TSUNAMI NEWSLETTER

International Tsunami Information Centre

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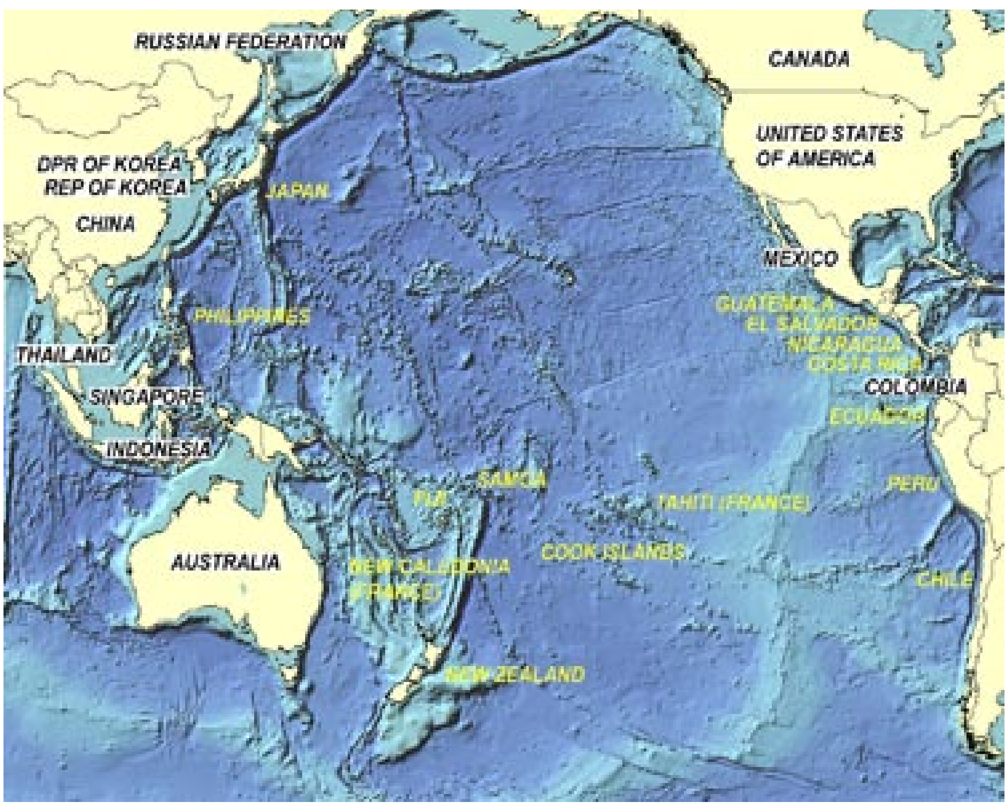

In this issue, we publish the National Reports submitted for the XIXth Session of the ICG/ITSU held in Wellington, New Zealand 29 September to 3 October 2003. During this time, 34 participants from 15 ICG/ITSU Member States, two organizations, and two observing countries met to review intersessional progress since ITSU XVIII in 2001 and make recommendations on the priorities of action for the 2004-2005 period. The Reports published in this issue are presented as received from Member States in the suggested format adopted by the ICG/ITSU; only minor editing was performed to improve readability. For each country, the report should include the ITSU National Contact in 2003, a summary, information on the Member States' local and distant tsunami procedures, its sea level and seismic networks, and a description of activities.

AUSTRALIA

Member Since: 1986

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Summary Status in 2003

The main focus of activity in Australia during the recent inter-sessional period has been on organizing tsunami services in light of changing organizational requirements and structures, and the partially implemented plans to develop the Australian Tsunami Alert Service (ATAS). The ATAS is to be co-managed by the Bureau of Meteorology (BOM), Geoscience Austrlia (GA) and Emergency management Australia (EMA), with the support of the National Tidal Facility Australia (NTFA). Two key factors in this regard are changes to sea level monitoring and tidal prediction activities and the establishment of a major oceanographic services initiative.

The proposed transition of the NTFA to a new National Tidal Centre (NTC), will better support the development of national operational tsunami warning activities. The proposed NTC would subsume the functions and responsibilities of the NTFA and would run under the aegis of an existing operational agency of the Australian federal government. The proposal is subject to funding and approval by government.

The BOM has established an Oceanographic Services Program, to foster the development of ocean services to the community. The new Program is a major commitment, paralleling the Weather Services Program which has delivered a very large range of weather services to the community over many decades. It now has management responsibilities for operational tsunami services. The increased focus and attention on these services will better facilitate the development of plans for an ATAS.

Australia has adopted a two stage approach to developing its tsunami warning systems, involving the initial development of the ATAS and the longer term objective of a more fully established warning system. Plans have been partially implemented, on the Australian western coasts, and informally in Australia's Pacific coastal areas. Plans further focus on:

- Consolidation of operational tsunami alert activities involving BOM, GA and NTFA/NTC for all coastal regions;
- Recapitalisation and review of observing networks for detecting tsunamis in Australia;
- Development of decision support for run-up prediction;
- Development of public awareness and education material on the tsunami hazard in Australia;
- Development of a broader tsunami mitigation strategy with other key national stakeholders or potentially interested participants.

Australia is also interested in jointly exploring partnerships with other national agencies in the region to further common tsunami warning objectives, and with ITSU in particular in the nearby areas of the Indian Ocean basin.

Local Tsunami Procedures

In Australia operational advice about tsunamis and provision of tsunami alert information is provided by a joint activity of three federal government agencies (G3); the Bureau of Meteorology (BOM), Geoscience Australia (GA), and Emergency Management Australia (EMA), with support and advice of the National Tidal Facility (NTFA)*. EMA provides advice on management of emergency response actions and public communications aspects. GA provides national seismic detection capabilities, and advises the BOM and the NTFA of the location, size and characteristics of the event. Tsunamigenicity is determined after monitoring of relevant tide gauges by the NTFA and advice from GA. The BOM then sends that advice or warning to EMA's National Emergency Management Coordination Centre.

On receipt of advice, EMA immediately notifies the operations centres of the relevant Australian State & Territory emergency management organisations which have responsibility for the provision of emergency services in Australia. These responsibilities in Australia are based on State and Territory jurisdictions. In addition to that notification process, tsunami advices and warnings are issued via the BOM network of regional offices to State and Territory Disaster Committees. The BOM is responsible for promulgating any public advices and warnings relevant to the event.

These State and Territory-based agencies act on advice from the G3 as to the status and extent of any continuing tsunami hazard associated with an event. They manage as appropriate, the threat or actual impact of the tsunami hazard. In the event that State resources are overwhelmed, Australian Government resources can be requested through EMA in accordance with well practised disaster plans.

**These details may change during the latter part of 2003, following reorganization of national arrangements for operating sea level and tide prediction services. Plans to establish a new National Tidal Centre (NTC) to incorporate the functions of the NTFA were pending governmental approval at the time this report was prepared.*

AUSTRALIA, *continued*

In the event of a tsunami impacting on a country in Australian's region of interest, a request for Australian assistance can be made through the Australian International Aid Agency, AusAID, with delivery coordinated by EMA.

Distant Tsunami Procedures

Pacific Ocean

The Bureau of Meteorology is the main civilian contact point for tsunami advices and warnings originated by the PTWC, and distributes them to a range of organisations including response agencies such as emergency services groups. The Australian Defence Department also receives these advices and has its own internal procedures.

Initial detection of a seismic event is provided by GA, which advises BOM and the NTFA. Currently the PTWC provides estimated travel times to Australia's Pacific coastlines but not detailed predictions of run-up conditions. Given the very large Australian coastline this is to be expected. Advice from the NTFA, based on hydrodynamic modelling, would be sought to provide guidance as to the most vulnerable areas and potential run-up heights and impacts.

The PTWC advices provide confirmation of tsunamigenicty of the event, although NTFA would also become involved in detecting sea level response from gauges in the region, e.g., from the South Pacific tide gauge network.

The BOM is responsible for promulgating any public advices and warnings relevant to the event.

Indian Ocean

In the state of Western Australia, which strictly lies outside the geographic scope of ITSU, the arrangements described above are formalised in operational procedures for tsunamis originating in the eastern Indian Ocean basin. National procedures are moving towards a system based on "Alerts" rather than "Warnings", given the lack of monitoring and warning infrastructure in eastern Indian Ocean basin countries, and underdeveloped scientific decision support more generally. Note that Australia wishes to formally explore further with the ICG the suggestion put to ITSU-XIII, that the scope of operations of ITSU be extended to the Indian Ocean as a matter of high priority. To this end a discussion paper has been submitted under Agenda Item 6.3. In particular, Australia seeks ITSU's facilitation of the intergovernmental arrangements and cooperation required amongst those countries neighbouring Australia's maritime north-west, which would be an essential factor underpinning the success of any sub-regional tsunami warning arrangements.

The BOM is responsible for promulgating any public advices and warnings relevant to the event.

Information on Tsunami occurrences

There have not been any significant tsunami occurrences in Australia during the intersessional period.

National Sea Level Network

Location	Latitude	Longitude	Date installed
Cocos Islands (Australian Territory)	12° 12'S	098° 88'E	Sep 1992
Groote Eylandt	13° 50'S	136° 30'E	Sep 1993
Darwin	12° 28'S	130° 51'E	May 1990
Broome	18° 00'S	122° 13'E	Nov 1991
Hillarys	31° 49'S	115° 44'E	Nov 1991
Esperance	33° 52'S	121° 54'E	Mar 1992
Thevenard	32° 09'S	133° 39'E	May 1992
Port Stanvac	35° 07'S	138° 28'E	Jun 1992
Portland	38° 21'S	141° 37'E	Jul 1991
Lorne	38° 30'S	143° 59'E	Jan 1993
Stony Point	38° 22'S	145° 13'E	Jan 1993
Burnie	41° 03'S	145° 57'E	Sep 1992
Spring Bay	42° 33'S	147° 56'E	May 1991
Port Kembla	34° 29'S	150° 55'E	Jul 1991
Rosslyn Bay	23° 09'S	150° 47'E	Jun 1992
Cape Ferguson	19° 17'E	147° 03'E	Sep 1991

The tide gauges in this network are SEAFRAME gauges, using Sutron 9000 Remote Terminal Units, having five sensors:

- primary water level sensor (the Bartex "Aquatrak" acoustic-in-air sensor);
- wind speed, direction and maximum hourly gust;
- air temperature;
- sea water temperature; and,
- atmospheric pressure.

A sixth channel contains data from the backup Sutron 8200 data logger unit.

AUSTRALIA, *continued*

Activities Narrative

A considerable effort has been expended by agencies of the Australian federal government to resolve difficulties which have arisen for the continued operation of the National Tidal Facility Australia (NTFA). The NTFA was established as an arm of the Flinders University of South Australia and was designated as the national tidal organization in 1989. The University has decided that it no longer intends to support the operations of the Facility. The Steering Committee, which oversees the activities of the NTFA, has developed plans for transitioning the management and operations of the Facility within the Australian government framework. Whilst the plans have not been completely resolved, the proposal to establish a new National Tidal Centre (NTC) within the Bureau of Meteorology (BOM) may be approved for implementation later in 2003. The NTC would subsume the functions and activities of the NTFA. The proposal is subject to funding and government approval. Following ITSU-XIX interested parties should consult the Director of the NTF or the Oceanographic Services Program Manager in the Bureau for further information in this regard.

The NTFA plays a significant role in monitoring tsunamis in the Australian region, and has built up key expertise in the area of tsunami modelling for predictive applications. Its existing operating environment, as an arm of the University, has proved to have been a major impediment to its active collaboration on public good projects such as the planned ATAS, especially in an operational context. Under the proposed new arrangements involving the NTC, the coupling of existing NTF expertise, know-how and systems with the operational activities of the BOM and Geoscience Australia (GA) should provide a seamless and effective sea level monitoring system which will be beneficial to the overall development of tsunami services.

The BOM has recently established an Oceanographic Services Program, which is a major new commitment to a program to develop ocean services comparable in scope to the weather services that have been developed and provided to the community over the last 100 years or so. The new Program is responsible for developing national tsunami warning services. This new focus of effort on tsunami activities will better facilitate the development of operational alert or warning capabilities, and the development of skills and expertise for putting in place necessary infrastructure, systems and decision support. National tsunami warning arrangements are in place for the western coasts of Australia, which fall outside the remit of ITSU. These arrangements will be reassessed in light of plans to initially develop the ATAS as part of a staged approach to establishment of a fully fledged warning system and future arrangements concerning NTFA. While the PTWC provides warning advices for Australia's Pacific coastlines, the intention is to develop expertise to supplement PTWC guidance especially with real-time run-up forecasts and possibly inundation estimates.

19 September 2003, Phil Parker,
Acting Superintendent, Public Weather, Marine Weather & Oceanographic Services Program

CANADA

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Summary Status in 2003

Canada maintains a network of 13 Permanent Water Level Network stations on the Pacific coast. Two of these stations are also designated as tsunami warning stations, as is the station at Langara Island. During the intersession period all of the stations except Langara Island provided a 100% data return. The station at Langara is situated in a very exposed location, is now more than 30 years old, and is starting to show signs of age. The analysis of gauge records following a tsunami event in 2001 indicated that although the Langara tsunami station is recording tides relatively well, long waves in the tsunami frequency band are strongly distorted and this distortion is likely due to deterioration of the sensing (bubbler) system. A funding proposal ($75K) was recently made to rebuild the Langara tsunami station, but it is not yet known if this proposal will be successful.

Canadian network gauges provided high quality records of tsunami from earthquakes on October 12, 2003 (M_W = 6.3, Queen Charlotte Islands, Canada) and January 22, 2003 (M_W = 7.4, Colima, Mexico). The October 12, 2001 earthquake is the first pure thrust earthquake recorded in the Queen Charlotte Islands region. New broadband stations were used to quickly determine a robust focal mechanism and seismic moment for the event. The Queen Charlotte region is primarily a transform boundary, but there is significant convergence across that boundary that

CANADA, *continued*

allows thrust earthquakes to occur.

A three year modelling study, funded by the National Search and Rescue Secretariat, is being carried out to predict coastal sea level changes and currents in southern British Columbia harbours due to tsunami that may result from a megathrust earthquake in the Cascadia Subduction Zone. The model used for this study is MOST (Titov and Synolakis, 1998), a shallow-water wave model used by NOAA to study tsunami effects along the west coast of Washington, Oregon and California, and in the inland waters contiguous to Canada and the United States. Adopting this model allows for data sharing (e.g. bathymetric data), and also produces results which can be combined for studies of the entire Cascadia area.

The present modelling effort uses bathymetric grids up to several orders of magnitude finer than previous studies. The finer resolution gives more accurate results and allows us to see variations within harbours not possible with previous models. This will assist Coast Guard SAR in preparing emergency response plans for their facilities and for the local marine communities they serve. The study will model those harbours on the west coast of Vancouver Island most susceptible to tsunami originating in the Cascadia Subduction Zone. For most of these areas modern hydrographic surveys exist, but the survey data in many cases was not initially in digital format. Much of the effort of the first two years was directed at converting and validating this survey information.

Initial modelling efforts were directed at harbours where digital data was already available. Fortunately, excellent multibeam coverage was available for both Victoria and Esquimalt Harbours on the south end of Vancouver Island. These harbours are located approximately 60 nautical miles from the mouth of Juan de Fuca Strait. Using these data sets it was possible to build a high-resolution (10-m grid) shallow-water equations model, linked to the source region with several lower-resolution nested grids.

Results of the first model runs have been extremely valuable and informative. The model shows that maximum amplitudes outside the harbours in Juan de Fuca Strait are about 2 metres. This is comparable with previous modelling studies using 2 km grids, where the computed maximum amplitudes were typically about 1.5 metres. In the harbours the response is quite different. The maximum amplitude in Victoria Harbour is about 3 metres, but in Esquimalt Harbour the maximum amplitude is nearly 5 metres. Maximum currents in both harbours exceed 5 metres/sec (10 knots.)

The study is now in its final year and the data conversion required to produce digital copies of the hydrographic field sheets for the west coast of Vancouver Island is nearly complete. This information is being used to build the intermediate coastal grids (50-100 metre resolution) and the high-resolution grids (10-20 metre resolution) for the harbours and harbour approaches. The modelling of two more harbours is complete and high–resolution grids are presently being prepared for an additional three harbours.

In October 2003, high-resolution topographic data will be collected at one location using topographic LIDAR. The topographic grid produced using this data will be merged with the bathymetric grid to produce a seamless high-resolution grid so that the effects of inundation can be accurately modelled. The resulting model results will hopefully provide motivation for additional funding directed at the collection and integration of more topographic LIDAR data.

A major focus of the past year has been the compilation and validation of historical data for a Canadian tsunami catalogue. This project is being carried out in partnership with the P.P. Shirshov Institute of Oceanography. The first phase of the project validated and expanded upon the pre-1981 work done by Wigen, Soloviev and Go. The second phase of the project is focusing on identifying all tsunami events since that time. In addition to three known tsunami events, work has identified at least three previously undocumented events.

It is now widely recognized that megathrust earthquakes occur along the Cascadia subduction zone, and that the last of these earthquakes occurred in January 1700. These finding have produced a great deal of interest. Much of the public education for earthquake preparedness is provided by scientists at the Pacific Geoscience Centre, and experts from the Institute of Ocean Sciences regularly provide information on tsunamis and tsunami response to researchers, schools, insurance industry representatives, the press, and the general public.

As part of the on-going public education program, all telephone directories for communities in BC coastal areas contain information on earthquake and tsunami response. The present modelling studies and the tsunami catalogue will provide valuable information for public education and mitigation planning.

Local Tsunami Procedures

Procedures for dealing with local and distant tsunami are provided in the British Columbia Tsunami Warning and Alerting Plan 2001 Edition, a copy of which is available on the web at *http://www.pep.bc.ca/hazard_plans/hazard_plans.html*.

- Tsunamigenic events in the immediate source area are identified by the West Coast/Alaska Tsunami Warning Center (regional warning center for BC) and the Pacific Geoscience Centre (PGC) in Sidney, BC, Canada. The Pacific Geoscience Centre operates the seismograph network in Western Canada and advises

CANADA, *continued*

Provincial Emergency Program (PEP) on earthquake events and seismic hazards. Web site: *http://www.pgc.nrcan.gc.ca/seismo/table.htm*.

- Earthquakes within the WC/ATWC area of responsibility (AOR) over magnitude 7.0 trigger a warning covering the coastal regions within 2 hours tsunami travel time from the epicenter. When the magnitude is over 7.5, the warned area is increased to 3 hours tsunami travel time. This information is transmitted to PEP via the NOAA Weather Wire system and other means. The Pacific Geoscience Centre and the Canadian Hydrographic Service (CHS) provide observational data and advice to PEP to support their decision making.
- The Provincial Emergency Program is responsible for acting upon the above information in accordance with the British Columbia Tsunami Warning and Alerting Plan.
- A tsunami Cancellation Bulletin is issued to cancel all previously issued tsunami advisory bulletins, and when it has been determined that the threat has ended. The circumstances may be such that a wave exists (but has been observed to be too small to be damaging), or if previous bulletins were based on erroneous information.

Distant Tsunami Procedures

- Tsunamigenic events from a distant source area are identified by the West Coast/Alaska Tsunami Warning Center and this information is transmitted via the NOAA Weather Wire system to the Provincial Emergency Program. In addition, the Pacific Geoscience Centre, which operates the seismograph network in Western Canada, advises PEP on earthquake events and seismic hazards.
- Formal warning and alerting for the province is the responsibility of PEP, which has undertaken the coordination procedures outlined in the British Columbia Tsunami Warning and Alerting Plan.
- The Provincial Emergency Program is responsible for acting upon the above information in accordance with the British Columbia Tsunami Warning and Alerting Plan.
- A tsunami Cancellation Bulletin is issued to cancel all previously issued tsunami advisory bulletins, and when it has been determined that the threat has ended. The circumstances may be such that a wave exists (but has been observed to be too small to be damaging), or if previous bulletins were based on erroneous information.
- No watches or warnings were issued by the WC/ATWC during the intersession period. The CHS looked for possible tsunamis in tide station records following major earthquakes on March 5, 2002 (Indonesia), September 8, 2002 (Papua New Guinea) January 22, 2003 (Mexico) and August 21, 2003 (New Zealand). Smaller local earthquakes on October 17, 2001 and July 12, 2003 were also investigated for possible tsunami. In addition, the PEP Duty Officer contacted the CHS Tsunami Advisor whenever a WC/ATWC bulletin was received for an earthquake of magnitude greater than 6.5. This occurred about once a month and served to test communication procedures.

National Sea Level Network

ID	Name	Latitude (N)	Longitude (W)
7120	Victoria	48 25.5	123 22.3
7277	Patricia Bay	48 39.2	123 27.1
7654	New Westminster	49 12.0	122 54.6
7735	Vancouver	49 17.2	123 06.6
7795	Point Atkinson	49 20.3	123 15.2
8074	Campbell River	50 02.5	125 14.8
8408	Port Hardy	50 43.3	127 29.3
8545	Bamfield	48 50.2	125 08.2
8615	Tofino (+TWS)	49 09.2	125 54.8
8735	Winter Harbour (+TWS)	50 30.8	128 01.7
8976	Bella Bella	52 09.8	128 08.6
9354	Prince Rupert	54 19.0	130 19.4
9850	Queen Charlotte City	53 15.1	132 04.3
9964	Langara Point (TWS only)	54 15.3	133 02.7

CANADA, *continued*

Permanent Water Level Network (PWLN) configuration:

The PWLN was maintained at 13 tide stations. The network is jointly maintained by Water Survey of Canada (WSC) and CHS. Each station presently utilises a Sutron 8210 Data Logger coupled to a dual BEI encoder/ladder-chain float and counterweight system. One-second water levels are collected and averaged to provide 1-minute data. Each site is accessible via modem and all gauges and modems are backed up with dual batteries. Data acquisition is via PCBase2 software and is downloaded automatically once a day. Gauge clocks are checked weekly and downloads are checked daily from IOS. All acquired data are further processed to compensate for hardware and site specific limitations. CHS, WSC and local attendants acquire periodic 1-minute averaged tape readings, which are used to verify corrected water levels.

The stations at Tofino and Winter Harbour have both a telephone modem and a satellite link. In the event of a Tsunami Warning/Watch designated personnel will use telephone modem and/or MSAT software to establish a link with each station. Either method can be used. The MSAT link is costly and will only be used in the event of a test, an event alarm, or a Tsunami Warning/Watch. The telephone link can be accessed from any modem, but will be susceptible to phone line congestion or outage in the event of a major earthquake.

The station at Langara is a not a PWLN station (tsunami warning only) and due to its exposed location is equipped with a Paroscientific pressure sensor and bubbler system. In the event of a tsunami watch or warning data can be transmitted to IOS using the MSAT communication system, but data is normally copied to memory chip once a month and mailed to IOS. The station at Tofino also has a bubbler system with external orifice to complement the standard PWLN configuration (as siltation in the horizontal intake pipes sometimes degrades system response to higher frequency signals).

Information on Tsunami Occurrences

On October 12, 2001 an earthquake with a magnitude M_W = 6.3 occurred on the continental slope of the Queen Charlotte Islands, This moderate earthquake generated a tsunami, which was recorded at four locations on the coast of Vancouver Island. Maximum tsunami wave heights at these stations were: 14.5cm (Port Hardy), 22.7cm (Winter Harbour), 18.2cm (Tofino), and 11.3cm (Bamfield). Unfortunately, the Langara tsunami station was not operating at the time. The tsunami was not recorded at other nearby stations (Bella Bella, Queen Charlotte, Prince Rupert), probably because of coastal sheltering and spatial decay.

The January 22, 2003 earthquake near Colima, Mexico (M_W = 7.4) generated a tsunami, which was recorded at Winter Harbour, Tofino and Bamfield. Analysis of this data is not yet complete.

Activities Narrative

In addition to regular servicing and maintenance of the Tsunami Warning System (TWS) the CHS has carried out several required upgrades. The software routines and batch programs were rewritten and integrated to the NBHOST programs. Software upgrades to the remote MSAT operating system at Tofino and Winter Harbour were performed to compensate for a switch over by the MSAT systems to the American satellite frequency for the lower latitude stations.

The alarm feature has also been expanded to forward ongoing data following an alarm event. Additional future enhancements will provide the capability to access the IOS tsunami computer by laptop or palmtop computer using a cellular phone. This will provide immediate access to the data and station parameters, including the ability to change the station parameters. A continuing planned enhancement is to have incoming data automatically placed on a web site for reference by selected users (ATWC, PTWC, PEP etc.). A constraint at the moment is the cost of more frequent downloads by telephone or satellite.

Notification of all communication tests initiated by WC/ATWC, as well as summaries of these tests, are received and reviewed by the CHS on a regular basis. During the period September 2001 - August 2003 response times for the ATWC dissemination tests were typically less than 5 minutes at both CAA FSS Prince Rupert and PEP.

The analysis of gauge records following a small tsunami event in 2001 indicated that although the Langara tsunami station is recording tides relatively well, long waves in the tsunami frequency band are strongly distorted and this distortion is likely due to deterioration of the sensing (bubbler) system. A funding proposal ($75K) was recently made to rebuild the Langara tsunami station, but it is not yet known if this proposal will be successful.

On October 12, 2001 a magnitude M_W = 6.3 earthquake with a pure thrust mechanism occurred on the west coast of the Queen Charlotte Islands. Using the new broadband stations, a robust focal mechanism and seismic moment was determined quickly for this event. This is the first pure thrust earthquake recorded in the Queen Charlotte Islands region. The earthquake generated a small tsunami that was recorded on tide gauges on Vancouver Island with maximum amplitude of 22 cm. The Queen Charlotte region is primarily a transform boundary, but there is significant convergence across that boundary that allows thrust earthquakes to occur.

CANADA, *continued*

GSC Contact: Dr. Garry Rogers, rogers@pgc.nrcan.gc.ca

In September 2001, the Provincial Emergency Program conducted exercise Seaswell 5. The purpose of this exercise was to test the resource call-out and information fan-out procedures, and to validate provincial, federal and local emergency plans and contacts. The exercise involved PEP staff, emergency radio operators, local governments in coastal communities, major utilities, and seismic/tsunami advisors. The exercise was deemed to be a success, as information got to those who needed it in a timely manner.

As well as responding to periodic pager calls from Provincial Emergency Program (PEP) and Prince Rupert Coast Guard, CHS staff also verified MSAT pager alarm messages. An annual meeting between CHS, PEP and the Pacific Geoscience Centre took place in December 2002 at IOS. In January 2003 CHS staff met with the new Emergency Management Analyst at PEP to review provincial tsunami procedures.

Recently, numerical modelling of landslide-generated tsunamis in the Strait of Georgia was carried out for two areas of potentially unstable sediment deposits. Simulated tsunami wave amplitudes for the chosen slide parameters reached 6 to 8 metres in the Malaspina Strait region and 18 metres in the southern Strait of Georgia region. Considerably more geotechnical data will be required, however, before rigorous assessments can be undertaken.

Publications of Interest

Rabinovich, A.B., R.E.Thomson, B.D. Bornhold, I.V. Fine and E.A. Kulikov. Numerical modelling of tsunamis generated by hypothetical landslides in the Strait of Georgia, British Columbia, 160 (2003) 1273-1313.

Rabinoivich, A.B., and F.E. Stephenson. Longwave measurements of the coast of British Columbia and improvements to the tsunami warning capability. Revision submitted to Natural Hazards, August, 2003.

CHILE

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Summary Status in 2003

During the period significant improvements have been made to address tsunami risk in three general areas:

(1) improvement in seismic and tide data acquisition,

(2) heightened public awareness of the tsunami threat and

(3) improvement in communications.

1.1.Seismic data acquisition:

Approximately 60 seismic stations are run by different universities around the country. Most of them are linked via radio telemetry, Internet, or modem to a central analysis office where earthquake location and magnitude can be retrieved. However, since this is a university system, it does not operate after working hours. Recognizing the need for a prompt and reliable source of seismic data, SHOA received funds in 1995 to install a TREMORS broadband station inland from Valparaíso, that provides estimates of the epicenter and seismic moment in real time. Additionally, a computer continuously receives hypocentral information from earthquakes around the globe from different sources.

1.2.Tide data acquisition:

The old mechanical and bubbler gauges, some of them operating since 1942, started being replaced in 1985 with satellite data collection platforms, with help from the U.S. National Weather Service, Pacific Region, and especially the support of the late NWS/PR Director Richard Hagemeyer. Data from these platforms are received in near-real time (delays of up to an hour) at SHOA. A new project is under way to get sea level information from these DCP's in real time through the Navy's communications system. Presently, there are 18 satellite sea level stations operating along the Chilean coast. During 2003, a DART System buoy will be deployed off the northern coast of Chile in order to improve the early tsunami warning capability in both Chile and the Pacific.

2.1. Educational efforts:

Since 1992, SHOA has been publishing educational textbooks on earthquakes and tsunamis with support from IOC. In addition, several tsunami pamphlets for the general public have been printed in Spanish, and English by SHOA; *Tsunami: The Great Waves*, *Surviving a Tsunami: 11 Lessons from the 1960 Chilean tsunami*, and

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Tsunami Glossary. In addition, new colour versions of the educational textbooks for the first two educational levels and a new educational pamphlet called *The Infant Buoy* have been published. Both can be found on the SHOA web page.

Several meetings with the community and local emergency managers have been organized by SHOA in order to explain the applications of tsunami inundation maps.

2.2. Tsunami inundation maps:

The project, 'Processing Tsunami Inundation Maps for the Chilean Coast', which follows techniques of the TIME Modelling Project, has been funded since 1996. Twenty six maps were published before 2003, and 3 more are scheduled for production in 2003. These maps are given to the local authorities to aid them in developing their own community tsunami response procedures.

3.1. Communications within the system:

Improved communications with PTWC and the U.S. West Coast/Alaska Tsunami Warning Center have been implemented through the use of an e-mail address dedicated exclusively to receiving tsunami messages. Also, since 1999, regular tsunami test exercises are performed with the Peruvian Dirección de Hidrografia y Navegación de la Marina de Guerra and the local sea level network. To ensure greater redundancy in the communication system, in 1998, Chile installed a terminal of the U.S. operated communications system Emergency Managers Weather Information Network (EMWIN), which provides various emergency management data, including tsunami watches and warnings from PTWC through the GOES satellite system.

3.2. Communications with the public:

The National Emergency Office of the Ministry of Interior (ONEMI) is responsible for disseminating Tsunami Watches and Warnings to the general public and the media. SHOA and ONEMI are linked by VHF and HF radios, in addition to the common communication systems. ONEMI and SHOA also work on a 24 hours basis monitoring any and all emergencies occurring in the country through these radio links.

3.3 International Cooperation:

After a request from Colombia and Ecuador and in behalf of the agreement celebrated at ICG/ITSU-XVIII, which included the visit of a tsunami consultant from Chile, Mr. Emilio Lorca, Head of the Marine Geophysics Section from SHOA, was sent to Tumaco, Colombia and Guayaquil, Ecuador, in August 2002, funded by IOC and the Colombia and Ecuador Navies, in order to assist with the development of a "National Tsunami Plan".

In June 2003, a Hemispheric Consultation on Early Warning took place in Antigua, Guatemala, as part of the preparations leading the Second International Early warning Conference (EWCII) which will take place in Bonn, Germany,15-19 October 2003. The objective of this regional consultation was to identify existing early warning systems, responsible persons/organizations, as well as other relevant aspects of early warning systems such as financial aspects, cost of investment and sustainability. The tsunami aspects of early warning were covered by Dr. Laura Kong, Director ITIC and Mr. Emilio Lorca from SHOA, Chile, who were invited by the organizers, the Government of Germany under the auspices of the United Nations and promoted by the Inter-Agency Secretariat of the International Strategy for Disaster Reduction and UNDP.

Local Tsunami Procedures

SHOA is operating 24 hours per day, 7 days per week and has the responsibility to identify and characterize events that have the potential to generate local tsunami with the help of a TREMORS station and the Seismological Service of the University of Chile. The threshold for declaring a potential local tsunami emergency is a magnitude Ms 7.5 or a seismic moment of 5x1021 N.m. This information is sent to ONEMI also operating on a 24 hours per day basis and all the Navy authorities under high priority messages. They act locally in coordination to deal with the emergency.

The emergency situation is terminated when SHOA detects no sea level anomalies at the near-field mareographic stations. SHOA issue a tsunami bulletin: "tsunami warning or tsunami watch is cancelled".

Distant Tsunami Procedures

The organization that identifies and characterizes tsunamigenic events from a distant source is SHOA. SHOA receives all messages from PTWC. Furthermore, it is able to get seismic moment data coming from the broadband station ELRO (TREMORS system) and location information from several sources through e-mail and web pages, seismic data coming from NEIC, PTWC bulletins, and monitors sea level data of the islands stations where any distant tsunami is recorded before reaching mainland Chile. If the recorded tsunami waves have amplitudes of 2 meters or more, a Tsunami Warning is transmitted including arrival times to the coast using the Tsunami Travel

CHILE, *continued*

Time software.

The information provided by PTWC is immediately routed to ONEMI and Maritime (Naval) Authorities who will start operating at a local level if a tsunami watch or warning is declared by the national TWS.

Sea Level Stations

Station	Latitude ºS	Longitude ºW
Arica	18º 29'	70º 19'
Iquique	20º 13'	70º 10'
Antofagasta	23º 39'	70º 25'
I.San Felix	26º 16'	80º 07'
Caldera	27º 04'	70º 50'
I. Pascua	27º 09'	109º 27'
Coquimbo	29º 56'	71º 21'
Valparaiso	33º 02'	71º 38'
San Antonio	33º 35'	71º 38'
I.J.Fernández	33º 37'	78º 50'
Talcahuano	36º 41'	73º 06'
Corral	39º 52'	73º 26'
P. Montt	41º 29'	72º 58'
Ancud	41º 52'	73º 51'
P. Chacabuco	45º 28'	72º 50'
I. San Pedro	47º 43'	74º 54'
P. Arenas	53º 10'	70º 54'
P. Williams	54º 56'	67º 37'

All station are Vaisala 555 C platforms

There was no information of tsunami occurrences during the intersessional period.

Activities Narrative

A. Developments of the National Tsunami Warning System:

Tsunami Inundation Charts: Since 1997, after the TIME training course in Chile, The National TWS has been producing inundation charts of the main ports to help the Civil and Maritime Authorities to plan and mitigate the effects of a tsunami. During the period 2002-2003, eight charts have been produced under the project "Processing of Inundation Maps by Tsunamis for the Chilean Coast". The cities included in these charts are: Los Vilos, Constitución, Coronel, Lebu, Huasco, Quintero and Papudo.

Publications: During the intersessional period several publications were distributed and others edited as follows:

Maremoto del 22 de mayo de 1960 en las Costas de Chile, 2ª. Edición, 2000, (SHOA N°3012). (Tsunami of May 22th, 1960 along the coast of Chile)

Instrucciones Generales sobre el Sistema Nacional de Alarma de Maremotos, 4ª. Edición, SHOA N° 3203, 2000. (General Instructions about the National Tsunami Warning System).

Cómo sobrevivir a un tsunami. Once lecciones del tsunami ocurrido en el sur de Chile el 22 de mayo de 1960. SHOA, 2000. (translation of the USGS, *Surviving a Tsunami – Lessons from Chile, Hawaii, and Japan*). This publication can be found at SHOA's web site: http://www.shoa.cl/shoa/publicacionesespeciales.htm.

Tsunamis, Las Grandes Olas. Recently translated from the English version: *Tsunami, The Great Waves*. Will be distributed during the XIX Session. This publication can be found at SHOA web site: http://www.shoa.cl/shoa/publicacionesespeciales.htm.

ITIC Web Page: In cooperation with the Associated Director of ITIC, who is permanently updating the ITIC web page, SHOA is incorporating to the page all the following new publications:

Updated color version of *Earthquakes and Tsunamis, pre-elementary school textbook*, in Spanish.

Updated color version of *I invite you to know the Earth I,* in Spanish.

CHILE, *continued*

The Tsunami Glossary, in English and Spanish.

The Infant Buoy, animated in Spanish.

Instrumental and technical developments: In order to give the tsunami early warning capability to the NTWS, a DART buoy system will be deployed in near of the northern Chile coast, where a large seismic gap exists. This system will be deployed with help from PMEL and NDBC on board the *R/V Roger Revelle*, in November 2003.

B. Experiences in the operation of the TWS

Once every other month a tsunami dummy exercise is performed with all the tide gauge stations.

Periodically communication tests with Peru´s Dirección de Hidrografía y Navegación are performed in order to improve the response of both national systems.

C. Meetings, seminars, workshops, etc.

The VII International Congress "Earth Sciences 2002": This congress organized by the Military Geographical Institute was held on 7-11 August, 2002 in Santiago, Chile. A special session was dedicated to papers related to the Peruvian 2001 tsunami earthquake, June 23, 2001. Dr. Viacheslav K. Gusiakov and Dr. Salvador Farreras were special guests and presented a paper related to the topic.

Several seminars have been carried out, with the communities of Arica and other coastal communities of the central Chilean region, explaining the National Tsunami Warning System operation and the application of the flood maps.

D. Future Plans

During 2004 new tsunami inundation maps will be edited for Taltal, Ancud and San Vicente. With the publishing of these maps, project CITSU will be complete.

Improvements of the tide data collection: data coming from the satellite tide gauge stations still are transmitted every hour. As it is known, this time delay is too long to get information during a near-field tsunami. This time lag can be improved if data from the tide stations could be capture in real time through a telephone modem. Dedicated lines from the Navy will be used for this purpose.

Protection against lightning are being installed to protect the site where the TREMORS broadband station is operating. Several times in the past the operations of the station was stopped by destruction on GPS and transmitters. This winter no problem has arisen from the frequent storms in the area.

July 2003, Emilio Lorca, SHOA

CHINA

Member Since: 1968

ICG/ITSU National Contact: Mr. Luo Yuru

Director, National Bureau of Oceanography

Beijing, People's Republic of China

Summary Status in 2003 Unknown, no National Report received.

COLOMBIA

Member Since: 1980

ICG/ITSU National Contact: Prof. Hansjürgen Meyer

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Summary Status in 2003

Steps were taken to better understand the effects a tsunami would have along the Pacific Coast of Colombia, especially around Tumaco Bay. Tumaco Bay is found to have the highest tsunami risk in the country. Not only is it located very near an offshore seismic gap, but the topography of the area is a low-lying plain, with high population density, (especially in the low tide areas) with most building not constructed to withstand earthquake hazards.

Relevant activities include vulnerability studies that weigh various sociological aspects of Tumaco and risk assessments for tsunami-generated flooding and liquefaction. These studies make it possible to determine the factors needed as the basis to formulate evacuation plans. In the area of research, it is also important to mention the work carried out by

COLOMBIA, *continued*

CCCP to evaluate the flooding that would be occur in Salahonda and Buenaventura given several possible scenarios. Variables include source location and tide conditions which determine maximum run-up calculations, estimated times of arrival, and the areas that would be inundated. Several seminars have been held to present these scenarios to the community. These seminars carried out to incorporate the vulnerability of risk into Territorial Ordinance Plans; another was held to inform teachers about the Emergency School Plans, and another was celebrated, with representatives of 4 coastal municipalities of Nariño participating, about the formulation of Emergency and Contingency Plans. From among these activities it is important to emphasize the one carried out with support of COI and DIMAR, thanks to recommendation made in the XVIII Session of ITSU, for a Chilean expert to assist in supporting the Local Emergency Committee of Tumaco to determine the basic approach to formulate the Emergency Plan.

We have made significant progress in developing plans, and expect to have the Emergency Plan and Contingency Plan for tsunami in Tumaco available by the meeting. The plans will include evacuation areas, along with evacuation routes, equipment and material inventories, and will describe the roles of responsible institutions during an emergency. These documents will be used as a model for other coastal communities. The plans will be implemented in increments associated with increasing levels of heightened public awareness. Implementation includes practice of tsunami drills in 16 Tumaco schools at the end of a unit of instruction about the prevention and hazard of disasters. Each school's Emergency School Plan was made to include tsunami. We plan to schedule the drills during the second semester of the year.

Local Tsunami Procedures

· What organization identifies and characterizes tsunamigenic events in the immediate source area? OSSO (detection/warning system – based on TREMORS - in development)

· What is the threshold for declaring a potential local tsunami emergency? The available time between a seismic event and the arrival of tsunami wave to the 19 villages located in Tumaco Bay is 30-40 minutes. In Buenaventura Bay, it is 65-90 minutes.

· What organization acts on the information provided by the agency responsible for characterizing the potential local tsunami threat? CLOPAD (Comité Local de Prevención y Atención de Desastres) is the organization that acts in each case, presided over by a mayor. In the case of tsunami in Tumaco, the CCCP (Centro Control Contaminación del Pacífico) acts as other members of CLOPAD, supplying information to the mayor.

· How is the emergency situation terminated? The emergency situation is finished between 4 to 6 hours after the occurrence of an earthquake, according to the Local Emergency and Contingency Plan.

Distant Tsunami Procedures

· What organization becomes aware of tsunamigenic events from a distant source? OSSO

· What action does this organization take with regard to tsunamigenic events from a distant source?

- Only PTWC/ATWC messages demanding action are evaluated.
- As backup to PTWC messaging, EMSC and NEIC are continuously monitored (and relayed via E-Mail to 5 cellular phone of OSSO staff) for large and shallow events in the Pacific.
- Evaluation takes into account source location, depth and magnitude (checked with EMSC and NEIC), historic information numerical models (TIME) for various source regions, tide-level reports from intermediate sites (Galápagos etc.), information via telephone from along-path services, etc.
- Evaluation results are communicated via phone/fax and bulletin to more than 40 authorities and organizations with responsibilities.
- Mass media are contacted directly in case they receive information from elsewhere and are reporting the news.

· What are the criteria for initiating tsunami mitigation procedures? Reasonable evidence for probable dangerous wave heights, from numerical modeling and distant tidal levels (there is no history of distant-source tsunami waves on Colombia's Pacific coast)

· What actions were taken in response to warnings issued by PTWC during the intersessional period? Only one watch (01/21/2002 Michoacán, México event; danger for Colombian coast was found to be nill, based on historic information and event depth (EMSC); a bulletin was issued to all listed Colombian organizations.

National Sea Level Network

Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM) is responsible for this information. The mareograph installed in the jetty of the Port Society of Tumaco is maintained and verified by the CCCP and it has access to the information thanks to an agreement reached with IDEAM.

COLOMBIA, *continued*

be very useful to have the plans ready before then.

Education

From 2001 to 2003, more than 60 tsunami presentations were given by CCCP in schools or to organized groups. Presentations on research results were made at the 'Seminar of Sciences of the Sea' in Santa Marta in April 2003 and at an international course on marine geology, in August 2003.

Other education materials aimed at various audiences include:

Interactive presentations in Compact Disk : Didactic 1 and Didactic 2
Powerpoint presentations about various aspects of the topic: 32
Game of billboards for schools without video capabilities: 5
Pedagogic activities designed and implemented: 12
Publication: *Hello Wave*

Implementation of Plans

Supplementing the education activities, a program was carried out called "The Seven Steps", which prepared facilitators of 16 Tumaco's schools. These programs were also attended by aid entities (Civil Defense, Cruz Roja, Firemen, Hospital) and the CCCP, to make an analysis of risks of their respective schools and then elaborate on the specific school conditions, with special emphasis to tsunami topics. This exercise was carried out during four months.

The seven steps considered:

1. Identify the formers in each school and create emergency committees for schools,
2. Train the tsunami formers in emergency management,
3. Create school curriculum with support of teachers in the region,
4. Formulate emergency school plans and evacuation plans in case of tsunami,
5. Integrate the plans with each other according to the Municipal Plan,
6. Implement plans into the schools that include tsunami drills for the community,
7. Conduct drills or tsunami exercises (first in the classroom, then for the school and finally at several schools).

The same exercise was broken into 4 phases:

Phase I: Basic Knowledge (What is a tsunami, how is it mitigated, how does civil defense operate, etc),
Phase II: Operative Knowledge (First Aid, what to do in case of earthquakes, fire, etc),
Phase III: Elaboration of documents (Analysis of school risks and school emergency plans),
Phase IV: Drills or exercises.

To date (June 2003), there are six schools with Emergency School Plans. Although some have not yet conducted drills, it is forseeable that these will be conducted in the second half of 2003. These may in some instances be linked to aid agencies or governmental entities; whether agencies of education, traffic and transportation or public works, remains to be seen.

Incorporation of tsunami information into other activities

Contributions to the National Technical Committee of Tsunami have been centered on discussions of the advances made in studies by various entities, and the collaboration between institutions and contributions made to the National Contingency Plan of Tsunami.

Participation in the Territorial Ordinance Plan of Tumaco. The contribution has been verified that the risk for tsunami is incorporated, the information would be appropriately interpreted, and the proposed mitigation would be carried out according the risks. Actually the CCCP is advising the Tumaco area, controls the quality of work realized by the consultant group hired to incorporate the variable risks to the Plan.

Support the strengthening of CLOPAD. The actions here are related to maintaining an integrated group, to guide processes in the absence of the coordinator of the municipality, to deploy equipment and other resources, to present the proposal for signaling in Tumaco, and support with logistics information of the building of PLEC, among others.

Acquisition of portable and fixed equipment and radios to establish the communication networks of CLOPAD in Tumaco, worth $70 million.

Acquisition of basic resources for firemen, Civil Defense and Red Cross valued at $400 million.

Design warning signs for tsunamis that take into account the international standards.

Support cartographic of SIG for socialization plans.

1 July 2003, National Technical Tsunami Committee

COOK ISLANDS

Member Since: 1982

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Summary Status in 2003 Unknown, no National Report received.

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Summary Status in 2003 Unknown, no National Report received.

ECUADOR

Member Since: 1970

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Summary Status in 2003

Actually Ecuador doesn't have a Tsunamis Warning System, but it coordinates with the International System, from the messages sent by PTWC. The Oceanographic Institute of Ecuadorian Navy is responsible for receiving messages directly from PTWC. It then communicates to the Port Captaincies and Civil Defense Agencies. Together they are responsible for alerting the population if a tsunami occurs.

We have been working very hard to develop our Local Warning System, and to establish suitable thresholds. During this intersessional period, the Oceanographic Institute of the Navy has acquired new tide meters, to renovate all the stations. INOCAR has two automated stations, they are located in Esmeraldas and La Libertad. They have been transmitting data in real-time consistently.

Local Tsunami Procedures

What organization identifies or characterizes tsunamigenic events in the inmediate source area?

There is not a National Tsunamis Warning System in our country but when a local tsunami hazard exists the Oceanographic Institute of the Ecuadorian Navy identifies and characterizes these events, based on the information provided by the Ecuadorian Geophysical Institute.

The goals for this year are to conform the Local Warning System from the flood risk maps. We have obtained an agreement between the Ecuadorian Geophysical Institute and INOCAR to work together in an effective manner.

What is the threshold for declaring a potential local tsunami emergency?

Actually, there is no threshold for declaring a potential local tsunami emergency. We have been working with that since 2002, when the Group at ITSU-XVI approved the change in the warning magnitude threshold from M=7.0 to M=7.5.

During a visit from Emilio Lorca, we looked at the possibility of establishing these thresholds. We began with a pilot area, in this case, Esmeraldas, where we have actually started developing a tsunamis mitigation plan with the first step to create a city flood map.

ECUADOR, *continued*

What organizations act on the information provided by the agency responsible for characterizing the potential local tsunami threat?

Civil Defense, together with the Naval Force, informs the coastal civil authorities of the possiblity of a tsunami occurrence, in order for them to alert the civil population and organize the evacuation from the riskiest flood areas.

A very important part of the process is accomplished by the Port Captaincies. They together with the Civil Defense are in charge of keeping the population alert and aware of the situtation during a tsunami event.

How is the emergency situation terminated?

Civil Defense and Naval Force will have been sending the necessary bulletins during emergencies. Finally, Captaincies and Civil Defense will alert the population when the threat is confirmed over.

Distant Tsunami Procedures

What organization becomes aware of tsunamigenic events from a distant source?

INOCAR becomes aware of tsunamigenic events from a distant source.

What action does this organization take with regard to tsunamigenic events from a distant source?

Once INOCAR receives the alert, it is retransmited by phone and other means to Port Captaincies and Civil Defense Agencies along the coast. They will notify the population of the arriving tsunami according to the message.

What are the criteria for initiating tsunami mitigation procedures?

In general, INOCAR receives messages from PTWC, but when INOCAR has received messages from other sources, these messages are investigated and compared with bulletins from PTWC before giving the alert.

What actions were taken in response to warning issued by PTWC during the intersessional period?

During the intersesional period, INOCAR wanted to improve this local warning system step by step. We have started by developing a flood map for tsunamis in Esmeraldas City.

In May of the 2002, INOCAR participated in The ITIC Visiting Experts Program in Honolulu, Hawaii. Since then, ITIC has helped support the reproduction of three brochures designed for our Tsunamis National Prevention and Mitigation Program. Furthermore, in February, we received support for our representative to attend training at CICESE-Ensenada- Mexico, that was given by Dr Modesto Ortiz.

Presently we are incorporating tsunami inundation maps on local urban maps of Esmeraldas with the vertical resolution of 1 m showing the distribution of buildings and land use. Next, we will develop an mitigation plan based on the vulnerability to tsunami flooding (based on the map) found along the Esmeraldas coast.

National Sea Level network

The current network of tidal and meteorological stations that are administrated by the Oceanographic Institute of the Navy (INOCAR) is comprised of the following stations:

PORT	LATITUDE	LONGITUDE	TEAM
Limones	1° 15.0´N	78° 59.0´W	GS-98 (STEVENS)
San Lorenzo	1° 18.0´N	78° 50.0´W	GS-98 (STEVENS)
**Esmeraldas	0° 59.0´N	79° 39.0´W	AXSYS – SDI (STEVENS)
Bahía de Caráquez	0° 36.0´S	80° 25.0´W	GS-98 (STEVENS)
Manta	0° 56.0´S	80° 43.0´W	GS-98 (STEVENS)
** La Libertad	2° 13.0´S	80° 54.0´W	AXSYS – SDI (STEVENS)
Data de Posorja	2° 42.0´ S	80° 15.0´W	GS-98 (STEVENS)
Pto. Nuevo Guayaquil	2° 16.0´S	79° 55.0´W	GS-98 (STEVENS)
Puná	2° 44.0´S	79° 55.0´W	GS-98 (STEVENS)
Pto. Bolívar	3° 16.0´ S	80° 00.0´W	GS-98 (STEVENS)
* Isla Baltra	0° 27.0 S	90° 17.0´W	HANMAR - STEVENS/NOAA
* Isla Santa Cruz	0° 45.0´S	90° 17.0´W	HANMAR – STEVENS/NOAA

* Platforms equipped with tide sensors from NOAA.

** Automatized stations. Transmission in real-time.

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The stations in the Pacific are[1]:

CODICO	CAT	NOMBRE	CORRIENTE	GRA	MIN	LAT	GRA	MIN	LON	ELEVA	ENT_O	A_OP	FECHA_ INSt
5103901	MM	TUMACO	PACIFICO	1	50	N	78	44	W	0	1	7	15/09/51
5311901	MM	BUENAVENTURA	PACIFICO	3	54	N	77	5	W	0	1	9	15/05/41

CODIGO	CAT	NOMBRE	ACTUALIZAC	LATITUD	LONGITUD	X_COORD	Y_COORD
5103901	MM	TUMACO	08/02/02	1,833333333	-78,733333333	481784,36771	694852,38673
5311901	MM	BUENAVENTURA	08/02/02	3,900000000	-77,083333333	666387,14362	923299,24863

[1] *Information provided by IDEAM*

Information on Tsunami Occurrences

The most recent disastrous tsunami occurred on 12 December 1979 along the coast of Nariño, the southernmost Province, following a large local earthquake. A detailed account is published in Science (211:4481,30 January 1981), *The Great Tumaco, Colombia Earthquake of 12 December 1979*, by Darrell G. Herd, et al.

Activities Narrative

During this intersessional period, many steps were implemented in the country with the purpose to understand the effects of tsunami on Pacific Coast, especially in Tumaco Bay, which is determined to be a high risk place in the country, not only because of its proximity to a seismically-active trench, but for the low lying area, the high population density of the low tide areas, and lack of earthquake-resistant construction in the existing structures.

These are the areas of activity:

Tsunami research
Workshops and seminars
Planning
Education
Implementation of plans and increasing tsunami awareness
Incorporation of tsunamis information with other initiatives

Tsunami research

The University of Cauca carried out a study on the vulnerability of the population in Tumaco. The results show:

- A high percentage of the population doesn't know what to do in case of a tsunami.
- Seventy percent of the population reported that they don't know about the Disaster Prevention System, nor what to do in case of a tsunami.
- Migration has increased the size of the population at risk.
- The Importance of including community leaders in the socialization process.

This year, OSSO conducted a study of physical vulnerability which showed that (final report still awaited):

- There are many essential buildings that don't have earthquake resistance conditions.
- Public services are highly vulnerable.
- Organizations needed for assistance in an emergency, like fire departments, civil defense and the Red Cross, are poorly organizied.

INGEOMINAS presented a study of liquefaction in the area of Tumaco. It compiled information on what happened during the tsunami in 1979, and dates of filling made in the islands and measures made with seismic cone. Finally, some areas were determined that will be potentially damaging in future cases.

The CCCP produced flood maps in the event of tsunami for more probable seismic levels in the next 50 years (information supplied by OSSO and INGEOMINAS). At this stage, many tide levels were recorded and several degrees of inundation presented. The CCCP also produced inundation maps of the municipalities of Salahonda and Buenaventura, with estimates of tsunami arrival times and identification of approximate at-risk populations.

Using previous studies as a basis, events were promoted to use this information to do the Territorial Ordinance Plan of Tumaco, like the elaboration of basic criterions to formulate the Emergency and Contingency Tsunami Plan. The DGPAD has given the results of mentioned research to the mayor of Tumaco to be incorporated in different actions of the municipality.

The CCCP is conducting investigations into the viability of using Guamo Island as a protective feature in Tumaco. This

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island completely subsided twice; in 1906 and again in 1979, each time the island was gone, but the tsunami impact to other Tumaco islands was less. The decrease of height of the tsunami and the flooded areas already have been demonstrated, and now we are working to balance the vegetation and coastal profile that will maximize protection of the population. Also the CCCP is verifying the consequences that this island would have on the navigation channel and the line of actual coast, as well as the possible environmental impact.

On the other hand, the CCCP will be programmed to repeat the experience realized in Tumaco, in other places located along to Nariño coast. It has been worked in a proposal to use LIDAR sensors that are installed in a plane with the objective to obtain precise information with a high resolution of the coastal fringe between 0 and 10 meters (zero is the level of low tides). The above mentioned will allow to have the information required to do numerical model of TIME. Today the necessary financing has not been achieved to obtain dates of LIDAR.

Tsunami workshops or seminars

During this period several seminars were held in Tumaco (area determined as area at highest risk of tsunami) some of them are:

November 2001: Workshop to formulate Tumaco's Contingency Plan, organized by the Colombian Civil Defense and the CCCP.

July 2002: Workshop organized by the Development Minister to incorporate the variability of risk in the Territorial Plans of Ordinance.

August 2002: Seminar "Initiative to consolidate a local system of answer in the event of tsunami in Tumaco" organized by CCCP with the assistance of the Chilean expert, Emilio Lorca, whose attendance was requested at ITSU XVIII and supported by COI and the Oceanographic and Hidrographic Service of the Navy of Chile. This event provided an important opportunity for the members of the Emergency Local Committee and several members of the National Tsunami Committee, to meet with national experts on the aspects of disasters. This is the first forum in which all the available information to date was examined, and several critical aspects of the Contingency Plan were determined for the municipality. Much of what was brought to light, changed peoples' viewpoints, of such features as; the use of sirens for alarms, the bridge Pindo as the sole evacuation route, concentration in the topic of wave. In general, there was a negative view of the situation that would result in panic without looking for solutions.

October 2002: Workshop on building the Emergency School Plans for the municipalities of Nariño Coast, directed by Civil Defense and logistically supported by CCCP.

Besides the above mentioned programs, the available information has been presented in the meetings of the National Technical Tsunami Committee of Colombian Commission of the Ocean, in meetings of the General Direction of Attention and Prevention of Disasters, and to the Vice President of the Republic.

Planning

There has been significant progress, although it should be recognized, not in accordance with the amount of work for several participant entities, especially some of them of the technical order as the CCCP, which has assumed the leadership of several processes lacking a commitment from the public administration of municipalities. The political situation in municipalites is such that elections were held for 43 mayors in the last year. This situation ended in April 2003, and although the situation hasn't improved in real terms, it looks hopeful that having a mayor in office assures some stability in getting to the issue of planning for tsunami hazard reduction.

For this reason, the Emergency and Contingency Plan of Tumaco isn't finalized (as of now, June 2003), in spite of having all basic parameters met; including the required cartography and the bulk of inputs. With the National Contingency of Tsunami Plan, the problem isn't the uncertainty of municipal administration, but the intermittence of the activities of participant entities, and the lack of a leader in the process to coordinate the others, as intentions are good yet no completion has been reached. Presently the plans have the following completion rates:

National Contingency Plan for Tsunami	60%
Emergency Local Plan of Tumaco	70%
Contingency Local Plan of Tumaco	40%

According to CCCP these percentages are subjective, and can change very quickly. It is possible to contract completion to a group, particularly the two local plans for Tumaco. If this were to happen, the plans would be finished by August 2003.

The National Plan is still under discussion as to how quickly dissemination of alerts can occur and how feasible is it to monitor sea level using a system like TREMORS, available in OSSO. Also, it needs to be decided which parties would be responsibile for the upkeep of the system. With participation in the Visiting Expert Programme in Hawaii pending, some effective recommendations for the country, may be possible thereafter, sometime in August. It would

ECUADOR, *continued*

Activities Narrative

Since the last months of 2002, INOCAR has been developing a TSUNAMI PREVENTION AND MITIGATION PLAN FOR ESMERALDAS CITY PROJECT. (Esmeraldas is a city in the northwest part of Ecuador.)

The main objectives of the project are:

- Tsunami hazard mitigation based on flood maps derived using mathematical models and other methodologies,
- Formulate plans and implement education programs for the population so they can efficiently respond before a tsunami and mitigate its effects
- Train responsible authorities in required areas
- Carry out evacuation exercises as fundamental part of the prevention programs.
- Risk reduction based on vulnerability studies and flood maps
- Safeguard the Esmeraldas City population, property, and installed infrastructure in order to maintain the country's socioeconomic development.

Our goals are:

·Reduce the population affected by tsunamis, as well as protect the public infrastructure and facilities located in zones of high risk.

·Educate the population to be prepared before seismic events ever happen, directly in the cities at risk, using educational materials, etc.

Results

During the first months the person-in-charge for the project has received training in the development of flood maps with ITIC and CICESE support.

By simulating the 12 December 1979 Colombia tsunami accurately (as indicated by the similarities between the recorded and simulated tsunami) we discovered more vulnerable areas of Esmeraldas.

Finally tsunami inundation maps will be incorporated into the local urban map of Esmeraldas with vertical high resolution. We expect to carry out these activities later this year.

EL SALVADOR

Member Since: 2003

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Summary Status in 2003

The Servicio Nacional de Estudios Territoriales (SNET) is a recently created institution that among other duties, has the responsibility for studying and alerting for possible tsunamis. In the past two years, it has been improving both its seismic and sea level networks and is currently taking steps toward hazard assessments. SNET has also been discussing with other Central American institutions about the possibility of creating a regional tsunami warning system, and has made progress in joining the International Co-ordination Group for the Tsunami Warning System in the Pacific.

Local Tsunami Procedures

· What organization identifies and characterizes tsunamigenic events in the immediate source area? The Servicio Nacional de Estudios Territoriales (SNET) characterizes local tsunamigenic events through the integration of information from its seismic (25 short period and 2 broadband) and sea level (2 sea level stations) networks.

· What is the threshold for declaring a potential local tsunami emergency? A Magnitude 7 or stronger earthquake along the Pacific coast of El Salvador.

· What organization acts on the information provided by the agency responsible for characterizing the potential local tsunami threat? The National Emergency Committee (COEN) is the national institution responsible for organizing several other institutions such as the armed forces, Red Cross, etc. However, at a local level, the municipality or local government also acts on a potential emergency.

· How is the emergency situation terminated? The emergency is terminated after SNET has evaluated the situation and decides that there is no threat of an event.

EL SALVADOR, *continued*

Distant Tsunami Procedures

· What organization becomes aware of tsunamigenic events from a distant source? SNET, through PWTC internet bulletins. Independently, COEN also reviews the same information.

· What action does this organization take with regard to tsunamigenic events from a distant source? Communicates with COEN so that they can respond to the threat.

· What are the criteria for initiating tsunami mitigation procedures? PWTC transmits a Warning for the Central American coastline.

· What actions were taken in response to warnings issued by PTWC during the intersessional period? No actions have been taken during the last period.

National Sea Level Network

Site Name and Install date	Site Number	Lat/Lon	Platform ID	1st xMIT	Xmit Interval	Channel
Acajutla, El Salvador 12/11/00	96489581	13°35'N/89°51'W	1401E004	02:03:00	180 min.	5E
Rio Lempa, El Salvador 08/10/01	96400011	13016' 37"N/88048'38 W	1406E230	01:57:00	180 min.	61E
La Union, El Salvador 08/14/01	96405071	13°20.0'N/87°49.3'W	1406D7AA	01:56:00	180 min.	61E

Information on Tsunami occurrences

The Tsunami Catalogue for Central America (1539-1996), developed by Enrique Molina reports numerous events affecting the coasts of El Salvador. However, of those reported only a few have been reported by various authors, the most important of which occurred along the western coast of El Salvador in 1906, causing approximately 100 casualties. A non-local event is also reported affecting the coast and is associated to the 1957 (M_S = 8.1) Aleutian Islands earthquake.

Activities Narrative

After the 2001 Earthquakes in El Salvador, the national institutions that were responsible for studies and monitoring of natural phenomena were restructured and grouped into the Servicio Nacional de Estudios Territoriales (SNET). This institution, which is part of the Ministry of Environment and Natural Resources, is integrated by Meteorological, Hydrological, Geological and Risk Management Divisions.

Since the creation of SNET, a lot of effort has been put into creating and augmenting its professional and instrumental capabilities, including the installation of several new short period seismic stations, two broadband stations, improving the current weather stations and adding new ones, adding hydrological stations as well as training new personnel and hiring additional professionals that contribute towards SNET's major goal: reducing loss of human life and resources due to natural events.

Historical information and data show that El Salvador's coastline has been repeatedly affected by local and distant source tsunamis. The recent 2001 earthquake reminds us of the high probability of local events. This, in addition to the fact that El Salvador's coastline is probably the most densely populated in the Central American region, (mostly as a result of tourism development) increases the urgency with which institutions such as SNET and COEN have to study the tsunami hazard and implement an efficient early warning system that will alert the population of a nearby threat.

SNET's seismic network consists of 25 short period station distributed along the length of the country, but concentrated around volcanic centers. Currently there are close to 50 strong motion station that belong to different institutions, however agreements between them and SNET allow for sharing of data. Two broadband stations have been acquired and one is currently installed in the central offices in San Salvador. As with the rest of Central America, SEISAN is used for determination of location and magnitude of events, which is done around the clock by the seismology personnel. The EARTHWORM system was installed during February 2003 and is currently being used for volcano studies.

Two sea level gauges are installed, one in the eastern port of La Union and the other in the western port of Acajutla, A third station is currently installed on the delta of the Lempa River, the data generated by this station is mainly used for early warning of flooding. These stations belong to the Instituto Geografico Nacional (IGN), existing agreements between both institutions will allow a direct link to the data.

Currently El Salvador does not have a program to study and monitor tsunamis but SNET has decided to implement a Tsunami Warning System and participate in the Pacific Tsunami Warning System. Progress has been made towards generating a "tsunami susceptibility map" based on geological formations and some bathymetry data. In addition to this, and in coordination with other Central American countries, SNET is also trying to contribute to a regional tsunami warning center by improving its capabilities of determining the hazard and developing procedures for early warning.

EL SALVADOR, *continued*

With assistance from ITSU through member countries that currently have sufficient experience and capabilities, SNET plans to acquire the necessary know-how and technology through training in the use of the TREMORS software and other software for determining tsunami inundation areas.

12 September 2003, Carlos Pullinger

FIJI

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FRANCE

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Summary Status in 2003

Local Tsunami Procedures

The only local tsunami of very rare occurrence are generated by cliff failure or submarine landslide. No local tsunami procedures are implemented.

Distant Tsunami Procedures

What organization becomes aware of tsunamigenic events from a distant source:

The Centre Polynésien de Prévention des Tsunamis (CPPT) implemented by the LDG/Pamatai.

What actions does this organization take with regard to tsunamigenic events from a distant source?

An alert message with recommendations on the actions to be taken is sent to the Direction de la Protection Civile that informs the general public and the media.

What are the criteria for initiating tsunami mitigation procedures?

A color-code of warning which is a function of the time delay and seriousness of the danger, has been adopted to facilitate the progress of actions during real warning. [see next page]

The seriousness of the danger is a function of 2 parameters:

- the delays available (3,6,9 hours)
- the event's magnitude, as established by the scalar seismic moment given by TREMORS system.

What actions are taken in response to warnings issued by PTWC during intersessional period?

Own TREMORS seismic stations are checked.

A proposal for a decision about the emission of a tsunami warning is prepared by CPPT and transmitted immediately to the Civil Defense.

National Sea Level Network

At the present time France has four sea gauges installed in harbours in French Polynesia, maintained by LDG/ Pamatai, PTWC and the University of Hawaii; one in Papeete (Tahiti harbour), one in Rikitea harbour (Gambiers Islands), and two in the Marquesas Islands. The two in the Marqueses are at Taiohae (Nuku-Hiva) and Tahauku Bay (Hiva-Oa).

Information on Tsunami occurrences

No local tsunami occurrences in 2001-2003.

FRANCE, *continued*

The only distant tsunami detected was the 22 January 2003 Colima-Mexico tsunami generated by a 7.8 magnitude earthquake. On the Hiva Oa recent tide gage records, several waves of a few cm of amplitude and arround 20 minutes of period arrived just after the theoretical arrival time of the tsunami.

Activities Narrative

Sea Level Network

The French Polynesia sea-level network has been greatly improved in the last 2 years.

A new tide gauge was installed in January 2003, in Hiva Oa Island, Tahauku Bay. This bay is well known for its properties of extreme amplification for tsunamis coming from South and Central America. This project was financed by the French Government, with the support of PTWC. PTWC prepared and installed the equipment, and provided its expertise to the Centre Polynésien de Prévention des Tsunamis (CPPT) staff.

The data are sent to PTWC in real time via Handar Goes DCP and retransmitted to the CPPT by TELEX. A dedicated computer is used to plot the datat in quasi real time. In addition, it was an opportunity to take part in this mission to Marquises Island to help PTWC staff reinstall and update the Nuku-Hiva tide gauge.

TREMORS Station

One broad band station was installed in New Caledonia (DZM Station). TREMORS is implemented in IRD facilities in Nouméa and in DASE in France. This new station provides excellent detection and estimation of the tsunami risk for the South West Pacific Region, from Indonesia to south of New Zealand.

The results are posted in real-time to the European-Mediterranean web page; *http://www.emsc-csem.org*.

The TREMORS System has been upgraded. In addition to warning computed on the M_m magnitude and scalar seismic moment M_o, a seismic warning has been implemented on the P wave: it is based on the ratio STA/LTA (Short Time Average, Long Time Average) which can trigger a warning immediately on a large P wave (for example waves greater than 50 time the seismic noise level).

The recognition of the slow earthquakes, following the criteria given by Okal and Newman (*Teleseismic estimate of radiated energy: the E/*M_o *discriminant for tsunami earthquake*, 1998). The computation of the E/M_o discriminant is done interactively in a graphical interface, just by selection of the P wave.

Developments in the tsunami emergency plan in French Polynesia.

Taking into account the recent developments in technology and data analysis, a new tsunami warning plan has been re-considered and updated in collaboration with Civil Defense. Also, a color-code of warning which is a function of the time delay and seriousness of the danger, has been adopted in a similar way to Meteo-France's warnings for typhoons, to facilitate the procedures during real warnings. The seriousness of the danger is a function of 2 parameters; the delays available (3,6,9 hours) and the event's magnitude, (based on TREMORS seismic moment). The table below shows the color coded scale of warning as a function of the time delay (depending on the concerned regions) and the determined magnitude. The time delays were simply set at 9 hours, 6 hours, and less than or equal to 3 hours, and the actions corresponding to each color are listed.

YELLOW	Warning at the Laboratory Warning for Civil Defense, High authorities, State Governors, and Territorial Government, but no action required immediately. Further development of the warning to depend on several parameters, including the earthquake's location, tide gauge readings, external information, and reports by PTWC or other warning centers. The warning can be cancelled at any time based on external information or other reports.	Delay > 9 hours and Mm > 7.0
ORANGE	Warning of Civil Defense, City and Local Authorities and Municipalities, Police Headquarters, and other emergency responders, but a severe danger of tsunami has not been confirmed. The time delay is 6-9 hours before the tsunami arrival, and the population has not been informed of a possible evacuation.	Delay > 6 hours and Mm > 8.0
RED	Imminent danger (less than 3 hours from estimated time of arrival), or very severe danger of tsunami. General warning for evacuation of population along the coast, boats in harbors, and airport.	Delay > 3 hours and Mm > 8.0-------- Delay > 9 hours and Mm > 9.0

Preliminary Focal Mechanism Determination (PDFM)

This project was started in 1997 with the goal of achieving early solution of focal mechanisms for strong earthquakes in a context of tsunami warning. Knowledge of the seismic source is obviously of crucial importance in tsunami warning because the tsunami excitation is strongly dependant on focal depth, earthquake size (seismic moment), and fault geometry. On one hand, recognizing a true shallow thrust faulting event is of great importance for issuing

FRANCE, *continued*

a true warning, on the other hand, it is a matter of fact that tsunamis are poorly excited by shallow (even big) event with pure strike slip fault geometry (for example, quake of Macquarie Island of June 1985 and Balleny Island of March 1998).

In the PDFM project, the moment tensor is obtained from the inversion of surface wave spectra (Rayleigh and Love). In fact, we want to use the benefit of the analysis of each TREMORS stations, which send automatically the surface wave spectra via email to a central laboratory : spectra are ready for the inversion. Presently, it is not fully automated, and still needs operator intervention.

In 2002 and 2003, more than 25 focal mechanism were published on the EMSC web page.

PDFM was also tested through a study of large historical earthquake, for which no definitive focal mechanism have been published. As PDFM method needs only spectral amplitude without the phase information, there is no need of precise timing correction used for the phase velocity (used for standard inversion of moment tensor). Thus, the method was applied to study the large Banda Sea earthquake of February 1, 1938; the results show a very large moment approaching 1022 Nm, with a focal depth of 65 km explaining clearly why the obseved tsunami was small relative to the size of this earthquake.

A 2-day Tsunami Warning Exercise in the Marquesas Islands

In February 2003, to validate the new tsunami warning plan, and in conjunction with the official initiation of the Hiva Oa tide gauge, a 2-day tsunami warning exercise was held on several islands of South Marquises (Hiva Oa, Tahuata and Fatu Hiva) to test, in situ, the tsunami warning plan with local authorities, state administrators, municipalities, police and firemen. The general population was not involved.

The goal of this exercise was to identify potential communication problems during warning that might occur between the Civil Defense and local authorities. During this exercise, a realistic scenario of tsunami generated by a 8.4 magnitude earthquake located in Chile was chosen, and CPPT and Civil Defense transmitted one message per hour to local authorities, involving practical actions (inventory of radio, infirmaries, available cars, safe and high places to evacuate the populations, etc.).

At the same time, several sessions on tsunamis were held in schools, with a large distribution of educational materials on tsunami (The French version of the IOC's brochue, *Tsunami the Great Wave*), for a better understanding of tsunami and danger preparedness.

ITSU Cooperation

Twelve hundred copies of *Tsunami Glossary* were published in French. France offered Canada 200 copies of the glossary. France also provided the Associate Director of ITIC, a CD-ROM of all the artwork for the publication by Chile of the English and Spanish versions of the glossary.

French Antilles Volcanic Tsunami Occurrence

The Monstserrat volcano is active since 1996. A large eruption occurred on July 13 2003. Two large explosions occurred between 4:00 and 5:00 UTM. The following day, it was observed that a large part of the volcano's dome disappeared and had flown into the sea.

At the time of the explosions, a tsunami of 2 m high was observed in a river in Deshaies. The phenomena of 'mascaret' was observed 3 times. Several small boats were damaged in the river.

Tsunami Observation on the French Mediterrinean Coast

A strong M_W 6.9 earthquake occured on 21 May 2003 on the Algerian coast, near the city of Boumerdes, about 60 km east of Algiers. This shallow earthquake (less than 10 km) could partly explain the damage to buildings and the high death toll (2500 casualties).

Reports of sea disturbances along the Algerian coasts have been rather poor.

On the southeastern coasts of the Balearic Islands (250 km north from the epicenter), sea disturbance have been clearly observed. Wintnesses have reported waves up to 2 m high, and a mean observed period of 10-12 minutes. Ten boats sunk and several more were seriously damage.

A few tide gauges have reported sea level variations around the Mediterranean Sea. In Nice, 6 waves of 5 to 10 cm amplitudes were observed. The arrival time of the first perturbation was at 20:20, 100 minutes after the main shock.

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10 September 2003, François Schindelé, ICG/ITSU National Contact of France and Dominique Reymond, Director, Centre Polynésien de Prévention des Tsunamis (CPPT) – Tahiti French Polynesia.

GUATEMALA

Member Since: 1968

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Summary Status in 2003 Unknown, no National Report received.

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Summary Status in 2003

a. A five-day training on Earthquake Hazard Preparedness which includes Tsunami Hazard Mitigation was held in Jakarta, 19– 23 August 2003. The participants were 22 technical staff members coming from Geophysical Stations

INDONESIA, *continued*

and BMG Regional Centers. On August 23, Dr. Laura Kong of International Tsunami Information Center(ITIC) gave a lecture about tsunami hazard mitigation.

b. An International Seminar/Workshop on tsunami entitled, "In Memoriam 120 Years of Krakatau Eruption Tsunami and Lessons Learned from Large Tsunamis" was held in Jakarta and Anyer, 26 – 29 August 2003. The workshop concluded with recommendations which include the establishment of National Tsunami Warning Center for Indonesia and the possibility to further develop its area of service to cover the Southwest Pacific and Eastern Indian Ocean.

c. A project for the improving the National Seismic Monitoring Network is in progress. This includes seismic signal integration for real time monitoring and automatic data processing for quick hypocenter determination. The project is funded by the Islamic Development Bank(IDB) and to be completed in 2005.

posted to the ITSU Web Site, 5 January 2004

JAPAN

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Summary Status in 2003

On January 15, 2001, Japan began providing overseas authorities responsible for tsunami-disaster prevention with the tsunami forecasts on the Japan Sea. This was the first step toward the establishment of the regional tsunami center for the western North Pacific area. At the ICG/ITSU-XVIII Session, Japan requested that other Member States provide seismic data on a real-time or near (quasi)-real-time basis to generate more highly accurate focus data necessary to extend JMA's tsunami forecast area to the western North Pacific area. However, it is still undergoing development since considerable infrastructure is required to handle the data exchange. After the session, JMA has developed a method to determine hypocenter by using LISS (Live Internet Seismic Server) data of USGS and new formulas to estimate moment magnitude. Up until now, reliable performances have been realizied with both methods. JMA is steadily preparing for the implementation of the regional tsunami center for the western North Pacific area.

JMA will upgrade the Earthquake Phenomena Observation System (EPOS) in October 2003. As a result, tsunami forecasts and earthquake information will be issued more quickly.

Local Tsunami Procedures

Tsunami Forecast		Value of Tsunami Height to be issued
Tsunami Warning	Major Tsunami	"3m", "4m", "6m", "8m", "over 10m"
	Tsunami	"1m", "2m"
Tsunami Advisory	Tsunami Attention	"0.5m"

(Tsunami heights are measured from the ordinary tide levels)

Japan Meteorological Agency (JMA) watches the seismic activity around Japan. When a large earthquake is detected, JMA immediately determines the location and magnitude of the earthquake and executes the tsunami forecast operation using the numerical-simulation derived database. Tsunami forecasts are categorized into three types; Major Tsunami Warning, Tsunami Warning and Tsunami Advisory, depending on the forecast height of the tsunami as shown in the table above. JMA issues tsunami forecasts for 66 designated regions across the country. In the tsunami forecasts, the maximum height and the arrival time of the tsunami are indicated.

JMA provides the broadcasting media and the national and local authorities for disaster prevention with tsunami forecasts and other tsunami bulletins. Local officials are authorized to give residents in their municipalities instructions to evacuate for mitigating disasters caused by a tsunami.

Warnings and Advisories are cancelled when JMA concludes that the dangerous situation is over, that is, when the observed heights of a tsunami diminish to under 20 cm.

JAPAN, *continued*

Distant Tsunami Procedures

JMA receives information from PTWC and USGS on teleseismic events around the clock. In the case of tsunamigenic events from a distant source, JMA immediately executes the tsunami forecast operation after receiving the information (location and magnitude of the earthquake) in the same manner as the Local Tsunami Procedure. The criteria for the tsunami forecast for teleseismic events are same as those in the Local Tsunami Procedures. Overseas tsunami observations are also referred for the final decision of the estimation of tsunami height.

JMA carries out the tsunami-forecast operation using numerical simulation derived database with the focus data in the warning bulletin issued by PTWC and USGS, and determines whether the tsunami affects Japanese coast.

National Sea Level Network

Station name	Latitude	Longitude
Hanasaki	43°17´ N	145°34´ E
Ofunato	39°01´ N	141°45´ E
Omaezaki	34°37´ N	138°13´ E
Tosashimizu	32°47´ N	132°58´ E
Naha	26°13´ N	127°40´ E

(The stations of which observational data are transmitted via GTS)

There are 103 observational points for tsunami in Japan at which float-type (well-type) gauges are installed to monitor the sea level. At 66 of the 103 points, Huge-Tsunami Gauges are installed on the ground to observe the height of large-scale tsunamis that exceed the measuring range of the float-type gauges.

Information on Tsunami Occurrences (September 2001 – June 2003)

Details of the tsunamis observed from September 2001 to June 2003 are described below, where the time is UTC and the height of tsunami indicates the deviation from the ordinary tide level. [Note: The figures for tsunami heights in JMA's observation bulletin are defined as the vertical distances between a crest and preceding trough]. The tsunami forecasts on the events in this section were forwarded to PTWC and neighbouring countries.

a) A small tsunami was observed for the earthquake near Yonaguni Island, east of Taiwan, on 18 December 2001:

Earthquake source:
- Date 18 December 2001
- Time 4:02
- Latitude 23°53´ N
- Longitude 122°49´ E
- Depth 12 km
- Magnitude 7.3

Tsunami Observations

Station	Beginning time	Maximum height	
		Time	Height
Ishigaki	4:47	5:00	4cm
Yonaguni	4:12	4:17	12cm

Tsunami Forecast

Time	Grade	Region
4:09	Tsunami Attention	Miyakojima and Yaeyama Area
5:20	All Clear	

b) A small tsunami was observed for the earthquake near Ishigaki Island to the east of Taiwan, on 26 March 2002:

Earthquake source:
- Date 26 March 2002
- Time 3:45
- Latitude 23°12´ N
- Longitude 124°16´ E
- Depth 0 km
- Magnitude 6.6

Tsunami Observations

Station	Beginning time	Maximum height	
		Time	Height
Ishigaki	4:11	4:22	3 cm
Yonaguni	4:11	4:49	6 cm

Tsunami Forecast

Time	Grade	Region
3:54	Tsunami	Miyakojima and Yaeyama Area
	Tsunami Attention	Okinawa Islands
4:30	All Clear	

JAPAN, *continued*

c) A small tsunami was observed for the earthquake near Taiwan, on 31 March 2002:

Earthquake source:
Date 31 March 2002
Time 6:52
Latitude 24°14´ N
Longitude 121°58´ E
Depth 55 km
Magnitude 7.0

Tsunami Observations

Station	Beginning time	Maximum height	
		Time	Height
Ishigaki	7:38	7:51	6 cm
Yonaguni	7:05	7:19	12 cm

Tsunami Forecast

Time	Grade	Region
7:02	Tsunami	Miyakojima and Yaeyama Area
	Tsunami Attention	Okinawa Islands
7:40	All Clear	

d) A small tsunami was observed for the earthquake near the north coast of New Guinea, on 8 September 2002:

Earthquake source:
Date 8 September 2002
Time 18:44
Latitude 3°18´ S
Longitude 142°57´ E
Depth 13 km
Magnitude 7.3

Tsunami observations
(The data which was over 10cm and transmitted via GTS)

Station	Beginning time	Maximum height	
		Time	Height
Mera	9/ 02:--	3:33	10cm
Chichijima	8/ 23:--	1:09	10cm
Minamitorishima	9/ 0:--	8:41	14cm
Omaezaki	9/ 10:--	5:28	9cm
Owase	9/ 1:--	3:25	10cm
Kushimoto	9/ 0:56	8:54	11cm
Murotomisaki	9/ 1:--	1:54	21cm
Tosashimizu	9/ 0:--	2:11	17cm
Aburatsu	9/ 0:32	2:18	13cm
Makurazaki	9/ 1:--	1:58	14cm
Tanegashima	9/ 0:--	1:34	10cm
Naha	9/ 1:--	1:55	4cm

No tsunami forecast was issued.
Earthquake information with the possibility of slight sea level change was issued.

Activities Narrative

A. Developments toward providing tsunami forecast in the western North Pacific area:

JMA has improved techniques to determine more quickly and precisely the hypocenters and moment magnitudes of large teleseismic events. When large teleseismic events happen, JMA tentatively determines hypocenters of teleseismic events by using only the Japanese domestic array data for the triggers of the urgent operation. These estimated hypocenters and magnitudes are insufficient for the tsunami forecast because of their poor accuracy. Then JMA has normally used the information received from PTWC or USGS for its Distant Tsunami Procedures. In 2002, JMA started development of a method to determine hypocenters by using LISS data, which is maintained by USGS and provides raw seismic data obtained from observation sites around the world via the Internet. Although some delayed data are not available for the urgent forecast operation, reasonable hypocenters have been obtained by this method. The horizontal distances between hypocenters by the method and those determined and reviewed by USGS have been reduced to less than 30km.

As for the estimation of moment magnitude, the new empirical formulas using the waveform data of the STS2 seismometer of Matsushiro Seismological Observatory (MAJO) were derived. In the formulas, the root mean

JAPAN, *continued*

square amplitude within the period from arrival time of *P* waves to that of *S* waves or fixed time period (3min.or 5min, etc) from arrival time of *P* wave is used instead of the maximum amplitude. The standard deviation of the difference between magnitudes estimated by this formula and those by USGS is now approximately 0.2.

So far, the nearly identical results with those of USGS have been found in newly developed methods for determination of hypocenters and estimation of moment magnitude respectively. If more seismic data are obtained for the western North Pacific area through LISS, that should increase the accuracy of the determined hypocenters.

In addition to successive improvement and verification through the above methods, JMA began a study on the suitable divisions for the tsunami-forecast regions in the western North Pacific area, based on numerical simulation results. JMA has also improved techniques to determine the depth of hypocenters to further enhance tsunami forecasts.

B. Upgrading EPOS (Earthquake Phenomena Observation System):

EPOS is the JMA's integrated processing system for earthquake and tsunami operation, which consists of an on-line switching system for seismic bulletins, a platform for urgent operations, and review analysis, etc. All the seismic/ tsunami observation data and other domestic/overseas seismic bulletins are loaded into EPOS, and earthquake information and tsunami forecasts, such as Tsunami Warnings and Advisories, are generated and distributed from the system. Hypocenters and magnitudes are determined either automatically or manually on EPOS with the Quantitative Tsunami Forecast System. This is the huge database of assumed tsunami height and arrival times for various locations and types of fault models calculated by numerical simulations, connected with EPOS.

JMA plans the upgrade of EPOS in October 2003. Completely enhanced tsunami operation, i.e. quicker and precise response to earthquakes, is expected.

4 July 2003, Noritake Nishide, ICG/ITSU National Contact for Japan

THE DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

Member Since: 1987

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Summary Status in 2003

The Tsunami Warning System in the DPR of Korea consists of the National Tsunami Warning Center, Tsunami Watch and Communication Networks, and the Headquarters for Protecting Against Tsunami Hazard. The Central Meteorological Institute or CMI, of SHMA, as the National Tsunami Warning Center, issues storm surge and tsunami warning in the areas of our seas and informs the concerned agencies to take measures to protect against the surge hazard. The earthquake watch network consists of coastal and inland earthquake stations, and the sea level network consists of coastal oceanography stations at key locations on the east and west coasts. We have improved the domestic tsunami information system to more rapidly receive and process earthquake and sea level observations,enhancing the capability of the National Tsunami Warning System.

The communication network has been improved so that earthquake and sea level data could be transmitted immediately into the Seismological Institute and the Communication Center for Meteorological Data at the CMI. Also, data correcting and processing programs have been improved to monitor the information from PTWC, so, we are receiving the earthquake information or tsunami messages from PTWC on a regular basis.

Recently, a study of tsunami and storm surge models was undertaken to improve the tsunami and storm surge warning capacities in our country. The study, "A calculation method of tsunami in the coastal regions of our country", newly applied to operational tsunami warning, best describes the time and locations of tsunamis, the run-up and inundation at key locations, in more detail than other tsunami prediction models. We are now using this model for tsunami prediction in several coastal areas based on initial data of earthquakes occurring in water regions of our country.

Research on earthquake and tsunami characteristics are implemented systematically at the West Sea Oceanographic Institute of SHMA, the Department of Oceanography of Kim IL Song University, and at the Seismological Institute.

In the future, the major concerns of the National Committee for Oceanography and the National Tsunami Warning

DPRK, *continued*

Center will be to improve the national capability for tsunami warning and mitigate tsunami hazards by;

- improving observational and communication capacities of earthquake and sea level networks,
- developing more sophisticated tsunami prediction models,
- strengthening the tsunami warning transmission system and actively increasing public awareness.

Local Tsunami Procedures

The Seismological Institute is responsible for estimating the position and the magnitude of an earthquake occurring in our seas and the surrounding waters based on data from the domestic earthquake monitoring network, and for assessing the risk of the local tsunami. Local tsunami warning is issued depending on the threshold determined by the position and magnitude of the earthquake, the distance from the earthquake source to a relevant coastal water area, the coastal configurations and the geological characteristics of the sea bottom.

The tsunami warning is issued to the National or Local Natural Disaster Prevention Headquarters for mitigating natural disaster hazards (including tsunami and storm surges) and to related agencies.

Distant Tsunami Procedures

The Central Meteorological Institute (CMI) becomes aware of tsunamigenic events from a distance source. The Institute receives the earthquake and tsunami information from PTWC through GTS. Based on this information, a tsunami hazard assessment is made, considering the distance from the source to the relevant coastal areas of our country.

When the assessment indicates the tsunami warning criteria or threshold, the Institute issues the tsunami warning or messages to the relevant agencies.

For the local or distance tsunami warning, numerical tsunami models are used on the operational level. Using the model, the potential run-ups and inundation are obtained for the coastal areas. The criteria for the tsunami warning is the warning sea levels or risk sea levels being pre-determined at the corresponding coastal locations. The CMI, SHMA recently improved the communication system for receiving in time and processing the telegram data of tsunami warning and information from PTWC, and has developed a new tsunami numerical model for introduction into tsunami watch and prediction operations.

National Sea Level Network

Station	Position	Sensor
1 Chongjin	East Coast	Auto Sea Level Recorder
2 Wonsan		Auto Sea Level Recorder
3 Kosong	Coastal	Sea Level Ruler
4 Nampo	West coast	Auto Sea Level Recorder
5 Haezu		Auto Sea Level Recorder
6 Monggumpo	Coastal	Sea Level Ruler

In addition to these stations, we are also observing the sea level by mainly using gauges at the coastal marine meteorological stations including Sonbong, Kimchak, Riwon, Kajin, Sinpo, and Tongchon.

Information on Tsunami occurrences

Recently, there have been no significant tsunami events along the coastal areas of our country.

Activities Narrative

In our country, some measures have been taken to improve the capability of the national tsunami warning system.

The telephone and computer network for transmitting the information of tsunami events have been equipped so that the communication capacity between the Tsunami Waning Center and the seismic and sea level networks was strengthened.

The earthquake and tsunami monitoring and information system has been established between the national tsunami warning center and earthquake and tsunami communication center, by which the national tsunami warning center receives tsunami messages from PTWC in real-time and weighs the criteria for issuing the tsunami warning.

The study, "A calculation method of tsunami in the coastal regions of our country", which was released in recent years by the West Sea Oceanographic Institute of SHMA is used in operational works for tsunami. This method measures tsunami magnitude more effectively, more quickly and in more detail than the method in the previous study, and estimates the tsunami travel time history, predicts damage at any major location in the coastal plain of the Korean East Sea and West Sea and issues warning.

There have been meetings and discussions twice this year relating to marine meteorological hazards such as tsunami, and measures to mitigate these hazards. Meetings were held between Kim IL Sung University, the Earthquake

DPRK, *continued*

Institute, and SHMA through the National Committee for Oceanography, and resulted in work plans.

In order to raise the public awareness and concerns on natural hazards including tsunami, some of the papers were issued to magazines and newspapers, and introduced by means of radio or television broadcasts. Also, talks on the tsunami characteristics and risks were made in local communities at risk to tsunami hazard.

We conducted scientific research and technological investigations to minimize tsunami risks through construction of coastal structures and coastal area development.

1 July 2003, Mr. O Ryang Pyong, ICG/ITSU National Tsunami Advisor, The Central Meteorological Institute, SHMA, Pyongyang, DPR of Korea.

THE REPUBLIC OF KOREA

Member since: 1968

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Summary Status in 2003

Korea has been a member of the International Co-ordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) since 1968. Since hosting the Seventeenth Session of ICG/ITSU at the Korea Meteorological Administration (KMA) in 1999, Korea has been increasingly aware of the importance of preparedness against tsunami hazards.

During the late 1990s, KMA was equipped with a nation-wide earthquake monitoring system, established by the Earthquake Division, and began to prepare for the tsunami warning system. The KMA has been reinforcing the national seismic network by introducing broadband seismometers and training for preparedness, annually, using simulated tsunamis.

As part of the collaboration with the USA and Japan, KMA is exchanging tsunami information with the Pacific Tsunami Warning Center (PTWC) and the Japan Meteorological Agency (JMA). It also plans to exchange seismic data with Japan's National Research Institute for Earth Science and Disaster Prevention (NIED) in real-time.

Local and Distant Tsunami Procedure

Organization: Earthquake Division, Korea Meteorological Administration (Hours of Operation: 24 hours per day, 7 days per week)

The Korea Meteorological Administration (KMA) announces tsunami advisories/warnings and gives coastal areas information on the occurrence of large earthquakes, tsunami generation, expected tsunami arrival time and wave height. It reports to the organisations concerned, such as governmental bodies and broadcasting stations.

The tsunami advisory/warning is cancelled when KMA concludes that the emergency situation is over and the sea level anomalies return to below the danger level.

National Sea-Level Network

KMA operates a sea-level monitoring system on Ulleung-Island in the East Sea, the sea between Korea and Japan. The island is located about 130km from the eastern coast, so the early detection of a tsunami can be provided. KMA plans to establish two more sea level monitoring systems for tsunami detection on the western and southern coasts of Korea by 2006.

Information on Tsunami Occurrences

Korea is surrounded by three seas, including the East Sea, located between Korea and Japan. It has the potential for producing tsunamigenic earthquakes that might cause damage along the coasts of Korea and Japan.

In fact, in 1983 and 1993, two regional tsunamis, which were generated by earthquakes in the East Sea near Japan, caused damage along the eastern coast of Korea. As a result, the need for warning is recognizied, and proposals have been made to establish a rapid warning system for regional tsunamis.

Activities Narrative

A. Seismic Activity during the Period of January 2001 to June 2003

One hundred and fourteen earthquakes occurred during the period of January 2001 to June 2003, in and around the vicinity of the Korean peninsula. The largest earthquake among these (measuring 5.0 on the Richter Scale) occurred on March 30, 2003 in the western sea off the Korean Peninsula.

ROK, *continued*

The frequency of earthquakes recorded in Korea is higher now than before 2001, apparently due to the improvements to the seismic network of KMA.

Year	A	B	C	D	Total
2001		1	6	35	42
2002		1	10	38	49
2003	1	2	4	16	23
Total	1	4	20	89	114

A: Number of earthquakes with magnitudes between 5.0 - 5.9 on the Richter scale.
B: Number of earthquakes with magnitudes between 4.0 - 4.9 on the Richter scale.
C: Number of earthquakes with magnitudes between 3.0 - 3.9 on the Richter scale.
D: Number of earthquakes with magnitudes lower than 3.0 on the Richter scale.

B. Earthquake Monitoring System of KMA

In 1997, KMA started a project to strengthen the Korea National Seismographic Network (KNSN) and the tsunami warning system. The new system of seismographs, completed in 2002, is composed of 12 broad-band seismometers, 19 short-period seismometers and 75 accelerometers. This network was designed to provide an automated solution of seismic event for immediate response to tsunamigenic earthquakes. It records both the velocity and acceleration of the ground. When an earthquake occurs, the seismic signals are transmitted through KMA's intranet system to the central processing station. The recorded seismic waveform are analyzed and estimated automatically.

When an earthquake occurs, data gathered from each station are automatically analyzed within five minutes. In this way, a rapid tsunami warning can be issued immediately for a tsunamigenic earthquake occuring near Korea.

C. Simulated Tsunami Preparedness Drill

KMA has been working to assure prompt and accurate tsunami information. In fact, detailed and rapid tsunami information for people residing in at-risk areas is essential to mitigate tsunami hazards. For this reason, KMA has been conducting tsunami exercises to evaluate the tsunami warning and notification system each year. KMA conducted one such drill on July 29, 2002 and will conduct another in June, 2003.

During the exercises, KMA analyzes the magnitude and location of a virtual tsunamigenic earthquake as quickly as possible, and reports this information to the organisations concerned. All the acquired information from the related organisations (PTWC, JMA, etc.) is collected, along with returned messages and then analyzied.

KMA headquarters provide the simulated tsunami report to more than one hundred organisations involved, including regional offices. About eight hundred organisations are involved in the exercise.

KMA uses the drill result to diagnosis any problems in the communication system. Estimates are made of promtness of both sent and returned messages.

Problems occuring during the drills are thoroughly discussed to improve the KMA tsunami warning system.

D. International Cooperation

As mentioned in the summary, KMA is currently exchanging tsunami information with PTWC and JMA as part of the international collaboration with the USA and Japan. When a large earthquake occurs outside Korea, KMA informs PTWC of the *P*-wave arrival time of the event, recorded in its seismic network, through the Global Telecommunication System and e-mail. KMA then receives information on the event as well as on tsunamis generated by the event from PTWC and JMA.

KMA will hold a workshop titled 'International Workshop on the Historical and Recent Earthquakes having occurred in the Korean Peninsula' in Cheju Island this year. Participants from China, Japan, Italy and Korea will discuss historical earthquakes and tsunamis, recent trends in earthquake research, and other areas of common interest. It is hoped this workshop will help in the evaluation of historical earthquakes in Korea and also Korea's earthquake engineering.

The second meeting of the working group on seismological cooperation between the representatives of KMA and China Seismological Bureau (CSB) was held in Beijing, China on June 5, 2002. Both sides reached an agreement on the exchange of information, data, publications and personnel. KMA proposed conducting a joint research project regarding on the seismo-tectonic structure, seismicity and earthquake precursors in the Sino-Korean Platform. The CSB responded to the proposal positively. As part of this project, KMA invited one earthquake expert and performed joint research with CSB for four months in 2002.

On May 21, 2003, KMA reached an agreement with National Research Institute for Earth Science and Disaster Prevention of Japan (NIED) to exchange seismological data between both organisations in real-time. The purpose

ROK, *continued*

of this cooperation is to improve the capability of monitoring seismic activity in and around Korea and Japan, and to mitigate earthquake and tsunami disasters in both countries. The contact points of both sides will discuss and determine the specific methods of implementation of the projects in detail.

E. Information for the General Public

KMA published four books on earthquakes and related fields from 2001 to June 2003:

- In December 2001, KMA published a book titled 'The True Nature of Earthquakes', which describes the structure of the earth's interior, earthquake mechanisms, the principle of seismographs, seismicity, and earthquake preparedness. It was published for ordinary people who are interested in earthquakes and earth science.
- In March 2002, KMA published 'Earthquake Catalogue of 2001', which describes seismic activity in Korea, the historical and current status of the seismic network of KMA, major earthquakes with intensity maps, and provides a list, with epicentral maps, of the earthquakes which occurred in Korea in 2001.
- In November 2002, KMA published 'Wow! This is an Earthquake!', which describes the earth, the interior of the earth, earthquakes, volcanoes, tsunamis, the earthquake and tsunami monitoring system of Korea, and preparations against earthquakes and tsunamis. This book was written in simple words for children.
- In April 2003, KMA published 'Earthquake Catalogue of 2002', describing seismic activity in Korea, the historical and current status of KMA's seismic network, major earthquakes with intensity maps, with a list of the earthquakes which occurred in Korea in 2002 with epicentral maps, waveforms, and P and S wave arrival times.

F. Research Activities in Korea

Korea Meteorological Administration (KMA)

A study for establishing a system for detection and analysis of tsunamigenic earthquakes was made by KMA. The study includes such fields as a spatial study of the tsunamigenic earthquakes around Korea, a quantitative study of defining detection environment of the tsunamigenic earthquake, a study on establishing an algorithm for detecting the tsunamigenic earthquake, and a study of initial sea surface change due to tsunamigenic earthquakes.

A study on the tsunami itself has been also done. In this study, the numerical models describing the transoceanic propagation across an ocean and associated run-up process along a shoreline, are investigated and updated. A database system of virtual tsunami events has also been made.

A study on establishing an algorithm for detecting the tsunamigenic earthquake has been performed using Borland C++ Builder 4.0 as a development tool. Although this algorithm is not currently based on real-time analysis, it will be updated to handle real-time data soon. It uses GUI (graphic user interface) technology for presenting fault information as well as synthetic seismograms.

Other institutions

Many university researchers, involved with earthquakes and tsunamis, take part in the activities of the Korea Earthquake Engineering Research Center (KEERC) by sharing information and research on earthquakes and tsunamis. A project on tsunamis, a subtask of the second phase of KEERC research (2000~2002), was carried out and the third phase (2003~2005) is being carried out now. At present, studies using the parallel FEM simulation model and prognostic tsunamis are being performed to produce inundation maps along the eastern coast of Korea.

In addition, National Institute for Disaster Prevention (NIDP) and Korea Ocean Research & Development Institute (KORDI) have performed numerical investigations of tsunami hazards of the East Sea or have a plan to study it with various methodologies this year.

MEXICO

Member Since: 1980

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Sumary Status in 2003 Unknown, no National Report received.

NEW ZEALAND

Member Since: 1968

ICG/ITSU National Contact: Mike O'Leary
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Summary Status in 2003

During the inter-sessional period New Zealand has responded to 30 Tsunami Bulletins, two Watches and 34 Dummy Messages issued by the Pacific Tsunami Warning Centre.

No locally-generated tsunami have occurred.

In the intervening period considerable work has been undertaken in increasing capability across the scientific and emergency management sectors. This includes:

- sea level gauges
- seismic measurement
- National Warning Systems
- Regional hazard awareness and planning

New Zealand now has a network of 19 high-quality, open-coast, sea level stations sited at strategic locations around the country operated by NIWA. The recorders routinely sample at five-minute intervals, and most of those on the east coast also now have a tsunami ring-buffer, where the latest 72 hours of data sampled at 1-minute intervals is continuously stored.

GNS operates a national seismic monitoring system for the detection and measurement of earthquakes occurring around New Zealand. Over the next year, commencing August 2003, the national seismic monitoring network ("GeoNet") will be upgraded with real-time data communications and new sensors to detect near shore earthquakes and report slow ones that have the potential to generate tsunami.

The MCDEM National Warning System has been significantly enhanced with the addition of a 24/7answering service, CDMA cellphone technology with internet and email capability the use of eFax and Emsg to inform a wide variety of audiences across an extensive notification list.

In December 2002, the Civil Defence Emergency Management Act 2002 came into force. The Act requires a risk management-based approach to the sustainable management of all hazards, both natural and man-made, at a district and regional level via Civil Defence Emergency Management Groups (CDEM Groups).

Each CDEM Group must produce an integrated CDEM Group Plan within two years of formation. These plans must specify the hazards and risks they face in each region, how those risks are managed and how their management is to be improved. As a result CDEMGs will be specifically addressing the hazard and risks associated with tsunami where relevant.

Local Tsunami Procedures

New Zealand is perhaps more at risk from local tsunami, generated "locally" by earthquakes and/or underwater landslides or volcanoes along our plate subduction zones off eastern New Zealand and southwest of South Island, than from distant tsunami. This hazard is high risk because of the potentially large tsunami wave heights and lack of adequate warning. One example is the tsunami that hit the Gisborne region on 25 March 1947, with heights of up to 10 m, probably caused by a combination of fault movement off the coast and an underwater landslide triggered by the earthquake. Unlike remote tsunami, little warning is possible for the pending arrival at the coast because of the close proximity of faulting, the continental plate subduction zone, and volcanoes along our coastline.

Research at The National Institute of Water and Atmospheric Research Ltd. (NIWA) is targeted at pinpointing geological features like previous seabed slumping, landslides and faulting on the ocean floor that may potentially cause a tsunami, and then how and where the resulting tsunami would propagate to the coast. Dr. Roy Walters is leading the work on developing novel computer models to simulate the behavior of sediment-rock-water mixtures in an underwater landslide and the ensuing tsunami.[1]

Tsunami generated by faults adjacent to New Zealand usually involve a travel time of less than 30 minutes. The Institute of Geological and Nuclear Sciences (GNS) operates the national seismic monitoring system that detects and measures all earthquakes occurring around New Zealand. The reporting of significant earthquakes to responding agencies can take 15 – 20 minutes but cannot predict the generation of a tsunami. Usually the first indication that New Zealand will get of a local tsunami is when it comes ashore. However, over the next year, commencing August 2003, the national seismic monitoring network (GeoNet) will be upgraded with real-time data communications and

NEW ZEALAND, *continued*

new sensors to detect near shore earthquakes and report the slow ones that have the potential to generate tsunami.[2] These steps will enhance New Zealand's ability to detect and respond to local tsunami.

Distant Tsunami Procedures

During the inter-sessional period New Zealand responded to 32 Watches and Bulletins.

National Sea Level Network

New Zealand has a network of 19 high-quality, open-coast, sea level stations sited at strategic locations around the country. The recorders routinely sample at five-minute intervals, but most of those on the east coast also now have a tsunami ring-buffer, where the latest 72 hours of data sampled at 1-minute intervals are continuously stored.

All the instruments have cellphone telemetry and are polled daily to retrieve the five-minute data that is used for analysis of seiche, tides, storm surges and long-period sea-level fluctuations. In the event of a tsunami, recorders can be interrogated manually to download the tsunami ring-buffer. In the future, we plan to upgrade all the recorders to the new cellphone technology: general radio packet system (GPRS), making data available continuously via the Internet.[3] This network is managed by NIWA. Further information is available through Dr. Derek Goring.

Figure 1 - New Zealand Sea Level Monitors (Courtesy of NIWA - www.niwa.cri.nz)

Information on Tsunami occurrences

No tsunami have affected New Zealand in the inter-sessional period.

Activities Narrative

Under Part 3 of the National Civil Defence Plan, the Director of Civil Defence and Emergency Management can issue warnings for all or part of New Zealand in respect of hazards that might lead to or worsen a civil defence emergency. Examples of such warnings are the impending arrival of a tsunami, a potential volcanic eruption or severe weather events. Where possible, early notification in the form of an alert may precede a warning.

The National Warning System gives effect to the Ministry's responsibility in this regard. On their part, each regional council, territorial authority, department and organisation is responsible to maintain its own warning system that includes measures to pass on alerts or warnings issued by the Director.

The Ministry's prime sources of information leading to alerts or warnings are the Institute for Geological & Nuclear Sciences (GNS), MetService and the Pacific Tsunami Warning Centre in Hawaii, the NZ Centre for Critical Infrastructure Protection (CCIP) and the United Nations (UNDAC). Standing procedures direct these sources on the notification to MCDEM of pending events.

Alerts or warnings are issued direct to:

- Regional councils and territorial authorities (TA's)
- The general public when appropriate
- Government departments and agencies, news media, lifelines and CRI's as appropriate

Messages are sent according to standard operating procedures by both fax and Email to the appropriate address lists. In the case of warnings, a copy of the message is also faxed to the three New Zealand Police Communications Centres who instruct Police Districts to check with local civil defence offices at the TA's whether they have received the message. Regional councils also check the same with TA's and confirm receipt by all to the Ministry's Emergency Management Advisors (EMA's) allocated to the respective regions. The EMA's confirm and report on the timings of receipt by all back to the national duty officer. In the event of a warning message being sent after hours, the EMA's will alert the regions by phone that a message has been sent or is forthcoming. The regions in turn will alert the TA's. In all cases regions and TA's also contact and warn other local agencies as appropriate.

NEW ZEALAND, *continued*

This is followed with a text (SMS) to all Regional Councils and TA's. MCDEM has recently added this capability to the Warning System so that text (SMS) messages can be sent further informing the emergency managers in the Regional Councils and TA's of the existence of a National CD Warning.

MCDEM provides a "value added" service in that all warning related information is received, assessed and considered as to whether it needs to be disseminated, and in what format e.g. an alert or a warning. Different standard operating procedures and criteria exist for the actioning of information related to weather, earthquake, tsunami and volcanic events respectively. While these procedures in some types of events e.g. tsunami and volcanic, provide clear guidelines on what action is warranted by what type of information, the element of judgement is, however, always present in deciding on the appropriate response. A balance between time (to facilitate fore-knowledge) and the quality of information (verification and threat analysis to avoid false alarm and achieve maximum value) has to be struck. This underlines the importance of a basic understanding of the nature of the different type of events by the relevant Ministry staff, and the value that the Ministry puts on maintaining a close relationship with its advisors and sources involved in the respective fields of speciality.

The Ministry conducts quarterly tests of the national warning system. A test message is sent (unannounced) to all Territorial Authorities and Regions as well as the Police Communications Centres. The tests offer the ability to check faults on address lists, response times and any system problems that might arise. Based upon the results of these tests, continuous "fine tuning" is done.

In addition, a "National Contact List for Emergencies" is maintained. The list is sent to all civil defence offices on a quarterly basis to be checked for changes and updates. The list contains the contact particulars of the civil defence officers, controllers and alternative controllers at all councils.

The new CDEM legislation requires the first National CDEM Plan to be completed within three years commencing December 2002. Amongst other areas, the National CDEM Plan must detail a national warning system. The drafting of the new Plan therefore implies scrutinising the existing Civil Defence Warning System (Part 3 of the existing National Civil Defence Plan).

As a precursor to the above process, the Ministry is in the process of establishing a working party existing of relevant sector stakeholders to help shape ideas around the improvement of the existing national warning system. It is also envisaged that the deliberations by this group will result in immediate changes to particular standard operating procedures relating to the existing system.

In addition, the investigation and employment of instruments aimed at enhancing decision-making and analysis of information related to alerts and warnings deserves constant attention. The Ministry is currently considering proposals for such instruments offered by systems capable of providing hazard information, risk analysis, modelling based upon scenarios and previous events, formatting of alerts and warnings etc.

Since the beginning of 2002, CDMA cell phone technology has been added to the Ministry's Readiness Unit and its Emergency Management Advisors in Christchurch, Auckland and Wellington. The new digital cell phones allow for email and Internet access by phone, and have already proved an invaluable instrument in the monitoring and warning capability. It enables personnel to receive text (SMS) information by email from key sources of information like the Institute of Geological and Nuclear Sciences (GNS), MetService and Pacific Tsunami Warning Centre (PTWC) without the need of access to an Internet-linked PC. Likewise, when the duty officer receives a telephonic alert call he/she has the ability to immediately access the websites of relevant agencies via the phone and any other sources to verify or interpret the information.

In a further attempt to improve on its response time to issue warnings, the Readiness Unit has also added a Telecom NZ service, efax, to its capacity. Through efax, email and fax warning messages can be sent to a wide variety of audiences and address lists by any Microsoft Windows-based computer.

National Warnings are terminated by a further message from the Director of Civil Defence.

In December 2002 the Civil Defence Emergency Management Act came into force. The Act requires a risk management-based approach to the sustainable management of all hazards, both natural and man-made. This management is applied in a comprehensive manner across risk reduction, readiness, response, and recovery (the '4Rs'), as well as being integrated through the involvement of all sectors and agencies within the wider CDEM community.

The new Act:

- Promotes sustainable management of hazards to improve safety of the public and property,
- Encourages communities to decide upon and achieve acceptable levels of risk,
- Requires local authorities to coordinate CDEM planning and activity,
- Provides a basis for integrating national and local CDEM planning,

NEW ZEALAND, *continued*

- Encourages coordination across a wide range of agencies that prevent or manage emergencies.

One of the key aspects of the nation's improved arrangements is the establishment of regional Civil Defence Emergency Management Groups (CDEM Groups) – consortia of local authorities working in partnership with emergency services (Police, Fire, Health), lifeline utilities and others to deliver emergency management within regional boundaries.

Each CDEM Group must produce an integrated CDEM Group Plan within two years of formation. These plans must specify the hazards and risks they face in each region, how those risks are managed, and how their management is to be improved. As a result CDEMGs will be specifically addressing the hazard and risks associated with tsunami. A standard risk-management methodology has been provided for the planning process (refer: CDEM planning Guidelines at *www.civildefence.govt.nz*). The process will improve New Zealand's disaster management by allowing national and regional planners to prioritise their hazard study programmes and functional planning activity.

1 August 2003, Mike O'Leary, Manager, Readiness Ministry of Civil Defence & Emergency Management New Zealand

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NICARAGUA

Member Since: 1993

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Summary Status in 2003

The Nicaraguan Seismic Network was expanded considerably in 2001-2003, considering the needs of the tsunami warning system. A broad band station was installed in the Seismic Data Center of INETER in Managua. TREMORS (problems of data format compatibility occurred) is tested and SEISAN software is used routinely with this station. A preliminary Tsunami Hazard assessment was carried out. The town of Corinto was identified as the site with the highest tsunami risk. The development of a Regional Tsunami Warning System for Central America has been promoted. A major upgrade of the Nicaraguan seismic network is planned for 2004-2005.

Local Tsunami Procedures

Organization that identifies and characterizes tsunamigenic events in the immediate source area:

Instituto Nicaragüense de Estudios Territoriales (INETER) by means of its national seismic network and its round-the-clock early warning system.

Threshold for declaring a potential local tsunami emergency: Magnitude M >= 7.0;

Location in the Pacific Ocean of Central America

Organization that acts on the information provided by the agency responsible for characterizing the potential local tsunami threat:

The National System for the Prevention, Mitigation and Attention of Disasters (SINAPRED) and the Defensa Civil of Nicaragua, emitting warning messages to the local authorities on the Pacific coast, using an emergency radio communication system.

Additionally, INETER contacts seismic networks and Emergency Commissions in the countries of Central America to inform of a tsunami threat.

How the emergency situation is terminated:

By a recommendation of INETER, transmitted to the population by SINAPRED and Civil Defense.

Distant Tsunami Procedures

What organization becomes aware of tsunamigenic events from a distant source:

Instituto Nicaragüense de Estudios Territoriales (INETER), by means of receipt of messages from PTWC via email, WMO/GTS.

Also, own data from the national seismic network and from the NEIC (National Earthquake Information Center) are used to detect large earthquakes in the Pacific Basin; institutions near the epicenter of the tsunamigenic event are contacted or Web pages are checked whether a tsunami has occurred.

What actions does this organization take with regard to tsunamigenic events from a distant source?

NICARAGUA, *continued*

An alert message with recommendations on the actions to be taken is sent to the SINAPRED that informs to all institutions members of SINAPRED, the general public and the media.

Additionally, INETER contacts seismic networks and Emergency Commissions in Central America to inform of the tsunami threat.

What are the criteria for initiating tsunami mitigation procedures?

-PTWC issues a warning for Central America, and/or

-INETER estimates that a tsunami threat could exist, based on its own seismic data, or other local, regional or remote sources.

What actions are taken in response to warnings issued by PTWC during intersessional period?

If it is a case of a distant tsunami: Monitoring is intensified, independent information is checked; own seismic recordings are checked; other institutions are contacted or their Web sites are monitored whether a tsunami has occurred; media are monitored.

A decision to release a tsunami warning is made by INETER and transmitted immediately to the SINAPRED and the Civil Defense.

National Sea Level Network

At the present time Nicaragua has two (2) sea level gauges installed on the coast of the Pacific Ocean, maintained by INETER. One station is installed in Corinto with data transmission via GOES satellite. Problems exist with the maintenance and fast data access to these stations.

Information on Tsunami Occurrences

No local tsunami occurrences.

Activities Narrative

Seismic Network and Data Center

The Nicaraguan Seismic Network was greatly expanded in 2001-2003 with consideration of the needs of the tsunami warning system. A broadband station (STS-2 seismometer, Quanterra Q330 datalogger, direct access to INETER LAN) was installed in the Seismic Data Center of INETER in Managua, to support the National and Regional Tsunami Warning System. TREMORS Software was installed and tested with the registration of this station. But problems of data format compatibility have yet to be solved. Meanwhile SEISAN software is used for interactive determination of location and magnitude with the registrations of the station. A procedure for automatic location and magnitude determination, part of SEISAN, is being testing.

A digital radio communication link between the Seismic Data Center of INETER and Civil Defense headquarters in Managua was installed. This link permits the automatic transmission of data, alert messages and direct access of Civil Defense to INETER's web site, GIS and databases.

Tsunami Hazard Assessment

A preliminary study on tsunami hazard along the Pacific and Atlantic coasts has been carried out. The town of Corinto was found to be the site with the highest tsunami risk in Nicaragua based on the unfavorable local topographic conditions (very low elevation), the relatively large population and the long distances to secure places. In case of tsunami waves of more than 5 meters, many people could be killed. In case of a local tsunami warning people would have to run more than 10 km to get to high ground.

Regional Cooperation

Contacts with the other Central American countries and CEPREDENAC (Center for Disaster Prevention in Central America, Intergovernmental organization) were established to promote the establishment of a Regional Tsunami Warning System.

Publications

A poster about the Nicaraguan Tsunami Warning System was presented at the Annual Meeting of the Seismological Society of America, in Puerto Rico (Strauch, W., 2003. The Nicaraguan Tsunami Warning System. SSA Annual Meeting, San Juan Puerto Rico, 30 April-01 May, 2003).

Future plans

The Nicaraguan Seismic Network will be further developed in 2003-2005. The installation of 12 broad band stations is planned for 2003. In 2004-05 the telemetered (analog data transmission) network will be completely reorganized installing three-component sensors, digital data acquisition on the site and digital data transmission to the data center. A regional seismic array will be installed. Additional short period and broadband stations will be installed on the Atlantic side of Nicaragua. The Regional Tsunami Warning System will be made fully functional. Detailed tsunami hazard studies are planned in 2004-05 for Corinto, Puerto Sandino, Masachapa and San Juan del Sur; towns located along the Pacific coast.

24 July, 2003, Claudio Gutiérrez Huete, ICG/ITSU National Contact of Nicaragua

PERU

Member since: 1972

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Summary Status in 2003

La creación del Sistema Nacional de Alerta de Tsunamis en el Perú (SNAT) se remonta a 1970, año en que el país se integra al Sistema Internacional de Alerta de los Tsunamis en el Pacífico y se designa como su representante oficial del Perú a la DHN, para los fines de coordinación del sistema.

Este Sistema Nacional de Alerta de Tsunamis desde el año 1997 viene elaborando cartas de inundación en caso de tsunamis, y a la fecha se encuentra innovando nuevas publicaciones como folletos, revistas, películas en VHS, CD, DVD, material informativo en CD, etc.

Procedimiento Tsunami de origen local y lejano:

Organización: Dirección de Hidrografía y Navegación (DHN)

Criterio: En caso de la ocurrencia de un evento sísmico el IGP, determina la localización del epicentro y da aviso a la DHN, para que esta ejecute y analice los pronósticos de tsunami, utilizando para esto, sus Cartas de Inundación en caso de tsunamis para origen local y las Cartas de tiempo de Propagación de tsunamis para origen lejano. Las alertas se difunden a toda la costa Peruana, a través del Sistema de Comunicaciones Navales, a todas las capitanías del litoral. También, la DHN mantiene con el IGP el Sistema TREMORS, sistema para la detección de tsunamis de origen lejano y recibe información de Alertas de tsunami del Pacific Tsunami Warning Center (PTWC) las 24 horas del día, los siete días de la semana.

Acción: La DHN elabora un mensaje de alerta en caso de Tsunami, enviándolo a los organismos involucrados en el Sistema Nacional de Alerta de Tsunamis, con la finalidad de que estos ejecuten sus planes de evacuación y/o emergencia, en las poblaciones costeras que pudieran estar en peligro.

Cancelación: Los avisos o mensajes de alerta serán cancelados cuando la situación de peligro o el terremoto no genere un tsunami o maremoto, y/o aviso de cancelación de parte del PTWC.

Descripcion

Elaboración de cartas de inundación, vías de evacuación y zonas de refugio en caso de tsunamis

Estas cartas tienen por finalidad dar información que nos permita en caso de ocurrencia de un tsunami determinar la zona inundable, las vías de evacuación peatonal y vehicular, así como las zonas de refugio de emergencia y temporal para reducir las pérdidas de vidas humanas y los daños materiales.

Programa de Charlas en prevención de Tsunamis

Se realizan charlas de información, prevención y mitigación en caso de desastre por tsunamis en Colegios, Universidades, Capitanías de Puertos y Dependencias y Unidades Navales de la Marina de Guerra del Perú que estén asentadas en el litoral peruano.

Ejercicio Regional de Comunicación con Chile sobre Alerta de Tsunamis para optimizar el Sistema TREMORS

La DHN estableció comunicación con el Servicio Hidrográfico y Oceanográfico de la Armada de Chile (SHOA), diseñando entre ambos un formato de comunicación el cual se envió al SHOA para su afiliación, en el año 2002 se estableció un cronograma de ejercicios y el presente año se efectúa el entrenamiento con eventos tsunami génicos ficticios.

Carta de Inundación en caso de Tsunamis “Caleta El Chaco”, ubicada en la localidad de Pisco, Departamento de Ica Formato de comunicación regional de entrenamiento para ser utilizado con el Sistema Tremors

Programa de Visita de Expertos al Centro Internacional de Información de Tsunamis (ITIC) Honolulu Hawaii USA 2002

El año 2002 la Comisión Oceanográfica Intergubernamental (COI) por intermedio de la UNESCO invita a la DHN a participar en este programa, representando a la Institución el Capitán de Fragata Sergio ROUILLON Pardo.

El programa se desarrollo en las oficinas administrativas del ITIC y se complementaron con trabajos de campo, observándose los avances en la mitigación y prevención de Tsunamis por parte del Sistema Internacional de Alerta

PERU, *continued*

de Tsunamis.

Implementación del enlace del Sistema Nacional de Alerta de Tsunamis dentro de la Página Web de la Dirección de Hidrografía y Navegación

Dentro de nuestra pagina web *http://www.dhn.mil.pe*, se creo un enlace especial para el Sistema Nacional de Alerta de Tsunamis en el Perú, en la cual se puede encontrar información sobre Tsunamis, sus causas, generación, folletos, revistas, etc.

Proyecto "Sistema de Vigilancia de Tsunamis"

Este proyecto nos permitirá monitorear en tiempo real la variable que registre el Nivel Medio del Mar en caso de tsunamis, ya que existen numerosas zonas costeras del país amenazadas por tsunamis locales, los equipos con los que se cuentan en la actualidad son análogos, en consecuencia no se recibe la data en tiempo real.

También, se cuenta con estaciones automáticas océano – meteorológicas (SUTRON), las cuales fueron instaladas para monitorear el fenómeno de "El Niño", financiado por el Banco Interamericano de Desarrollo al gobierno Peruano en el año 2000. Estas estaciones tienen sensores configurados para recibir la data satelital cada 3 horas, en el caso del sensor de mareas este capta un dato cada hora, el cual viene a ser un promedio de dicha hora, por lo tanto solo recibe 3 datos del nivel de marea, no siendo suficiente para un monitoreo eficaz.

Este proyecto de vigilancia, requiere de un financiamiento para la adquisición del instrumental necesario con la finalidad de integrar a las 12 estaciones automáticas océano–meteorológicas (SUTRON) al PTWC con data de mareas en tiempo real.

La programación de las plataformas contemplaría la captura de la información de la data del sensor de presión de la columna de agua (nivel del mar), cada 2 minutos, Esta data será enviada cada hora al satélite GOES u otro satélite, en una ventana de tiempo y canal asignado.

La data recolectada por las plataformas será recibida por la Dirección de Hidrografía y Navegación de la Marina de Guerra del Perú utilizando la Antena Satelital Argos instalada en el Servicio Nacional de Meteorología e Hidrología (SENAMHI) ó adquiriéndose un Sistema Radio Satelital GOES, para lo cual se dispondrá de un equipo receptor de datos satelitales, el que será instalado en el Departamento de Medio Ambiente / Sala de Alerta de Tsunamis, o vía sesión Telnet directamente de la oficina NESDIS (National Environmental Satellite, Data and Information Service) dependiente de la NOAA (National Oceanographic and Atmospheric Administration).

THE PHILIPPINES

Member since: 1970

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Summary Status in 2003 Unknown, no National Report received.

THE RUSSIAN FEDERATION

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Summary Status in 2003

Observation, forecasting and the warning of tsunami threat on Far East of Russia now is carried out by the centres of the tsunami warning system (TWS) of ROSHYDROMET located in Youzhno-Sakhalinsk, Petropavlovsk-Kamchatsky

RUSSIA, *continued*

and Vladivostok, in close interaction with territorial structures of Ministry for Emergency Siuations of Russia and Ministry for Communications and Information of Russia, seismic stations of GS RAS and hydrometeorological stations. The TWS centres operatively cooperate with the TWS centres of foreign countries within the framework of participation of Russia in the International Pacific Tsunami Warning System (PTWS) working under aegis of UNESCO. A subsystem as a whole and the TWS centres work on the basis of the authorized rules and instructions of federal and local levels.

The divisions involved in the TWS provide continuous round-the-clock operations, including observations of seismic and sea level conditions, analysis and decisions regarding any tsunami threat, and acting sppropriately toward sending or cancelling messages.

For local tsunamigenic events the tsunami alarm is announced SS of GS RAS using magnitude and geographical criterion. The disturbing situation is cancelled by the TWS centres of ROSHYDROMET.

For distant tsunamigenic events the tsunami alarm is announced by the TWS centres of ROSHYDROMET on the basis of the information from both Russian and foreign SS, and sea level data also. The same tsunami centres cancel warnings.

During the intersessional period, no tsunamis were recorded along the Russian coast.

During the intersessional period, innovation projects were carried out to modernize the Russian TWS.

The basic directions of TWS modernization:

- TWS use of data from local radiotelemetering SS networks and digital SS on Kamchatka and Sakhalin,
- Equipping tide observing network with the new telemetering tsunami logger to transfer of data to the TWS centers.
- Introduction of new hardware-software arrangements and information technologies at the TWS centres.

Local Tsunami Procedures

In cases, where the tsunami is locally generated, it is identified by seismic stations (SS) of Geophysical Service of the Russian Academy of Sciences (GS RAS). These same seismic stations sound the tsunami alarm. Criteria for the cancellation of alarms are as follows:

- If the tsunami has been recorded, then the watch/warning will be cancelled when wave height is less than 0,5 meters for at least 2-3 hours.
- If the watch/warning has been announced, but a tsunami is not recorded at coastal hydrometeorological stations (GMS), the watch/warning will be cancelled between 30 minutes to an hour after the last expected arrival time of the wave anywhere along the coast.
- The cancellation is made by the tsunami centres/stations of ROSHYDROMET in Youzhno-Sakhalinsk, Petropavlovsk-Kamchatsky, Vladivostok.

Distant Tsunami Procedures

The alarm for tsunamigenic events in distant areas is announced by the same tsunami centres/stations of ROSHYDROMET in Youzhno-Sakhalinsk, Petropavlovsk-Kamchatsky, and Vladivostok.

After information on the parameters of the earthquake are received from SS of a GS RAS and foreign SS centres, the stations carry out the following actions:

- Estimate danger of tsunami for the Russian coast through magnitude and geographical criteria.
- Calculate the travel times of tsunami waves approaching coastal areas.
- Transfer the messages on GMS to increase the observations of sea level.
- Analyze the situation, including data from foreign centres.
- Make a decision on the tsunami threat; form, content and transfer of messages according to the rules and circuits of notification.

Now the danger of tsunami for the Russian coast is estimated by the following criteria:

- At the initial level - by magnitude-geographical criterion,
- During the tsunami event - on the data coming in on sea levels.

During the intersessional period, analysis was made of each event for which messages were sent by PTWS, including data from foreign tide stations. In all cases, danger for the Russian coast was absent.

National Sea Level Network

The coastal hydrometeorological stations (GMS), located in potentially tsunami dangerous places, carry out visual supervision over tsunami and their consequences.

In PTWC take part GMS in sities Nikolskoe (Bering island),Severo-Kurilsk (Paramushir island),. Yuzhno-Kurilsk (Kunashir island). There are some tidal instruments which now are useless and do not function in these places.

In Ust-Kamchatsk, Severo-Kurilsk, Malokurilskoe the registrars of a tsunami are established on the basis of data

RUSSIA, *continued*

gathering platform HANDAR, provided by IOC UNESCO, but for objective reasons they aren't part of PTWC now.

Information on Tsunami Occurrences.

No tsunami events were registered during the intersessional period along the Russian coastlines.

Activities Narrative

Since the last national report in 2001, the following basic projects were carried out:

The technical project of equipping the TWS of Russia with modern technology and methods was developed.

The International conference dedicated to tsunami, "Local Tsunami Warning and Mitigation" was held September 10-15, 2002 in Petropavlovsk-Kamchatsky. More than 70 representatives from 12 countries attended the conference.

The scientific basis was developed and experimental works on hydroacoustic location of areas of large underwater earthquakes were carried out. It has been shown, that use on shelf of the specialized hydroacoustic antennae focused on registration of ocean botton seismic activity, can give the new decision of a problem of the warning about local tsunami and raise efficiency of tsunami warning service considerably.

The new remote telemetering logger (TRL) of tsunami in coastal zones has been developed. The experimental model of TRL was manufactured and passed tests on Kamchatka.

There is planned the equipment of tide supervision network by TRL.

A series of works clarifying the spatial-temporal intercorrelation of tsunami and large earthquake distribution has been completed. It was concluded that a six-year periodicity exists for tsunami occurrence in the Pacific Ocean for the period 1950-2000.

The networks of automatic radiotelemetering SS on Kamchatka have been established. Their link to the TWS will raise reliability of tsunamigenic earthquakes definition essentially.

The scientific - methodical bases and base algorithmic maintenance for forecasting dynamic characteristics and estimation of tsunami danger degree for coastal places have been developed.

Annual field research of traces of adjournment paleotsunami and historical tsunami on Kamchatka and Kuril islands has been carried out. The obtained materials expand the coverage of events for 10000 years and improve the catalogue of tsunami on Pacific coast of Russia considerably.

02 July 2003, I.P. Kuzminykh, ICG/ITSU National Contact of the Russian Federation.

SAMOA

Member since: 1980

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Status since 2003 Unknown, no National Report received.

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Status since 2003 Unknown, no National Report received.

THAILAND

Member since: 1972

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Status in 2003 Unknown, no National Report received.

THE UNITED STATES OF AMERICA

Member since: 1968

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Summary Status in 2003

In the United States, the Tsunami Warning System (TWS) is operated by the National Weather Service (NWS) under the National Oceanic & Atmospheric Administration (NOAA). Another component of NOAA, the National Ocean Service (NOS), is primarily responsible for the maintenance of US tide gauges in the TWS. Tsunami research is conducted by NOAA's Environmental Research Laboratories and by various universities under the direction of the National Science Foundation (NSF). The World Data Center for Solid Earth Geophysics, including Tsunamis (WDC) is operated by NOAA's National Environmental Satellite, Data & Information Service (NESDIS), National Geophysical Data Center (NGDC). NESDIS also supports the TWS by providing communications from remote data platforms through NOAA's Geostationary Operational Environmental Satellite (GOES). The Japan Meteorological Agency (JMA) provides support to the TWS through the use of its geostationary satellite (GMS) to transmit data from US tidal stations. The US Geological Survey (USGS) is responsible for seismological research and its National Earthquake Information Center (NEIC) assists the TWS through the provision of real-time seismic data and in instrument maintenance and development. The US also continues to host the International Tsunami Information Centre (ITIC), as it has since the Centre's inception in 1965, by providing personnel and administrative support for the Centre to carry out its mission in support of the Tsunami Warning System in the Pacific.

The US continues to operate two major tsunami warning centers in support of the International Co-ordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU). These centers, the Richard H. Hagemeyer Pacific Tsunami Warning Center (PTWC) in Ewa Beach, Hawaii, and the West Coast/Alaska Tsunami Warning Center (WC/ATWC) in Palmer, Alaska, have access to large arrays of seismic and tide stations, either directly via telemetry from remote locations or indirectly via messages from local observers.

The more significant developments that have occurred during the period since ITSU-XVII include: establishment of a real time satellite downlink hub for data from up to eight Pacific broadband seismic stations in cooperation with the Global Seismic Network (GSN) of the Incorporated Research Institutions for Seismology(IRIS), installation of coastal run-up gauges to enable rapid confirmation of a potentially destructive local tsunami in Hawaii, the continued and expanded use of the Internet by the PTWC to collect Pacific wide seismic data, expansion of WC/ATWC's wave forecast model routines to include more source and run-up areas around the Pacific and implementation of this software at PTWC to assist in warning decision-making, the deployment of six real-time, deep ocean tsunami detection systems (DART buoys) capable of detecting tsunami waves only a cm in height for quick tsunami confirmation and future development efforts at tsunami forecasting, implementation of new procedures as recommended by ITSU-XVIII including the use of M_W [moment magnitude] and issuance of more informative bulletins, development of modular earthquake processing software and installation of EARTHWORM software for data collection and evaluation, implementation of recipicol backup capabilities for PTWC and WC/ATWC, enhancement of information products for potentially felt coastal earthquakes in the WC/ATWC Area of Responsibility, construction of a new WC/ATWC facility, continued production of inundation maps for coastal at-risk populations as necessary starting points for effective disaster planning and mitigation, and implementation of the TsunamiReady program as a means to actively engage

UNITED STATES, *continued*

local communities to prepare for tsunami hazards.

The NWS Pacific Region continues to support the activities of the Tsunami Laboratory of the Institute of Computational Mathematics and Mathematical Geophysics, Novosibirsk (NTL), in the development of the Historical Tsunami Database/US (HTDB/US) that is designed to provide US Emergency Managers with easy access to historical tsunami data for their area of responsibility. The HTDB/US supports a special option ("New Event") enabling a quick search for the run-up data generated by historical tsunamigenic earthquakes within a circular area centered around a new event. Additional features built in 2000 provide for tsunami hazard analysis through the calculation of the long-term tsunami risk for any particular coastal site should a sufficient number of historical run-up observations be available. During 2001, the HTDB coverage area was extended from the Pacific (within 65°S to 65°N and 80°E to 50°W) to the Atlantic (within 60°S to 72°N and 100°W to 30°E). In 2002, the updated versions of the WinHTDB graphic shells for both regions were finalized and distributed as region-specific WinHTDB/PAC and WinHTDB/ATL CD-ROMs, along with the Pacific and the Atlantic historical tsunami catalogs, the Users' Manuals, and the HTDB/US Project Summary. Work also continued to further verify and extend the tsunami event catalog and run-up catalogs for the Pacific and the Atlantic regions. The updating of the Atlantic catalog was carried out in close cooperation with the Department of Marine Science of the University of Puerto Rico at Mayaguez(UPR), which was funded by the US Federal Emergency Management Agency (FEMA) project "Puerto Rico Tsunami Warning and Mitigation Program" to develop a Caribbean Historical Tsunami Database. Currently, the UPR will be providing real-time seismic monitoring in support of a cooperative effort by the UPR and the NWS Pacific and Southern Regions and the NWS Forecast Office in San Juan, Puerto Rico, to implement a Regional Tsunami Warning System for Puerto Rico and the Virgin Islands.

During the intersessional period in accordance with Paragraphs 162-164, of the ITSU XVIII Summary Report, relating to the World Data Center for Solid Earth Geophysics, regarding the development of a joint NGDC/NOAA-ICG/ITSU-IUGG/TC Pacific Tsunami database product, NGDC, NTL, and ITIC, developed a plan to create a unified global historical tsunami database by merging the existing NTL HTDB/Pacific and Atlantic databases with the WDC/NGDC database, and establishing data quality standards and procedures for updating and collecting new event data. A meeting was held with the participants and other TWS users during the IUGG Meeting in Sapporo, Japan in July 2003 to discuss and approve of the collaborative plan. [See NGDC report for additional details.]

The NWS Pacific Region continues to work with PEACESAT to make the data on EMWIN also available on PEACESAT. The transmission of the EMWIN data stream began in September 2000. Data availability is currently limited by the drift of the GOES-7 satellite being used for broadcast.

The NOS continues to maintain a network of the Next Generation Water Level Measurement Systems (NGWLMS) at tide gauge sites in the US National Water Level Observation Network and at selected international locations. Data from these units are accessible to the WC/ATWC and the PTWC to support the TWS. As of 2002, 43 stations had been programmed to automatically convert to high frequency tsunami data acquisition mode whenever tsunami waves are detected. In this triggered mode, which can also be enabled manually by dialing up the station via modem, water level measurements are collected at one-minute intervals and transmitted via the GOES satellite every six minutes until signals abate. The tsunami transmissions are sent on channels designated for emergency transmissions.

The US, in Honolulu during February 2003, hosted a meeting of ITSU Officers in preparation for the Nineteenth Session of the Group.

TSUNAMI WARNING CENTER ACTIVITIES

Pacific Tsunami Warning Center (PTWC)

The PTWC is the operations centre for the Tsunami Warning System in the Pacific. In this capacity the PTWC provides information on earthquakes in the Pacific basin to Member States of ITSU, as well as to others who may be threatened by tsunamis resulting from these earthquakes. This information usually takes the form of Tsunami Bulletins issued for Warnings, Watches, Advisories, and for Information only. In response to recommendations approved at ITSU-XVIII, the procedures and criteria for issuing these bulletins were modified during the intersessional period as described in Section D of this report. The PTWC is also the national source of Tsunami Warnings, Watches, Advisories, and Information Bulletins for Hawaii, US possessions, and all other US interests in the Pacific located outside of the United States proper. Lastly, the PTWC operates the Regional Tsunami Warning Network for the State of Hawaii (HRTWN). In this capacity, the PTWC provides rapid warnings to the State of Hawaii for tsunamis generated by large local earthquakes associated primarily with Hawaii's active volcanoes.

A. Tsunami Watches and Warnings

On four occasions during the intersessional period, from June 2001 through May 2003, the PTWC issued regional Warning/Watch Bulletins in response to major earthquakes. Tsunamis were generated on all four occasions, and one caused numerous casualties.

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At 2033Z on 23 June 2001, a magnitude 8.4 (Harvard Mw) earthquake occurred at 16.0S, 73.3W, near the southern Pacific coast of Peru. An initial regional warning and watch for the area was issued by the PTWC at 2114Z. The size of the earthquake, the largest worldwide in more than thirty years, and the presence of tsunami waves measuring more than a meter in height on gauges at several widespread locations along the South American coast, raised concern that a destructive tsunami might be crossing the Pacific. After the issuance of seven more bulletins, approximately one per hour, that incrementally expanded the warning and watch areas, the warning was cancelled on June 24, 2003, at 0503Z when tsunami wave readings from the sea level gauge at Easter Island showed only a 0.4-meter height. Although widespread tsunami damage was not reported for this event, run-ups exceeded 8m near the coastal town of Camana, Peru, and up to 70 casualties were attributable to the tsunami.

A magnitude 7.6 earthquake occurred at 3.3S 143.0E, near the north coast of Papua New Guinea on 8 September 2002, at 1844Z. The PTWC initially issued a Tsunami Information Bulletin based on a preliminary magnitude of 7.4, then upgraded to a regional warning and watch a few minutes later when the magnitude grew to 7.6 based on additional data. The warning was cancelled at 2153Z based on only a 10cm height tsunami signal at the Manus Island gauge and no tsunami signal at the Kapingamaragi Island gauge. Although a local tsunami was generated by this event, run-ups along nearby coasts were generally less than a meter and no tsunami-related casualties were reported.

At 0843Z on 20 January 2003, a magnitude 7.8 earthquake occurred at 10.5S 160.8E, in the vicinity of the Solomon Islands. PTWC initially issued a Tsunami Information Bulletin based on a preliminary Richter magnitude of 7.3, but a regional warning and watch was issued about half-an-hour later when the magnitude grew to 7.7. The warning was cancelled at 1037Z when data received from the nearby sea level gauge at Honiara showed a tsunami signal only a few cm in height. A 2m wave was reported at Makira Island near Guadalcanal, but no damages, casualties, or injuries are known to have occurred.

A magnitude 7.3 earthquake struck near the Pacific coast of Mexico near Colima on January 22, 2003, at 0207Z. The PTWC issued a regional warning and watch for this event based on a preliminary magnitude of 7.6. The warning was cancelled at 0259Z following a revision of the magnitude to 7.3 based on additional data. This event generated a local tsunami that registered on the nearby sea level gauge at Manzanillo with a height of 1.2m. Coastal flooding from this tsunami apparently did not occur as tsunami waves did not exceed normal high tide levels. No damage or casualties were reported.

One additional tsunami occurred in Vanuatu on January 3, 2002 from a magnitude 7.5 earthquake that occurred at 1723Z. It registered 0.4m in height on the sea level gauge at nearby Port Vila. PTWC issued a Tsunami Information Bulletin for this event since the earthquake magnitude was below the threshold for a warning.

A total of forty Tsunami Information Bulletins were issued for shallow Pacific earthquakes with magnitudes between 6.5 and 7.5. Four hundred and two observatory messages were issued in response to earthquakes that triggered PTWC seismic alarms. These messages, sent primarily to other geophysical observatories, provide PTWC's preliminary earthquake location and magnitude. Twenty-three Local Tsunami Information Bulletins were issued to the State of Hawaii as a result of local earthquakes. No Local Tsunami Warning Bulletins were issued.

B. Seismic Programme

The PTWC's seismic programme continues to derive significant benefits as a result of the Consolidated Reporting of Earthquakes and Tsunamis (CREST) co-operative programme with the US Geological Survey(USGS). This programme provides dedicated digital communication links between PTWC and the USGS National Earthquake Information Center (NEIC) in Golden, Colorado, as well as to the USGS Hawaiian Volcano Observatory (HVO) on the island of Hawaii for the exchange of seismic waveform and parametric data. It also continues to support USGS-developed 'EARTHWORM' hardware and software to facilitate the exchange and processing the data.

For the local tsunami problem, PTWC receives continuous digital waveform data from thirty HVO seismic stations using the EARTHWORM system and CREST data link. It also continues to operate an array of ten seismic stations in Hawaii that provide telemetered waveform data from four islands in the Hawaiian chain. In addition, PTWC receives continuous waveform data from eight HVO stations over a radio/microwave link, and first arrival parametric data from more than 50 HVO stations over both the Internet and a dedicated circuit. These data enable PTWC to automatically determine earthquake hypocenters in less than a minute, and to interactively determine the event magnitude in less than five minutes.

For teleseismic earthquakes, PTWC receives continuous digital broadband seismic waveform data from more than eighty stations worldwide using the Earthworm system and CREST data link to NEIC. For redundancy, PTWC receives much of the same broadband data directly from a variety of other sources including some of the US regional seismic networks. During the intersessional period a cooperative programme was established with the

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Global Seismic Network (GSN) of the Incorporated Research Institutions for Seismology (IRIS) to have PTWC serve as a real time satellite downlink hub for data from up to eight Pacific broadband seismic stations. Links are now operational with stations at Pitcairn Island, Wake Island, Easter Island, and Midway Island. PTWC also receives parametric hypocenter and first arrival data from other USGS observatories over the Internet. In addition, first arrival data is received following each significant earthquake from many co-operating international observatories in the Pacific region. PTWC also operates three-component short and long period seismometers and an STS-2 three-component broadband seismometer in a seismic vault just a few hundred meters from its operations center. These combined data sources enable PTWC to determine preliminary earthquake locations and magnitudes for any Pacific earthquake in less than ten minutes, and to utilize the most modern seismic analysis techniques for determining earthquake parameters useful for tsunami warning decision-making.

C. Sea-Level Programme

For tsunamis generated within the State of Hawaii, the PTWC operates an array of eight continuous real-time telemetered sea-level gauges. The PTWC also operates an array of seven dial-up gauges that can be accessed as needed. To supplement this array, PTWC and the State of Hawaii have added an array of eight run-up gauges along coasts where historical local tsunamis have struck. Based on home security alarm technology, these inexpensive gauges will alert PTWC within about 40 seconds of being flooded and provide the most rapid confirmation if a potentially destructive local tsunami exists.

For tsunamis generated elsewhere in the Pacific, PTWC receives data from more than 90 sea-level gauges, most of which transmit data back to the center through either the GOES or GMS satellite on schedules that range from once per hour to once every three hours. About twenty of these gauges are operated and maintained by PTWC, while the rest belong to other organizations, including WC/ATWC, the US National Ocean Survey (NOS), the University of Hawaii Sea-Level Center (UHSLC), the Hydrographic and Oceanographic Service of the Chilean Navy (SHOA), the Japan Meteorological Agency (JMA), and Australia's National Tidal Facility (NTF). PTWC also receives real time data from eight Alaska sea level stations operated by WC/ATWC. In addition, PTWC is now receiving data from six deep ocean pressure sensors that are capable of detecting tsunami waves only a cm in height. Three are south of the Aleutian Islands, two are off the US West Coast, and one is in the southeast Pacific, just south of the equator. Developed by the NOAA Pacific Marine Environmental Laboratory and now operated by the US National Weather Service's National Data Buoy Center, these 'Deep-ocean Assessment and Reporting of Tsunamis' (DART) instruments provide the only accurate measure of a tsunami as it propagates in deep water, and will provide a key input for future tsunami forecasting using numerical models. Additional DART buoys are scheduled for deployment in coming years, including one that was purchased by Hydrographic Service of the Chilean Navy (SHOA) for installation in the Fall, 2003.

D. Procedures

Effective June 21, 2003, the PTWC made the following changes in the issuance and contents of international tsunami warning and information products:

1. The earthquake magnitude reported in the bulletins and used in criteria for determining the type of bulletin to issue is now the moment magnitude, M_W, instead of the Richter surface wave magnitude, M_S. M_W values are similar to M_S values for most shallow earthquakes. However, M_W provides a more accurate scale for very large earthquakes and for slowly rupturing earthquakes that have an enhanced tsunamigenic potential. M_W is also the standard magnitude now used by most seismic observatories.
2. Tsunami Information Bulletins (TIB) continue to be issued for shallow Pacific earthquakes with magnitudes between 6.5 and 7.5, inclusive. However, a TIB supplement will now be issued if data from nearby sea level gauges indicate a local tsunami was generated. A TIB will now also be issued for certain large Pacific region earthquakes that do not pose a tsunami threat to the Pacific Basin because they are inland or deep or are in a marginal sea.
3. A Spanish-language version of the TIB, formerly sent to a few locations in South America, will be replaced by the English-language version. This change is being made to eliminate the potential for confusion when PTWC staff make changes to pre-scripted language of the English version to accommodate a particular situation, but are unable to compose similar changes in the Spanish version.
4. A non-expanding regional warning, limited in areal extent to 1000 km from the earthquake epicenter, will be issued for shallow Pacific earthquakes with magnitudes between 7.6 and 7.8, inclusive.
5. An expanding regional tsunami warning and watch, formerly issued for shallow Pacific earthquakes with magnitudes of 7.6 or greater, will now only be issued for magnitudes of 7.9 or greater.
6. A number of additional warning points have been added. Warning points are locations used to determine if an area should be in a warning or watch based either on that point's distance from the epicenter or on the

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time remaining until the estimated arrival of the first tsunami wave at that point. The additional warning points are needed to improve the coverage and accuracy of warning and watch areas. Estimated arrival times will continue to be provided in bulletins for all warning points within warning and watch areas.

7. A few format changes have been made to the bulletins. Notable is that the earthquake parameters are now in a tabular rather than Activities Narrative form. In addition, the geographic coordinates of warning points are now provided whenever estimated arrival times for those points are listed in the bulletins.

The purpose of these changes is to help reduce the problem of over-warning, to provide more comprehensive and accurate warning and watch areas, and to otherwise make the bulletins more informative and effective. These changes are largely the result of recommendations made and approved at ITSU-XVIII.

E. Message Dissemination

The PTWC bulletins are disseminated through a wide variety of communication methods. Bulletins in text form are transmitted over the Global Telecommunications System (GTS), the NOAA Weather Wire (NWW), the Aeronautical Fixed Telecommunications Network (AFTN), the Emergency Managers Weather Information Network (EMWIN), the US Defense Communications System (DCS), soon to be replaced by the Defense Messaging System or (DMS), the Hawaii Interisland Data Network (IDN), and TELEX. Bulletins are also transmitted by voice over a dedicated Hawaii Warning System (HAWAS) telephone, and by e-mail and fax.

West Coast/Alaska Tsunami Warning Center (WC/ATWC)

The mission of the West Coast and Alaska Tsunami Warning Center (WC/ATWC) is to provide tsunami watches, warnings, information bulletins, and interpretative information to civilian and military officials in Alaska, Canada (British Columbia), Washington, Oregon, and California. In performing this mission, its primary responsibility is the detection, location, and determination of magnitude of potentially tsunamigenic earthquakes occurring in the area from Attu, Alaska to the southern California border. The WC/ATWC has this same responsibility for tsunamis generated by earthquakes located outside the WC/ATWC area of responsibility. The WC/ATWC also provides, within established criteria, earthquake parameters and other associated information to appropriate national and international interests. Although numerous non-tsunamigenic earthquakes are automatically detected and processed each month, only a small number of these earthquakes are released to officials and the public.

WC/ATWC personnel continue to conduct applied research and development to improve the present system, plus continue to analyze collected data. The Center is highly automated for processing earthquakes and disseminating critical information to intended recipients. The earthquake processing software developed at the WC/ATWC, known as EarlyBird, has been re-written to run under the Earthworm platform. The real-time system has been re-configured into approximately 12 modules. The modules operate independently, though interact through Earthworm message structures.Three new magnitude techniques have been incorporated into the EarlyBird system. The Mwp magnitude, under development for the past several years, is now fully integrated into the system. The Mm (Mw) magnitude technique, developed by the Centre Polynesien de Prevention des Tsunamis in Tahiti, French Polynesia and provided by the PTWC, has also been implemented as an EarlyBird module. Lastly, WC/ATWC has been working with the NEIC to implement their automated CMT technique as an EarlyBird module. This implementation is still under development. The EarlyBird system software was provided to both the National Earthquake Information Center and the Puerto Rico seismic network in 2002/2003.

A. Tsunami Products

During the intersessional period, no tsunami watches or warnings were issued by the WC/ATWC. However, having responded to some 554 earthquake alarms, a total of three Tsunami Advisory Bulletins, 27 Tsunami Information Bulletins, 101 Information Messages, and 143 P-time messages were issued.

Backup procedures between PTWC and WC/ATWC were improved significantly in the last two years. Both centers are now capable of providing each other's services in the event of a catastrophic failure at either center. The centers are also capable of providing a limited set of products through selected communication paths in the event that either center has an outage in just one of their pathways.

A new national policy directive and procedural instructions controlling both centers' operations were issued in May, 2003. Main procedures for the WC/ATWC stayed essentially the same, though there were some significant changes for the PTWC; those affecting the international tsunami warning system were implemented by PTWC on June 21, 2003, and are described in Section D. Procedures, of the PTWC report. Some of the changes impacting the WC/ATWC are: moment magnitude is the preferred method of sizing earthquakes; tsunami warnings can be left in effect for certain areas of the AOR and not enlarged with each new message; and backup procedures for PTWC were changed.

The WC/ATWC, in conjunction with the USGS and west coast states, has refined response criteria for potentially-

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felt coastal earthquakes within the AOR. Information message products are issued when earthquakes between magnitude 4 and 5 occur within 50km of the coast, earthquakes between magnitude 5 and 6 occur within 150km of the coast, or earthquakes between magnitude 6 and 6.5 occur within 250km of the coast. Earthquakes located in any west coast state, Alaska, or British Columbia over magnitude 6.5 will prompt the issuance of a tsunami information bulletin.

B. Seismic and Tide Data Acquisition

The WC/ATWC continues to maintain a network of 15 seismic sites located at remote places from the far western Aleutians to Sitka, Alaska, and local sites that are within driving distance from Palmer. The data are telemetered to the WC/ATWC for real-time processing and are recorded on computer disk. The WC/ATWC has proposed upgrading the aging analog telemetry equipment to a modern, satellite-based system. To this point, the proposed system has not been funded. The USGS Earthworm system is used to exchange the seismic data with other centers. Approximately 100 channels of seismic data are recorded and processed at the WC/ATWC. The WC/ATWC exchanges real-time seismic data with the USGS National Earthquake Information Center (NEIC), University of Alaska, Alaska Volcano Observatory, PTWC, USGS Menlo Park Observatory, University of Washington, University of Oregon, Incorporated Research Institutions for Seismology, the southern California Seismic Network, and the Pacific Geosciences Centre in Canada.

The WC/ATWC has access to more than 100 tide sites throughout the Pacific Basin. Most are maintained by NOAA's National Ocean Service (NOS). In addition to the NOS sites, other tide gauge networks are operated by agencies such as the Pacific Tsunami Warning Center, Japan Meteorological Agency, and others. The WC/ATWC maintains real-time telemetry equipment at seven NOS gauges in Alaska, and fully maintains an eighth tide gauge at Shemya, Alaska. Since the last National Report, the instrumentation at Shemya has been replaced with an above-water, radar pinging device. This device is proving to be a robust method for obtaining water-level data at remote sites.

C. Instrumentation, Maintenance, and Calibrations

The WC/ATWC continues to maintain its seismic network throughout Alaska, the Shemya tide site, and WC/ATWC's transmitters at each of the NOS tide sites. Equipment maintenance, additions, calibrations, and developments are on-going functions at the WC/ATWC's Center and field sites. Field sites are visited yearly or as soon as possible after equipment failure. At the Center, the incoming seismic and tide data are recorded on computer disk. The equipment and systems are monitored daily, by personnel and by other electronic equipment, to ensure a continuous data flow to the Center. Preventative maintenance, calibrations, and parts replacements are performed for all remote seismic and tide equipment, and for major equipment systems in the Center.

An in-depth information technology (IT) study of the two warning centers was completed in late 2002 by senior NOAA IT experts. Several recommendations were made in the study to enhance the WC/ATWC and PTWC's IT structure. The two centers are presently creating a plan to implement the recommendations.

D. Communications Systems

Methods for disseminating emergency and routine information are via the National Warning System (NAWAS), Alaska Warning System (AKWAS), National Weather Wire System (NWWS), VHF radio system, Federal Aviation Administration NADIN2 system, dedicated NWS circuits, commercial telephones, Alaska Division of Emergency Services, NOAA Weather Radio, Coast Guard HF Marine Weather Radio, Emergency Alert System (EAS) through the National Weather Service, the NWS Emergency Manager's Weather Information Network (EMWIN), web page posting, pager notification, and e-mail. The NAWAS, a voice disseminating system, NWWS, NADIN2, and dedicated NWS circuitry are the primary systems used to alert disaster officials in the US and Canada of large earthquakes. The AKWAS, which is the State side of NAWAS, permits immediate voice communication with Alaska disaster officials. The NWWS, NADIN2 system, and NWS circuitry provide recipients with hard copies of watch/warning and other information. Web Page updates, pagers and e-mail are considered secondary systems. All of these systems are monitored and tested daily to ensure that they are operational. The primary systems are also tested monthly using warning product headers. Message receipt at the main communication facilities is verified.

E. Community Preparedness

The WC/ATWC continues to provide a three-part community preparedness program which includes (1) visits to distant coastal communities from Shemya to Southern California; (2) visits to local groups, facilities and schools that are within commuting distance of the Center; and (3) tours of the WC/ATWC's facilities. Public tours of the center are offered weekly on Fridays at 1PM, 2PM and 3PM.

Some community preparedness is also done via email and telephone for special projects. Presentations in the community preparedness program usually include: a slide presentation concerning the origin and nature of earthquakes and tsunamis; a community's particular hazard potential and their expected response; and a summary

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of the Center's operations, missions, and capabilities.

During this reporting period, the WC/ATWC staff visited 15 Alaskan communities and participated in several mitigation meetings on the West Coast. The National Weather Service's TsunamiReady program, which was launched in 2001, has captured the interest of numerous at-risk coastal communities in Alaska, Washington, Oregon and California. To date 8 communities have been designated as TsunamiReady communities (Sitka, Seward, and Homer Alaska; Crescent City, California; Cannon Beach, Oregon; and Ocean Shores, Long Beach, and Quinalt Reservation in Washington). The program is based on the NWS 'StormReady' program with the purpose of increasing communication between the Warning Centers and participating communities, and improving tsunami hazard planning and awareness in the community.

F. Facilities

In April 2002, a ground-breaking ceremony was held on the Palmer, Alaska property for a new building to house the Center. Construction was completed in May 2003 and the move to the new facility was completed in June 2003. The modernized facility contains such upgraded features as a conference room, a dedicated electronics workshop, a Command & Control style operations console, raised flooring for computer and network cabling, modular office furniture, a reference library, and separate men's and women's bathrooms. The building was built with special consideration to energy-efficiency and is handicap accessible throughout.

Please refer to WC/ATWC's web site for further explanation of issues discussed above: *http://wcatwc.arh.noaa.gov/.*

RESEARCH ACTIVITIES

The US National Tsunami Hazard Mitigation Program

The following provides an executive summary of the individual reports for the five recommendations described in the National Tsunami Hazard Mitigation Implementation Plan. Each individual report describes the recommendation, what has been accomplished, and the impact of these accomplishments toward reducing the impact of tsunamis to US coastal communities. The summary report is organized to provide background, accomplishments and impact for each recommendation; a summary of future recommendations; identification of gaps in the present plan; and options for the future.

A. Background

The April 1992 California earthquake and tsunami brought into focus that the west coast of the US has a major subduction zone capable of producing destructive tsunamis. The 1992 tsunami raised the question as to the preparedness level of west coast residents to a local tsunami. In July 1994, the Senate Appropriations Committee directed the National Oceanic and Atmospheric Administration (NOAA), the Federal Agency responsible for issuing tsunami warnings, to formulate a plan for reducing the tsunami risks to coastal residents. Within 10 months, NOAA hosted three workshops involving over 50 scientists, emergency planners, and emergency operators from all levels of governments and universities and produced 12 recommendations, which were submitted to the Committee in March 1995. In October 1995, the Committee directed NOAA to form and lead a Federal/State working group to (1) review the 12 recommendations submitted in the 1995 NOAA Report, and (2) develop an action plan and budget. In February 1996, NOAA formed the Tsunami Hazard Mitigation Federal/State Working Group, composed of representatives from the States of Alaska, California, Hawaii, Oregon, and Washington, and three Federal agencies - NOAA, the Federal Emergency Management Agency, and the United States Geological Survey. By April 1996, the Working Group produced and submitted a Tsunami Hazard Mitigation Implementation Plan that provided technical and budgetary guidance for the implementation of five specific Program recommendations:

1. Produce Inundation Maps
2. Improve Seismic Networks
3. Deploy Tsunami Detection Buoys
4. Develop Hazard Mitigation Programs
5. Develop State/NOAA Co-ordination and Technical Support

These recommendations have been carried out over the past 7 years under the guidance of the Federal/State National Tsunami Hazard Mitigation Program (NTHMP) Steering Group. The Steering Group met twice each year to make funding decisions on the five elements, to report progress, and to make adjustments in the Program. Through the use of a web site, e-mails, telephone conference calls, and numerous individual meetings and telephone calls, the Group functioned as a team in implementing the Plan. The web site http://www.pmel.noaa.gov/tsunami-hazard/ contains the minutes for each meeting including progress reports for each element. The web site, designed and maintained by Ann Thomason, has also become a valuable Group resource and has won a Key Link Web Award for its tsunami information content.

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Since 1995, the media has shown exceptional interest in tsunami mitigation by broadcasting about 255 stories or about one per week. Tsunami stories related to the Program were included in newspapers, magazine articles, television news stories, television documentaries, radio programs, web stories, trade publications, books, and one comic strip.

Funding of US$2.3M was provided on a year-by-year basis for FY 1997, 1998, 1999, 2000, and 2001 through the Congressional add-on process. For FY 2002, the program became part of NOAA's base budget. In FY 2003 the budget was increased to $4.3M.

B. The Five Recommendations: Budgets, Accomplishments, and Impact

1. Produce tsunami inundation maps
   a. Accomplishments
      i. Inundation Maps. Since the 2001 report, eight inundation modeling and mapping efforts were completed that covered 37 communities with a population at risk of 516,846. This brings the grand totals to 27 inundation modeling and mapping efforts completed for 125 communities with a population at risk of 1,637,212.
      ii. SIFT Prototype. A prototype system for forecasting tsunamis has been developed by Project SIFT (Short-term Inundation Forecasting for Tsunamis), a collaboration of the NOAA Center for Tsunami Inundation Mapping Efforts (TIME), the NOAA Tsunami Warning Centers and academic scientists. SIFT combines numerical modeling and real-time tsunami measurement technologies. The current prototype provides offshore forecasts, advanced versions will provide site-specific forecasts of tsunami inundation.
   b. Impact
      i. Inundation Maps: A tsunami inundation map is a clarifying, galvanizing catalyst for action by Emergency Managers and citizens alike. Once a map is completed and available for study, previously vague concerns and abstract issues are suddenly and immediately clarified and rendered concrete. At this moment, effective, community-specific planning is truly begun – individual hazards can be identified and mitigation measures can be developed and implemented that are specific to that hazard. A map is thus the fundamental starting point for any effective planning and mitigation program, aiding the evaluation of critical issues such as population and infrastructure vulnerability, and the identification of feasible evacuation routes.
      ii. SIFT Prototype: This prototype and more advanced versions of SIFT will improve the speed and accuracy of tsunami warnings and reduce the number of false alarms.
   c. Research/Emergency management partnership: Because the academic scientists are well-respected and influential members of the tsunami research community, their vigorous involvement in hazard mitigation issues has had an important positive impact on the relationship of the tsunami research community to the emergency management community.
2. Improve Seismic Networks
   a. Accomplishments
      i. Seismic Stations: Installed 56 real-time, broadband, seismic stations in five states.
      ii. Software: Installed EARTHWORM software at each NOAA warning center that allows access to data from regional and global seismic networks.
      iii. Infrastructure Development: The EARTHWORM software has become a NOAA standard for linking all of the seismic networks in the US. This infrastructure now enables the tsunami warning centers to take advantage of improvements in seismic monitoring capability nationwide, as well as globally, even though such improvements may be undertaken by other monitoring agencies and organizations.
   b. Impact
      i. US earthquakes: Alaska, Hawaii, West Coast: Reduced the time required to locate and determine magnitude has decreased from 8 minutes to 2 minutes (if staff is on site).
      ii. Earthquakes outside the US: The time required to locate the earthquake is still governed by the time it takes for the P-waves to reach the most distant station in the network. Formerly, it would take 8-16 minutes to locate an earthquake, but now the time has been shortened to 1-12 minutes. The time to determine magnitude has decreased from 5-55 minutes to 2-20 minutes.
3. Deployed Tsunami Detection
   a. Accomplishments
      i. Deployed six-DART array as originally recommended since October 2001.
   b. Impact
      i. Tests and three earthquakes demonstrated that DART performed as designed.
      ii. Major upgrade in tsunami data acquisition for NOAA's warning centers.
      iii. Using DART data and numerical models, a NOAA tsunami forecasting capability is being developed.

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iv. Met goal of Quickly Confirm Potentially Destructive Tsunamis and Reduce False Alarms.

4. Develop Hazard Mitigation Programs
   a. Accomplishments
      i. Standardized tsunami evacuation and hazard zone road signs.
      ii. Published a strategic plan (Dengler, 1998).
      iii. Published a progress report (Jonientz-Trisler).
      iv. Published a Survival booklet (Atwater, 1999).
      v. Published Designing for Tsunamis guide for local communities (Mintier, 2000).
      vi. Published TsuInfo Newsletter 6 times/year.
      vii. Sponsored one multi-state workshop on local warnings and over 20 workshops within states for education, co-ordination, and inundation map review.
   b. Impact: Based on two west coast surveys of emergency management community - a few findings are listed below.
      i. Percent able to use tsunami messages doubled from 41% in 1994 to 86% in 2001.
      ii. Seventy-five percent indicate improvements since 1994.
      iii. Key factor on improvement is better planning and co-ordination.
      iv. Majority believes more improvements will take place if public education and better technology are emphasized.
5. Develop state/NOAA coordination and technical support:
   a. Accomplishments
      i. Ten warning coordinating meteorologists were trained in tsunami warning procedures.
      ii. Each state has some tsunami infrastructure in place to co-ordinate tsunami activities.
      iii. Developed and distributed historical tsunami database (HTDB/US project).
      iv. Developed agreement between NOAA and USGS to distribute information on small earthquakes via the Emergency Managers Weather Information Network (EMWIN).
      v. Assisted in relocation of NOAA weather radio transmitter to provide better coverage of Washington coastline.
   b. Impact
      i. Assimilated products from NTHMP into a TsunamiReady program that recognizes communities that have met minimum criteria to properly respond to NOAA tsunami warnings.

C. Conclusion

The first seven years of the NTHMP has met the initial goals of the program outlined in the Implementation Plan to raise awareness of the affected populations, supply evacuation maps, improve tsunami warning systems, and institutionalize mitigation planning. The culmination of these efforts has enabled the concept of certifying communities as TsunamiReady to become a reality. The TsunamiReady community will save lives within that community. For the community to survive the next tsunami, however, the community must become tsunami resistant. This requires a community to examine its vulnerability to tsunamis and make appropriate adjustments in the community infrastructure. The goals of the next five years are to significantly increase the number of tsunami ready communities and develop the tools necessary to become tsunami resistant.

INTERNATIONAL TSUNAMI INFORMATION CENTRE (ITIC)

The ITIC continues to receive support at a stable level from the United States through its National Weather Service. The United States recognizes the importance of the role of the ITIC in the international aspects of the Tsunami Warning System in the Pacific (ITSU) as a day-to-day monitor of the performance of the System and as a source of information on the operations of tsunami warning systems and tsunamis in general. The ITIC carries out its mission through the direct efforts of its Director, Dr. Laura Kong, and Technical and Office Assistant, Linda Sjogren. Dr. Kong replaced Michael Blackford, who retired in January, 2002. In addition, the ITIC continues to receive assistance from Cmdr. Rodrigo Nunez as Associate Director operating out of his office in Valparaiso, Chile, where he is a member of the Chilean Navy Hydrographic and Oceanographic Service. During the Fall, 2003, ITIC hired Tammy Kaitoku as its Internet Web Resource to improve and enhance its Web information services. In order to provide participants in ITSU with the timeliest information on the status of the System, the ITIC continually updates its web site with news of events and releases of papers and documents pertinent to the System, and additionally provides general information on the tsunami phenomenon and hazard preparedness of interest to the public. Through the efforts of Cmdr. Nunez, much of this information is also presented in Spanish. The ITIC presently maintains two sites, one in the USA and one in Chile; at the end of the calendar year 2003, the Chile site will close and all files and resources will be transferred to the ITIC USA web site and the newly-created ITSU web site.

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The ITIC Tsunami Newsletter is produced in-house in full-color on a bi-monthly basis, and distributed both as hard copies and electronically as a downloadable PDF-format file through the ITIC and ITSU Web Sites. Work is progressing on the completion of the ITIC Annual for 2000-2001 during 2003, which is meant to provide its reader with a detailed overview of ITSU and the regional or national tsunami warning systems of its Member States; the 2002-2003 Annual will be published in 2004. The ITIC continues to conduct its Annual Visiting Experts Programme (now renamed to be the ICG/ITSU Training Programme), which brings two visiting scientists each year to ITIC to learn about tsunamis and tsunami warning systems. During the summer, 2003, the ITIC library reference database was placed online on the ITIC USA Web Site, thus making it possible for the public to obtain listings of reference materials based on author, title or general keyword searches of the library collection. The ITIC also maintains the Tsunami Bulletin Board (TBB) list serve as an informational clearinghouse for tsunami researchers and other scientists. During the fall, 2003, the ITIC will move the TBB from its aging Sun computer text-based list serve to a web-enhanced version capable of more efficiently posting and archiving tsunami discussion subjects and other graphical products.

In addition to its tasks related to the operation of ITSU and action items generated by the International Co-ordinating Group of ITSU at its meetings, ITIC participates in many outreach programmes in tsunami education and tsunami awareness undertaken in Hawaii. The ITIC, through its Director, also participates in the USA National Tsunami Hazard Mitigation Programme, as a liaison to the international tsunami warning programme and its mitigation efforts. These national programmes provide the ITIC with valuable experience in evaluating those programmes that are most effective in giving vulnerable populations the necessary information that can be used to protect them in actual life threatening tsunami events. The ITIC continues to provide booklets and pamphlets on tsunamis and tsunami warning systems to such programmes. During the intersessional period, the following informational materials were revised or created: *Tsunami, the Great Waves* brochure was revised and reprinted in English; the English TWSP and ITIC informational brochures were revised and made available as downloadable PDF-format files; and tsunami safety magnets, luggage tags, stickers, and bookmarks were created in English and Spanish.

NATIONAL GEOPHYSICAL DATA CENTER (NGDC) & WORLD DATA CENTER (WDC) FOR SOLID EARTH GEOPHYSICS, BOULDER

The World Data Center for Solid Earth Geophysics, including tsunamis (WDC) is operated by NOAA's National Geophysical Data Center(NGDC). NGDC is one of three environmental data centers within the National Environmental Satellite, Data and Information Service(NESDIS). Operating both National and World Data Centers, NGDC acquires, processes and analyzes global data for terrestrial and marine environments. NGDC and the collocated WDC, have a major role in the post-event data collection (including the compilation, cataloging, and synthesis) of all available information on tsunami sources and effects to support modeling, engineering, planning and educational purposes.
The present NGDC Worldwide Tsunami Database(WWTD) includes more than 2,370 events since 2,000 BC and more than 6,700 locations where tsunamis were observed. Times of generating earthquakes, tsunami arrival times, travel times, first motion of the wave, and wave periods are included in the database. All of the NGDC natural hazards databases including the tsunami event, tsunami run-up, and significant earthquake databases are now stored in a relational database management system. These data are accessible over the Web as tables, reports, and interactive maps. The interactive maps provide integrated Web-based GIS access to the hazards databases as well as additional auxiliary geospatial data. The map services also provide hyperlinks to additional hazards information such as NGDC's extensive collection of geologic hazards photos. NGDC is now receiving more than 4,000 requests per month for interactive maps displaying natural hazards data. The address for the NGDC natural hazards Web site, which includes links to the interactive maps, is: *http://www.ngdc.noaa.gov/seg/hazard/hazards.shtml*. The tsunami database is available and searchable from the following Web site: *http://www.ngdc.noaa.gov/seg/hazard/tsu.shtml.*

As described in the Introduction, a collaborative plan to merge the NGDC WWTD with the NTL HTDB data was developed in the summer, 2003. The new unified database will summarize the long-term efforts of several research groups and individuals in collecting, refining and digitizing the tsunami data and will represent the updated, revised and homogeneous tsunami dataset. The benefits of having such a single, unified product are straightforward. First, this new product will reduce confusion for end users looking for a reliable source of information on historical tsunamis. And second, in the process of preparation of the joint product, many discrepancies and uncertainties in parameters of historical tsunamigenic events still existing in both the HTDB and WWTD databases will be resolved.

The official copy of the unified tsunami database is planned to be housed at the WDC/NGDC, which would then be able to take advantage of WDC/NGDC's existing institutional framework, human resources, and database archiving and delivery technologies, to support and enhance the tsunami database. As NTL also has users who are familiar with the data access and display applications available from the web-version of the HTDB, the data files would be exported from the unified database and be also available from the NTL website in Novosibirsk, Russia. Additionally, recognizing that some international users may not have ready access to the Internet, as well as recognizing the needs

UNITED STATES, *continued*

of individual researches to have an access to the historical data in "offline" mode (e.g. being on research ships or in the field during post-event tsunami surveys), it is suggested that the offline, standalone application (WinHTDB graphic shell) continue to be supported and distributed using the data files retrieved from the unified tsunami database.

Publications

Scientists at NGDC have published several papers in the Science of Tsunami Hazards Journal, including:

A Brief History of Tsunamis in the Caribbean Sea, by James F. Lander, Lowell S. Whiteside, and Patricia A. Lockridge (Volume 20, No. 2, 2002, p. 57-94, *http://sthjournal.org/202/carib.pdf*);

Tsunamis and Tsunami-Like Waves of the Eastern United States with Appendix 1: Table of Tsunamis and Tsunami-Like Waves of the Eastern United States, by Patricia A. Lockridge, Lowell S. Whiteside, and James F. Lander (Volume 20, No. 3, 2002, p. 120-157, *http://sthjournal.org/203/ec1.pdf* and *http://sthjournal.org/203/ec2.pdf*);

The Tsunami History of Guam: 1849-1993, by James F. Lander and Lowell S. Whiteside (Volume 20, No. 3, 2002, p. 158-174, *http://sthjournal.org/203/guam.pdf*); and

Two Decades of Global Tsunamis: 1982-2002, by James F. Lander, Lowell S. Whiteside, and Patricia A. Lockridge (Volume 21, No. 1, 2003, p. 3-88, *http://sthjournal.org/211/decades.pdf*).

Slide Sets

NGDC continues to collect photographs of damage caused by natural hazards. NGDC will be releasing the entire collection of geologic hazards photos (300 dpi resolution) and associated descriptions on DVD-ROM. The compilation includes over 900 images showing damage from tsunamis, earthquakes, volcanoes, and other geologic hazards.

ITSU SESSION PARTICIPATION

Nation	Participation	Joined
Australia	85(O),95,99,03	1987*
Canada	Always	1968*
Chile	68,72,76,78,80,84,85,87,89,91,93,95,97,99,01,03	1968*
China	84,85,87,89	1970*
Colombia	85,93,95,97,99,01,03	1982*
Cook Islands	95	1982*
Costa Rica	Never attended	1993*
Ecuador	76,78,80,85,01,03	1970*
El Salvador	03(O)	2003*
Fiji	74(O),78(O),80,82,85,89,03	1980*
France	68(O),70,72,74,76,78,80,85,87,89,91,93,95,97,99,01,03	1970*
Guatemala	72,85	Unknown
Indonesia	78(O),80,93,95,99,01,03	1980*
Japan	68,70,72,74,78,82,84,85,89,91,93,95,97,99,01,03	1968*
Korea,DPR	87,89	1987*
Korea,Rep.	85,89,91,93,95,97,99,01,03	1968*
Mexico	74(O),76(O),89,91,93,95,97	1980*
New Zealand	74,82,84,87,89,93,97,01,03	1970*
Nicaragua	93,99,01,03	1993*
Papua NewGuinea	03(O)	-----
Peru	72,76,80,82,85,87,93,95,97,99,01,03	1972*
Phillipines	70,72,74,76,78,82,87,93	1970*
Puerto Rico	97(O)	-----
Russian Federation	68,70,72,74,76,78,84,85,87,89,95,97,99,01,03	1968*
Samoa	Never attended	1980*
Singapore	Never attended	1976*
Thailand	72,78	1972*
Tonga	82(O),85(O)	-----
U.K.(Hong Kong)	84, withdrew in 1997	1980*
U.S.A.	Always attended	1968*

** joined during intersessional period,*
(O) attended as observer

ITSU SESSIONS

Meeting	Year	Place
I	1968 (25-28 Mar)	Honolulu, HI, USA
II	1970 (12-14 May)	Vancouver, BC, Canada
III	1972 (8-12 May)	Tokyo, Japan
IV	1974 (4-7 Feb)	Wellington, New Zealand
V	1976 (23-27 Feb)	Lima, Peru
VI	1978 (20-25 Feb)	Manila, Phillipines
VII	1980 (3-7 Mar)	Vina del mar, Chile
VIII	1982 (13-17 Apr)	Suva, Fiji
IX	1984 (13-17 Mar)	Honolulu, HI, USA
X	1985 (1-3 Aug)	Sidney, BC, Canada
XI	1987 (8-12 Sep)	Beijing, People´s Republic of China
XII	1989 (7-10 Aug)	Novosibirsk, USSR
XIII	1991 (10-13 Sep)	Ensenada, Baja California, Mexico
XIV	1993 (30 Aug - 3 Sep)	Tokyo, Japan
XV	1995 (24-28 Jul)	Papeete, Tahiti, French Polynesia
XVI	1997 (23-26 Sep)	Lima, Peru
XVII	1999 (4-7 Oct)	Seoul, Korean Republic
XVIII	2001 (8-11 Oct)	Cartagena de Indias, Colombia
XIX	2003 (29 Sept - 2 Oct)	Wellington, New Zealand
XX	2005 (3-7 Oct)	Valparaiso, Chile

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

The present 26 Member States are: Australia, Canada, Chile, China, Colombia, the Cook Islands, Costa Rica, the Democratic People's Republic of Korea, Ecuador, El Salvador, Fiji, France, Guatemala, Indonesia, Japan, Mexico, New Zealand, Nicaragua, Peru, Philippines, the Republic of Korea, Samoa, Singapore, Thailand, the Russian Federation, and the United States of America.

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