on this. How do we notify people at risk in varying situations (from large cities to remote islands)?

**Pillar: Awareness and Response**

The on-going awareness campaigns in Samoa and American Samoa clearly saved lives, although how many is hard to estimate. Public awareness and education required for quick response, but it must maintain for decades or longer because of the infrequency of destructive tsunamis. In American Samoa the month leading up to the event had seen an extensive education campaign and this played a part in the level of deaths. Similarly in Samoa, national exercises had been held since 2007, so the public was well informed about how to respond. For the future, continued efforts will be in building more tsunami awareness, and in reviewing and improving national disaster management plan, tsunami response plans and standard operating procedures, thresholds for issuance of tsunami alerts, and better integrating stakeholder response plans. At the community level, evacuation zones and routes based on likely scenarios for future tsunami need to be reviewed and developed. Similar efforts should be rolled out in the rest of this region.

**Summary:**

- The Samoa-Tonga tsunami demonstrated the success of public education campaigns, but also the reverse.
- After each event, stakeholder response plans,

**Looking Back, Looking Forward, *continued***

protocols, and procedures need to be reviewed and improved where necessary.

- The adoption of community-based evacuation zones and routes (with sign posting) would greatly improve the effectiveness of tsunami response in the SWP region.
- This fits in well with the move to forecast model based threat levels for pre-defined coastal zones. This approach needs to be rolled out in the SWP region.
- Training must be an important part of the process of moving to a threat level based system using forecast models for coast zones (levels of threat from a particular event).
- How do we sustain the high levels of awareness required over the long term?

**Chile, 27 February 2010**

*Captain Patricio Carrasco, Director, SHOA, Chile*

The earthquake (Mw8.8, 35.91°S, 72.73°W, USGS) occurred at 0334 local time. Many were woken by the strong earthquake shaking. A total of 524 people were killed, with 156 from the tsunami – about 100 of these were in Constitución where many perished because they were trapped on a islet in the mouth of a river with no evacuation route except by boat in darkness. Clearly, despite it being the middle of the night, people who lived along the coasts must have known that a tsunami might come after a strong earthquake, and they evacuated to safety. SHOA issued a warning to ONEMI, but with communication problems alert notifications did not have reach communities, so it's known that pre-event tsunami education and awareness played a large role in saving lives. A number of persons remembered the 1960 local tsunami and knew what to do, and recent reminders from the Indian Ocean (2004), Peru (2007), and Samoa (2009) had all contributed to building awareness on earthquake and tsunamis. Sea level gauges near the epicentre broke (like in Japan on 11 March) so SHOA was not aware of destructive tsunamis, and the ONEMI duty staff did not fully understand and act appropriately given the SHOA tsunami warning message that was issued; as communication systems were down, people needed to act for themselves to save their own lives.

While the 2010 Chile tsunami was a near-field tsunami

with little time for everyone to react, the March 2011 Japan tsunami was a far-field response for Chile and afforded much time for decision-making and forecast analysis. SHOA monitored the tsunami as it propagated across the Pacific and Easter Island, and consulted its tsunami forecasts. Based on these and PTWC forecasts, it maintained a tsunami warning resulting in the evacuation of the entire Chilean coast. Forecasts proved correct as waves nearly 3 m were observed and damage boats and harbors, and some towns occurred. Challenges continue in educating other government agencies and officials, the public, and the media on what a tsunami is (series of waves), concepts of models (they are estimates, and not exact) and limitations of warnings

SHOA and many in Chile expect the next tsunami to hit northern Chile, so efforts to increase preparedness are underway by many. The 2010 and 2011 tsunamis have made everyone more aware and highlighted as a great priority to be prepared for the worst scenario.



*Aground boats and floating shipping containers, Talcahuano Harbor, Chile, 27 February 2010. Photo courtesy of R. Nuñez.*

**Pillar: Risk Assessment and Reduction**

Chile's greatest threat today is from a tsunami north of Puerto Montt (northern Chile). Existing tsunami inundation maps will be reviewed and updated considering the worst-case scenarios. SHOA is working with university scientists through its Chile Tsunami Science Advisory Council, and is building expertise in earthquake seismology working with universities.

**Pillar: Detection, Warning and Dissemination**

From the February 2010 event, the ONEMI (NDMO) showed that they did not understand fully what to do when the SHOA tsunami warning message was received. To improve, SHOA is revising its threat criteria and actions in order to make it less confusing and

**Looking Back, Looking Forward, *continued***

simpler for ONEMI to take action. At the same time, to help its own TWC staff, a warning decision support system is being developed to enable all pertinent data, earthquake and tsunami forecast analyses to be available to the duty staff to make better decisions more quickly. To learn from others, SHOA has visited Japan and India, attended ITIC tsunami trainings, and PTWC and ITIC have visited SHOA. Seismic and sea level monitoring networks have also been significantly improved with the National Seismological Center providing real-time earthquake monitoring, and SHOA has densified and upgraded its sea level network with 35 gauges transmitting at 1-5 minute intervals by satellite; they will also purchase a 2nd DART.

**Pillar: Awareness and Response**

Chile SHOA is placing high priority on training of Chile authorities and the public on the threat, evacuation zones, and comprehension and action to SHOA tsunami warning centre messages. Because of its local tsunami threat, everyone has to understand what the threat is and how to react without waiting. It is a big effort, and they would like to work with everyone.

**Japan, 11 March 2011**

*Takeshi Koizumi, Senior International Coordinator for Earthquake and Tsunami Information, JMA, Japan*

The earthquake (MJMA 9.0, 38.1°N, 142.9°E, JMA) registered at 6-7 JMA intensity (Modified Mercalli Intensity (MMI) XII). The earthquake early warning was available starting about 8 seconds after the earthquake, and JMA issued its first national tsunami warning 3 minutes afterward based on a magnitude 7.9. Since the earthquake happened close to the coast and the magnitude was large enough to issue the "Major Tsunami Warning", the maximum threat level, JMA issued the warnings just after the estimation, followed by several updates based on the observation of GPS buoy and sea level gauges on the coast; estimated forecasts had maximums to 10 m nearest to the earthquake source (Iwate, Miyagi, Fukushima prefectures). The fault rupture of the earthquake, however, continued for more than 3 minutes and resulted in the huge magnitude as 9.0, the final estimation (Mw8.8 was determined 1-2 hours afterward). As observations were received, JMA reported these and upgraded and expanded their national warning to the entire country – this was the 1st time in its history for Japan (in operation since 1952). The highest wave on tide gauges was over 9.3

m, and several gauges ceased operating soon after the 1st wave hit due to sensor malfunction (broken) or communications outage. Runup maximums range through 25 m with few measurements over 35 meters in narrow inlets. As of 16 May 2011, the Ministry of Internal Affairs reports 23,965 dead or missing.



*The 12-story Alto Río apartment building was knocked over during the 27 February 2010, M8.8 Chile earthquake. Concepción, Chile, March 2010. Photo courtesy of L. Kong.*

**Pillar: Detection, Warning and Dissemination**

JMA started its Earthquake Early Warning (EEW) service in 2007, after developing after the 2003 off-Hokkaido earthquake that caused derailment of the Shinkansen train. The EEW determined its 1st location after 8 seconds and continued to work, enabling JMA to issue a Major Tsunami Warning 3 minutes after the earthquake. However, the magnitude was an underestimate, which would be expected since the actual earthquake was M9.0 and so was still rupturing for minutes after. Despite its success, there has been concern that the underestimate, which resulted in a lower wave forecast, may have resulted in the public feeling safe not to evacuate, and as a result, JMA is looking to implement calculating faster and more precise magnitudes so that the first update will be done sooner (during the event, it was done 28 minutes after confirmation by sea level records of a large tsunami). Because of the many aftershocks spaced close in time, the EEW algorithm was unable to associate seismic phases correctly, so both real and false earthquake notifications resulted; this was corrected by JMA soon after. Dissemination of the alerts went according to procedures, with announcements immediately broadcast on NHK and television and radio, and it is assumed that most locally sirens and other notification systems triggered. Live television footage immediately confirmed to everyone the giant tsunami heading to



**Looking Back, Looking Forward, *continued***

shore. After the initial wave(s), there may have been problems with local notifications in some places due to communications outage caused by the impacting waves, and if batteries powering loudspeakers or sirens lost power. Communications problems also affected data monitoring streams to JMA, so that sea level stations in the tsunami-affected area were not available for determining the full size of the wave, nor when waves were subsiding to determine cancellation.

**Pillar: Awareness and Response**

In Iwate, Miyagi and Fukushima prefectures, which were most severely affected by the tsunami, all local municipalities had developed tsunami hazard maps, alert notification systems for tsunami warning, and guides for evacuation. Awareness efforts to make the knowledge well-instilled had been carried out in the region as well. Maps included estimates of how long and high local tsunamis (1986 Show, 1933 Sanriku) had impacted. Towns also had extensive sea walls, breakwaters, and water gates as protection. However, in most cases, the largest waves overtopped the protections so tsunamis did inundate home and buildings causing significant damage. Modeling has shown that without these hard countermeasures, inundation and runups would have been much greater and more destructive.

Several views have been expressed so far, but careful investigation should be done before the concrete lessons learned from this tragedy are decided. Some people in Miyako City may have thought, based on the 1st warning of expected maximum of 3m, that they were safe, and due to communications failures or other problems, may not have received the upgraded warnings. However, a warning does mean to evacuate from the hazard zone, so they should have not stayed. Some may have been saved by the warning. Some may have saved themselves by their own knowledge. Some may have waited too long for further confirmation or to gather family, or other reasons.

**Looking Back - Tsunami Warning**

*Chair – Dr. Charles McCreery, PTWC, USA*

PTWC provided a review of tsunami warning operations (seismic monitoring and analysis, wave forecast and products, sea level monitoring), emphasizing lessons learned and challenges. The intersessional period witnessed the biggest test of the PTWS since its

formation in 1965 with two significant teletsunamis (Chile (cancelled 27:06 hrs), Japan (cancelled 24:50 hrs)) and three major local tsunamis (Samoa/American Samoa/Tonga (cancelled 3:48 hrs), Chile, Japan), reaffirming that local and distant tsunamis are different challenges that require different solutions. Currently, PTWC uses more than 400 seismic stations globally and is able to provide 1st international messages in 10 minutes. It receives sea level data from coastal stations and deep-ocean sensors globally to confirm a tsunami, and runs three different tsunami forecast models (SIFT/SIM, AFTM, RIFT). He noted that the local tsunami is the biggest challenge for warning centres since:

- Tsunami waves are largest
- Time to impact is shortest
- No observations before impact
- Details of source important for forecast, but not known before impact
- Communications infrastructure for official warning may be damaged by earthquake and/or tsunami
- Public awareness and education required for quick response – but must maintain for decades or longer

In terms of warning centre operations, he highlighted warning cancellation as a confusion point for some countries and the media. He noted

- Tsunami Warning Centre can only monitor sea level variations and only where there are reporting coastal gauges
- Tsunami effects can vary greatly along the coast
- Tsunami Warning Centre cancellation means sea level variations are diminishing and have fallen below dangerous levels on gauges
- Local authorities must determine when to declare All Clear and allow people to return based upon their evaluation of continuing wave action and/or damages at each location

Finally, he reminded everyone that every event presents different challenges to a warning centre. e.g.,



**Looking Back, Looking Forward, *continued***

- Initially, TWC will underestimate size of great earthquakes if they must issue alerts immediately while the earthquake is still rupturing
- Slow earthquakes versus normal earthquakes – we do not know what causes them, and where or when they will occur
- It is not easy to forecast local impacts – the time is too short and the details of source unknown
- A tsunami can be caused by the rupture of subsidiary faults or landslide-induced tsunamis – in general, the TWC cannot monitor these sources, and each may not trigger a warning since the associated earthquake (if any) may be less than the magnitude threshold
- Complex resonances and wave interactions at the coast are hard to forecast

**4. Looking Forward: Technical & Regional Working Group Priorities and Actions****PTWS Working Group 1, Risk Assessment and Reduction**

*Chair – Dr. François Schindelé, CEA/DASE, France*

On the topic of tsunami hazard assessment, the WG 1 Chair noted that the three last large tsunamigenic earthquakes (Samoa 2009, Chile 2010, Japan 2011) were not expected in the short term; their location, fault type, magnitude or dislocation values were not expected. Given this reality, there should be an urgent priority to re-examine globally what the potential tsunami sources are. There is a WG 1 priority to identify the largest potential tsunami sources and provide the best estimated parameters (magnitude, dislocation, size, etc). The question is: Should we expect magnitude 9 events, with 20+ m slip along all subduction zones? To answer this question, research on historical and paleo-tectonic earthquakes and tsunamis needs to be conducted.

The consequence of this ‘under-prediction’ for March 11 was that the tsunami waves were much larger than expected (10-30 m height), while sea walls were much lower. It is important that the tsunami impact area from large tsunami waves (> 3 – 5 m to 10 m) be identified for local, regional, and far-field sources (based on historical data and numerically-simulated inundation maps).

In developing inundation maps and for tsunami wave forecasting, a number of different modeling softwares are being utilized. There is a need by PTWS WG 1 (and globally for the new TOWS Task Team) to provide an overview of what software is available, their advantages and disadvantages (limitations), and their applicability for different scenarios. The Indian Ocean endorsed a NOAA benchmarking standard, and that could be used as a model or example to move forward with.

Concerning risk reduction, it should be highlighted that one 16 m sea wall in Fudai, Japan, saved 3000 people and all the village houses and facilities from large tsunami waves. However, in most municipalities, the lower sea walls were over-topped. In locations where the tsunami flow depth was greater than 8 m, only reinforced concrete or steel buildings more than 4 floors remained standing. A number of buildings were designated or used as vertical evacuation buildings, which saved lives. In places around the world where there is no time to escape inland and to higher ground from a local tsunami, these types can serve as temporary vertical refuges from tsunami waves. Coastal areas prone to tsunami flooding should also be designated as non-build zones and critical infrastructure or schools, hospitals, and first responder facilities should not be built there.

Recommendation ICG/PTWS-XXIV.1 revised WG 1's terms of reference, taking on a work plan that addresses tsunami hazard identification, credible seismic scenarios, model reviews and cooperation on coastal inundation models, and metadata guidance for bathymetry, hydrography, and topography.



*Most steel-reinforced structures several stories high survived the tsunami, including this 6-story building in Minami Sanriku, Japan that was designated as a Vertical Evacuation Refuge. Photo courtesy of L. Kong.*

**Looking Back, Looking Forward, *continued*****PTWS Working Group 2, Detection, Warning, and Dissemination**

*Chair – Dr. Charles McCreery, PTWC, USA; Vice-Chair – Daniel Jaksa, Geoscience Australia, Australia*

The WG 2 Chair noted that for the distant warning, the system worked well for all three events but there is room for improvement in detection, warning, and dissemination for local and regional tsunamis. The Chair emphasized the three top priorities for the Working Group, which are

1. Enhance tsunami warning products. He noted that the Indian Ocean will be using graphical products, and PTWC will introduce new enhanced products during the intersessional period, including tsunami travel time maps, energy diagrams, coastal forecasts, and maps of historical events and seismicity of the region.
2. Conduct sensitivity analyses of seismic and sea level networks to identify and then fill in gaps to improve detection and analysis, and provide faster alerts.
3. Improve seismic source characterization quickly—each event was underestimated in size and as a result initial wave forecasts would be underestimated. Real-time GPS shows good potential to directly measure crustal deformation, and finite fault seismic wave inversions for slip distribution are close to being implemented in warning centres.

Four other topics came up for discussion in plenary.

- Shall products be public or private. It was noted that some products need understanding and without sufficient training or explanation could be easily mis-interpreted by the media or public, resulting in conflicting information. The ICG for Indian Ocean Tsunami Warning & Mitigation System (ICG/IOTWS) will use a private site to provide technical information. However, it was noted that 'hiding' information can cause a problem because you're hiding info that could have been useful to someone, and with respect to media, 'leaks' could occur and cause confusion if information is incomplete.
- On the media, it was felt that countries should prioritize and build relationships and understanding with their local media. It was

also noted that since turnover is high with the international, and sometimes national media, it would be more productive to train TWC staff to respond appropriately, rather than to train media. Japan and JMA have a special arrangement with NHK, which must support disaster prevention; in this case, JMA invites media once a year for brainstorming and training.

- On the enhanced new products, it was suggested that this should be discussed also globally under TOWS so that a standard and common set of information or symbols is used on all international products; feedback and ideas from each country on what it would like would be good.
- On forecast products noting the interest of many countries, it was suggested that Member states collaborate on the development of interoperable forecast tools and products for warning. The collaboration can be in the form of joint workshops and training, joint development of compatible forecast products, comparisons of forecast products, or other work.

Recommendation ICG/PTWS-XXIV.1 revised WG 2's Terms of Reference and includes WG 2 Task Teams on Emergency Communications (Warning Dissemination), PTWS Exercises (PacWave11), Enhanced Products, Sea Level Monitoring, and Southwest Pacific Seismic Data Sharing.

**PTWS Working Group 3, Awareness and Response**

*Chair – David Coetzee, MCDEM, NZ*

The WG 3 Chair noted that the PTWS has been in existence for 45 years. Over this time, the PTWS has successfully established itself as a capable and reliable international system for detecting, evaluating, and alerting about distant tsunami. Over the last decade, further advances have been made to enable warning centres to respond better and faster, thus also effectively warning about regional source tsunami.

Yet, we still experience catastrophic loss of life during near-source tsunamigenic earthquakes as was experienced on three occasions in the intersessional period. In all three occasions, governments and communities had minutes to respond before the tsunami struck- faster than what many of our warning systems are capable of responding to. In at

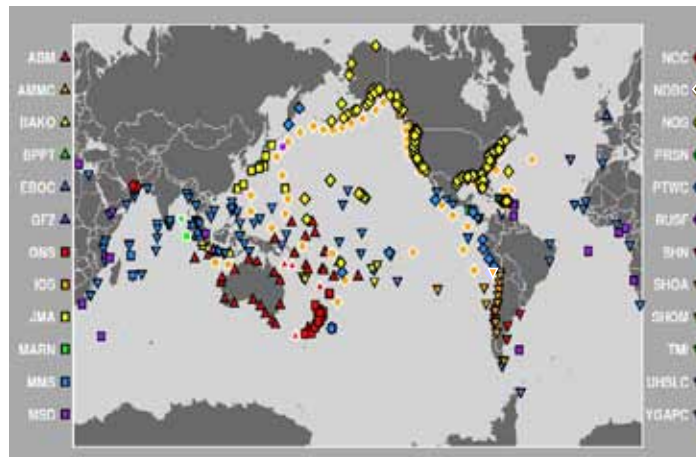
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## PTWC Seismic Network

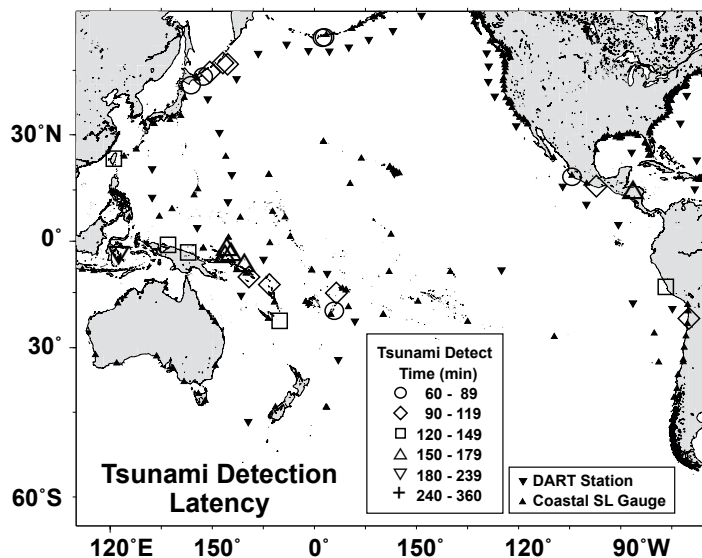


PTWC Seismic Network used to monitor global seismicity, May 2011. More than 400 stations are received in real time. Figure courtesy of PTWC.

## PTWC Sea Level Network



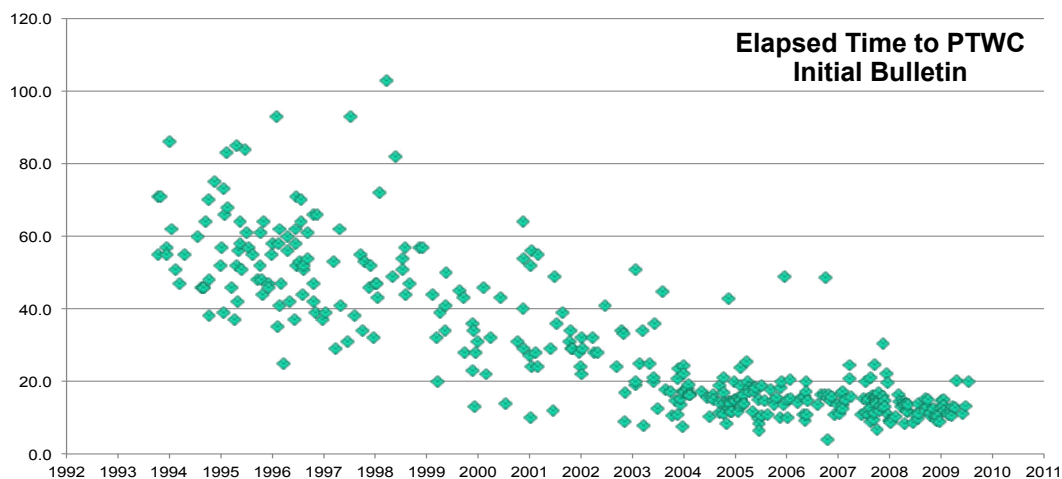
PTWC Sea Level Network used to monitor global sea levels for tsunamis, May 2011. Stations are owned and operated by many countries and agencies, and are sharing their data in real time to the PTWC. Figure courtesy of PTWC.



## Tsunami Detection Latency

Distribution of detection latency using historical tsunamis and the 2008 PTWC Pacific sea level monitoring network. The detection latency is defined to be the sum of the tsunami travel time to the two nearest sea level gauges or DARTs, 30 minutes for recording, and the transmission data latency. While detection latencies of 1-1.5 hours are adequate for distant tsunami warning, they are inadequate for local and regional warning decision-making. Large latencies mean that PTWC warnings or cancellations will be delayed since they must wait for tsunami confirmation. A number of coastal sea level stations still transmit at 1-hr intervals, but are being upgraded to 3-15-min transmission frequencies in 2010. Credit: Y. Igarashi, L. Kong, M. Yamamoto, and C. S. McCreery, *Anatomy of Historical Tsunamis: Lessons Learned for Tsunami Warning*, *Pure Appl. Geophys.* (2010) j: 1-17 DOI 10.1007/s00024-011-0287-1.

Elapsed time to the 1st bulletin issued by PTWC globally has steadily decreased over the last decade from 14 minutes on average in 2007 (330 events) to under 8 minutes in 2011 (388 events). Data courtesy of PTWC.





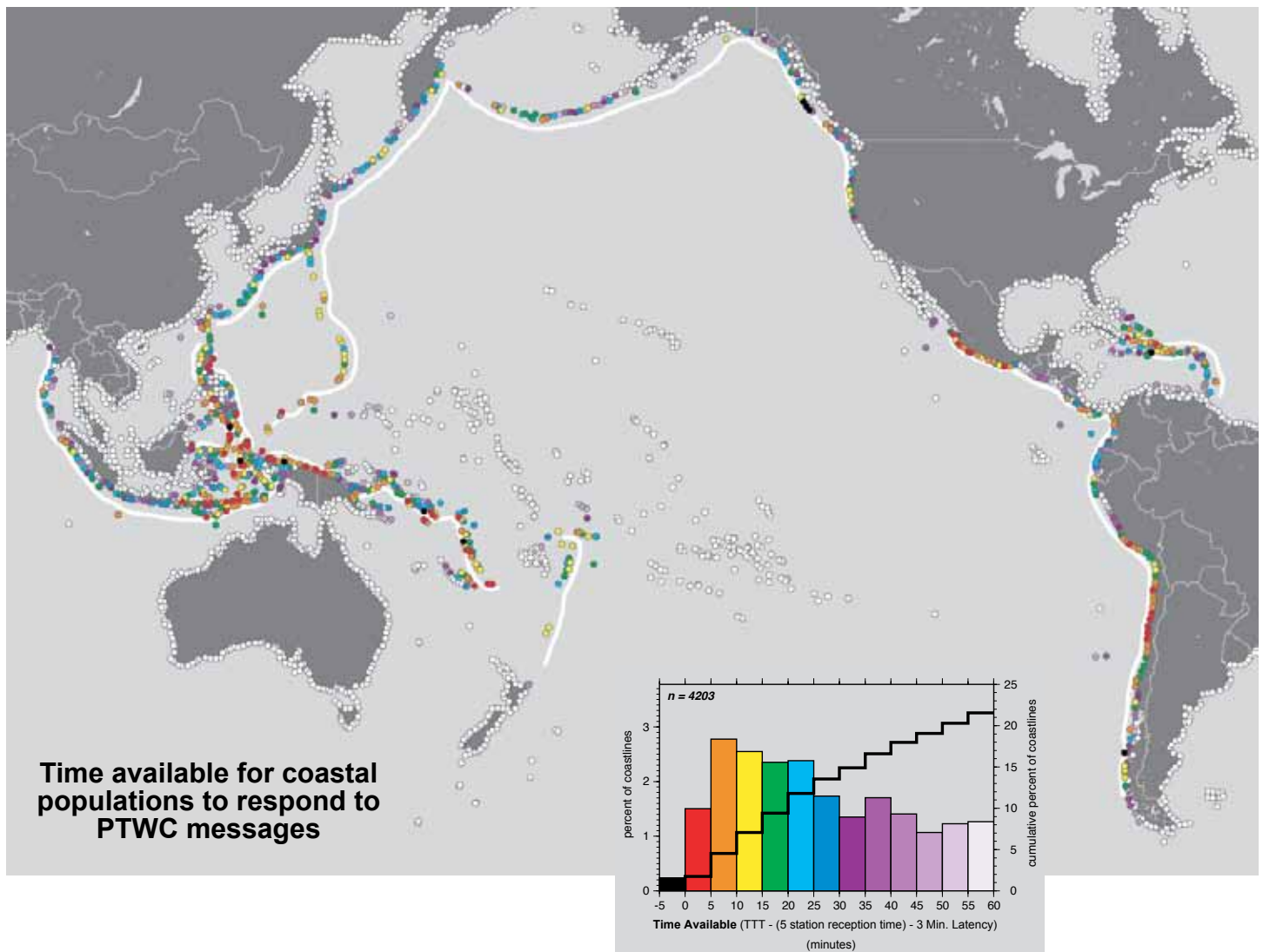
## PTWC Sensitivity Analyses Assess Country Reaction Times

Sensitivity analyses using existing seismic and sea level stations have been performed to assess the amount of time countries have to react to PTWC's international tsunami alerts. The map below shows the response time available for worst-case scenario tsunami sources (earthquake generates a local tsunami) as the difference between the calculated tsunami travel time (TTT) and the amount of time PTWC will take to analyse and issue its tsunami bulletins. PTWC analysis time assumes earthquake locations require a minimum of five seismic stations, earthquake magnitudes require at least two minutes of waveform data to estimate  $M_{wp}$ , and messages take at least one minute to be sent and received.

The analysis shows that PTWC can give 78.5% of the world's coastlines more than an hour's warning before the arrival of the first tsunami wave, but can give only 4.5% of coastlines less than 10 minutes' warning, and cannot warn 0.3% of coastlines for which the first tsunami wave will arrive before the message. Globally, the most vulnerable coastlines that can have no more than 5 minutes' warning (or no warning at all) are in eastern Indonesia, the Philippines, Papua New Guinea, Yap, the Solomon Islands, Vanuatu, New Caledonia, Chile, Peru, the Pacific coast of Mexico, the Dominican Republic, Cuba, Canada's Queen Charlotte Islands, and the eastern Mediterranean. For some of these areas, reaction time can be improved with the installation of additional seismometers. Geography limits options in other areas, however, and in these cases rapid characterization of earthquakes may be aided by installing seismic arrays or cabled seafloor seismometers.

The worst cases are all very close to trench axes, indicating that for these areas the only way for these coastal populations to save themselves (short of establishing a local TWC with its own local seismic network) will be for them to react to natural warning signs.

Credit: Geographic Variation in Tsunami Warning Center Response Time: Identifying Areas of Greatest Concern, N. B. Necker, V. Sardinia, R. K. Cessaro, G. J. Fryer, and S. Weinstein, PTWC, 2010 Fall American Geophysical Union, Paper NH33A-1377.



**Looking Back, Looking Forward, *continued***

least one instance, people returned to danger areas before the threat was over. The events have yet again shown that in an end-to-end warning system, for 'the last mile,' countries are largely by themselves and that the preservation of life then largely depends on decisions made by the governments and communities themselves at the frontline. For distant and regional source events, our international system can support governments and communities to make the correct decisions, but we are constrained by time and minimal data to provide that support during local source events. So clearly, this is where our focus must be - we must ask ourselves how can the PTWS support effective decisions by local TWCs, DMOs and communities to respond appropriately to especially local-source tsunami?

At least some of the answers to the above must lie with risk reduction, in-country response processes and linkages, as well as in public awareness. With the adoption of the PTWS Medium Term Strategy in 2009, we acknowledged these elements with the establishment of Working Groups for 'Risk Assessment and Reduction', and for 'Awareness and Response'. The Terms of Reference of these working groups have been agreed at the previous session of the ICG, yet progress appears to be slow. Based on the experience since the previous session, I suggest that the following priorities be considered during the Working Group meetings during ICG/PTWS-XXIV:

- Review how we attend to reduction, assessment, awareness and response within the framework of the PTWS. Technical Working Groups 1 and 3 were poorly represented by Member States in the previous inter-sessional period and therefore that did not support progress. We need to consider how we can improve that.
- Consider enhancement of the partnership between science and disaster management in the PTWS. In particular, increase representation of NDMO's in our Member State delegations to the ICG and inter-sessional working groups.
- Consider enhancement of the partnership between NTWCs and NDMOs within our Member States. The PTWS cannot make those relationships happen, but it could facilitate if required, and it could challenge its Member States in this regard.
- Consider enhancement of tsunami awareness,

information and communication in our communities. This responsibility normally rests with NDMOs, and whereas the PTWS as such, does not have direct access to local communities, a larger involvement of NDMOs in our activities proves critical yet again.

Recommendation PTWS-XXIV-3 outlined priorities and activities for action during the intersessional period, including a focus on capacity building and training, enhancing science and disaster management partnerships with the warning centres, community-focused activities, and coordination of international post-tsunami survey participation with Tsunami National Contacts.



*Ship left aground by tsunami, Kamaishi, Japan. Photo courtesy of Professor A. Yalciner (Turkey), who led an ITST team in late May 2011.*

**Central American Pacific Coast Regional Working Group**

*Chair – Dr. Alejandro Rodriquez, INETER, Nicaragua*

This Group did not present during the Technical Workshop

Recommendation PTWS-XXIV-1 rewrote its Terms of Reference to include specific actions, which are to assist countries in the development, improvement and implementation of their national systems, recommend to CEPREDENAC to determine whether Nicaragua or El Salvador (or both) could act as an interim Regional Tsunami Warning Centre under an agreed-on regional communications and warning plan, invite CEPREDENAC to form a Technical Committee for the Development of Regional Tsunami Warning and Mitigation Systems, and facilitate tsunami hazard and risk studies in the region.

**Looking Back, Looking Forward, *continued*****South East Pacific Regional Working Group***Acting Chair – Jorge Cardenas, INOCAR, Ecuador*

This Group did not present during the Technical Workshop

Recommendation PTWS-XXIV-1 confirmed its Terms of Reference consistent with the other PTWS Regional Working Groups.

**South West Pacific Regional Working Group:***Chair – Dr. Ken Gledhill, IGNS, New Zealand*

The Southwest Pacific is a tectonically active region with many large earthquakes; 14% of the world's observed and confirmed tsunamis have occurred in this source region historically, and local tsunamis are its greatest tsunami hazard. In the past 5 years, there have been 2 deadly tsunamis in the region, with the 29 September 2009 tsunami causing 192 deaths in Samoa, American Samoa, and Tonga, and the 1 April 2007 tsunami causing 52 deaths in the Solomons. On 3 January 2010, the Solomons experienced another local tsunami, but no casualties resulted. The region is comprised of many small island nations. Furthermore, a number of Pacific island countries (both south and north Pacific) are composed of several geographically-dispersed islands adding to the communication challenges for warning dissemination. Currently, in most countries, the National Meteorological or Weather Service serves as the National Tsunami Warning Center (NTWC) and conveys information to the national disaster management office (NDMO) for further public safety advisement. Most depend on the PTWC and/or NWPTAC to provide guidance on their national threat, as they do not have independent capabilities to monitor and analyze earthquake in real-time, nor pre-calculated tsunami simulation databases from which to estimate their tsunami threat. A challenge for this region is in early detection as currently the seismic detection network is relatively sparse, thus precluding rapid-enough response for local warning; (currently about 10 minutes from PTWC); the PTWS SW Pacific Seismic Data Sharing Task Team was formed in 2009 to address this gap. The sea level network is also sparse but is being upgraded for more frequent transmission in order to be able to confirm tsunamis more quickly.

The SWP WG Chair identified the following priorities for the region:

- The deployment of more sensors in the region to allow effective regional detection and warning. A question still to be answered is how will regional “warnings” be done (by whom and in what manner)?
- Warning Centres, supported by their national or regional/international agencies, should invest in efforts to use and understand forecast models to enable more effective alerting (e.g., implement warnings using terminology that provides threat level assessments by coastal zones).
- Communities need to designate evacuation zones and develop and identify “escape” routes and safe assembly areas or shelters based on the different warning centre specified threat levels and coastal zones.
- Continued implementation and sustained support of effective community awareness programmes is essential given the local tsunami threat.
- A challenge for every country, and especially small island countries, is how do we sustain the necessary high levels of awareness over the long term? How do we sustain the whole end-to-end system long term when events may happen only once per generation or less?

Recommendation PTWS-XXIV-1 confirmed the SW Pacific WG Terms of Reference, which are to determine the capabilities and ascertain the requirements of countries for effective end-to-end warning, facilitate hazard and risk studies, upgrades of detection networks and real-time sharing of the seismic and sea level data, and improvement of educational programmes, and facilitate opportunities for capacity building, including the development of a virtual centre of expertise in a multi-hazards context within SPC/SOPAC in line with the regional Early Warning Strategy.

**South China Sea Region***Chair – Dr. Mohd Rosaidi Che Abas, MMD, Malaysia*

The South China Sea is bordered by nine countries (China, Vietnam, Cambodia, Thailand, Malaysia, Singapore, Indonesia, Brunei, and Philippines). The main tsunami hazards are from the trench systems to the west of the Philippines, principally the Manila Trench. Presently, the PTWC and NWPTAC provide interim services for the region. However, to date the



**Looking Back, Looking Forward, *continued***

numbers of seismic and sea level stations available in real time for monitoring are relatively few making timely detection and warning difficult. The South China Sea Working Group Chair, Dr. M. Rosaidi, Malaysia, emphasized that after March 2011 where a very destructive tsunami was not necessarily expected soon, it is imperative that all possibilities should be considered, and available information should be taken into account even though some records have large uncertainties. For the South China Sea, it is important to share experience and work together, and that an end-to-end approach be adopted – this would encompass risk knowledge, efficient and rapid tsunami wave detection, and warning dissemination to a prepared community capable of appropriately responding. It may thus be desirable to develop a Sub-Regional Tsunami Early Warning and Mitigation System. Vietnam agreed. China provided a working paper, Outlook of Tsunami Warning and Mitigation System of South China Sea, to the PTWS-XXIV for discussion by the South China Sea Region Working Group. Recommendation PTWS-XXIV-1 confirmed its Terms of Reference consistent with the other PTWS Regional Working Groups. Recommendation PTWS-XXIV-4 decided to establish a sub-regional Tsunami Warning and Mitigation System for the South China Sea region within the framework of ICG/PTWS using the Outlook as a basis for its establishment.

**Summary - General Regional Working Group Terms of Reference**

All the Regional WGs (Southeast Pacific, Southwest Pacific, and South China Sea Region) have common Terms of Reference except the Central American Pacific Region which has more specific terms of reference. The common ToRs are.

1. To evaluate country capabilities for providing end-to-end tsunami warning and mitigation services,
2. To ascertain country requirements for tsunami warning and mitigation services,
3. To promote and facilitate tsunami hazard and risk studies,
4. To facilitate cooperation in the establishment and upgrading of seismic and sea level stations and networks and communication systems, and their interoperability in accordance with ICG/PTWS requirements,

5. To facilitate improvement of the education programs on tsunami mitigation, such as the inclusion of hazard and response information in curricula, and development and dissemination of educational materials taking into account regional social, cultural and economical reality,
6. To facilitate capacity building and the sharing of tsunami information, including the free and open exchange of data.

**5. Looking Forward: Strengthening the PTWS**

*Keynote speech by the former ITSU and PTWS Chair (3 terms) – Dr. François Schindelé, CEA/DASE, France*

Dr. François Schindelé provided an overview based on his long experience in the Pacific and as the Chair of the ITSU and PTWS during the 2000s. The strategy of the PTWS was established in the 1990s and elaborated in the ITSU Master Plan (rev 2004). The PTWS Medium Term Strategy was approved in 2009 (for 2009-2013) and is based on 3 main pillars:

i. Hazard and risk assessment and risk reduction; ii. Detection, warning and dissemination; and iii. Awareness and response. Looking backward, we can see that before 2004, the system improved slowly, but by 2004, much of the basic tsunami awareness documentation was already created and published through ITIC.

The three recent tsunamis demonstrate that the following are critical for an effective system:

- The Preparedness pillar plays a very important role in saving lives;
- Knowledge about hazard and risk assessment, and improved mitigation, gained from data collected during post tsunami surveys to build a comprehensive database is essential (Recommendation ICG/PTWS-XXIV.3);
- Assessment of the PTWS for the major tsunami



*Dr. François Schindelé, former Chair ITSU/PTWS. Photo courtesy of C. McCreery.*

**Looking Back, Looking Forward, *continued***

events provides information about the accuracy, robustness, and timeliness of the system and the baseline for improving (e.g., IOC Technical Series 92 for 27 February 2010 tsunami);

- Exercises that started at international level with Exercise Pacific Wave 2006 (in 2011, PacWave 11, Recommendation ICG/PTWS-XXIV.2) help to increase readiness and sustain awareness, and so should be organized regularly, such as every 2 years.

The Indian Ocean changed totally the situation. After 2004, the number of Member States increased from 26 to 32, the seismic and sea level networks were drastically enhanced, in particular the DART buoys (6 in 2004) grew to a network of 39 stations in 2011. Several new national centres were implemented and PTWC, JMA and WC/ATWC have extended their responsibilities to the Indian Ocean and/or the Caribbean region and eastern coasts of US and Canada.

The recent 11 March 2011 Japan tsunami demonstrated that the far-field system runs fine, with a caveat to note that the wave heights were mostly moderate in the far field so the tsunami was not as powerful and destructive as in the 1946 and 1960 tsunami. Thus, we still do not know how well all Member States would manage a larger far-field tsunami.

To improve the system, several sub-pillars should be improved.

Concerning the geophysical aspects, the parameters of the seismic source should be known very fast. Several techniques exist now to compute quickly and should be implemented by warning centres.

- Focal mechanism and slip distribution should be made available. For example, dissemination of Centroid Moment Tensor (CMT) solutions within 30 minutes should be possible from most earthquakes.
- The acquisition of real-time GPS data and processing to determine slip distribution shows great useful potential. Several very good networks exist in Japan, US and several countries, and these data streams should be incorporated into warning centre operations. All subduction zones should be monitored by GPS stations, especially those close to very large cities.

Concerning the sea level component, tsunami confirmation and use of observations to improve forecasting can be made more robust and faster:

- Coastal stations remain important but are limited in their locations and are contaminated by local conditions. DART buoys provide a clean, deep-ocean signal
- Sea-surface GPS buoys were shown in March 2011 to be a very useful indicator of tsunami severity. This type of buoy completes the tsunameter-type station.
- The data of all tsunameters should be transmitted in real time to the tsunami warning centres
- All geophysical and oceanographic data types should be used for real-time forecast

Concerning governance, issues should be noted.

- The need to implement sub-regional systems to improve the sub-regional cooperation is recognized.
- However, the greatest responsibility lies at the national level, which is where the downstream part (inundation, evacuation, awareness) of the system is. It is critical that National Tsunami (Coordination) Committees be established in most of the countries, in particular those located on or close to subduction zones. Improving a country's national system is its highest priority, as a strong national system then can contribute to the sub-regional system.
- Currently, there are 32 Member States of the PTWS, where as in 1999 there were 25. All countries should officially be members for a total of 45 Member States.
- At the global level, the different groups and task team established in the four regions (PTWS, IOTWS, CARIBE-EWS, NEAMTWS) should find a way to work together, sharing their experiences implementing the system, standardized when necessary and also recognizing differences and priorities in each region (e.g., TOWS Working Group and its Task Teams, e.g., TOWS-IV Summary Report, May 2011).



## 11 March 2011 Great East Japan Earthquake and Tsunami



*Left Top: The 11 March 2011 tsunami left cars atop buildings, including this 3-story building in Onagawa, Japan. Photo courtesy of L. Kong, June 2011.*

*Left Bottom: Boat left stranded atop 2-story building amidst debris from destroyed homes. In the foreground, an orange torii gate typically found at the entrance to Shinto shrines lies fallen, Otsuchi, Japan. Photo courtesy of Y. Fujii, April 2011.*

*Right Top: Tsunami waves overturned at least four buildings landward, Onagawa, Japan. Shown is a 3-story building that was located ~125 m inland from the harbor. For scale, a person can be seen entering the former 2nd floor door. Photo courtesy Y. Fujii, April 2011.*

*Right Bottom: Tsunami waves overtopped 4.5-m high sea walls destroying much of the town of Taro, Japan. Photo courtesy of B. Shibazaki, April 2011.*

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

The 35 Member States with Tsunami National Contacts and Tsunami Warning Focal Points are: Australia, Canada, Chile, China, Colombia, Cook Islands, Costa Rica, Democratic People's Republic of Korea, Ecuador, El Salvador, Fiji, France, Guatemala, Indonesia, Japan, Malaysia, Mexico, New Zealand, Nicaragua, Niue, Panama, Papua New Guinea, Peru, Republic of the Philippines, Republic of Korea, Russian Federation, Samoa, Singapore, Solomons, Thailand, Tonga, Tuvalu, U.S.A., Vanuatu and Vietnam.

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