

Intergovernmental Oceanographic Commission
Reports of Governing and Major Subsidiary Bodies



**International Co-ordination Group
for the Tsunami Warning System
in the Pacific**

Fifteenth Session

Papetee, Tahiti, French Polynesia, 24-28 July 1995

In this Series	Languages
Reports of Governing and Major Subsidiary Bodies, which was initiated at the beginning of 1984, the reports of the following meetings have already been Issued:	
1. Eleventh Session of the Working Committee an international Oceanographic Data Exchange	E, F, S, R
2. Seventeenth Session of the Executive Council	E, F, S, R, Ar
3. Fourth Session of the Working Committee for Training, Education end Mutual Assistance	E, F, S, R
4. Fifth Session of the Working Committee for the Global Investigation of Pollution in the Marine Environment	E, F, S, R
5. First Session of the IOC Sub-Commission for the Caribbean and Adjacent Regions	E, F, S
6. Third Session of the ad hoc Task team to Study the Implications, for the Commission, of the UN Convention on the Law of the Sea and the New Ocean Regime	E, F, S, R
7. First Session of the Programme Group on Ocean Processes and Climate	E, F, S, R
8. Eighteenth Session of the Executive Council	E, F, S, R, Ar
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11. Nineteenth Session of the Executive Council	E, F, S, R, Ar
12. Sixth Session of the IOC Scientific Committee for the Global Investigation of Pollution in the Marine Environment	E, F, S
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14. Second Session of the IOC Sub-Commission for the Caribbean and Adjacent Regions	E, F, S
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62. Fifteenth Session of the International Co-ordination Group for the Tsunami Warning System in the	E, F, S, R

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Fifteenth Session

Papetee, Tahiti, French Polynesia, 24-28 July 1995

IOC/ITSU-XV/3
Paris, 29 November 1995
Original: English*

SC-95/CONF.223/LD.1

- Report translated into French, Spanish and Russian. For reasons of budgetary constraints, the Annexes remain in English only.

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1. OPENING AND ARRANGEMENTS FOR THE SESSION

1 The Chairman, Mr. H. Gorziglia, opened the Fifteenth Session of the IOC International Co-ordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) at 10.00 on 24 July 1995.

2 The Chairman welcomed the participants and pointed out that the tsunami programme of IOC is one of the most important as it is targeted to saving lives and property. The last years have seen an unusually apparent increase in the frequency of destructive tsunami events. Though all these tsunamis have been local in their effects and impact, the total death toll was almost 2,000 people, and the damage presented a figure in billions of dollars (Figure 1, Tables 1 and 2). The goal of the Group is to diminish the effects of this disaster, to identify and co-ordinate efforts of Member States in the Pacific in making people's lives safer.

3 The Chairman wished the participants every success and thanked the local organizers for the arrangements for the Session. He then invited the Representative of the French Government to welcome the participants.

4 Dr. R. Bagnis, in charge of the questions on research and technology for the French Minister of National Education, Higher Education, Research and Professional Training, and as the Representative of the High Commissioner of the French Republic in French Polynesia, acknowledged the importance of tsunami mitigation and warning for the population of French Polynesia.

5 He referred to the recommendation made in Paris at the Colloquium on the Environment in the South Pacific, relevant to the importance of the installation of monitoring networks on natural risks and warning systems adapted to each risk. He praised highly the international co-operative scientific efforts made by many states of the Pacific region under the auspices of IOC to improve knowledge on tsunami, to evaluate potentially tsunamigenic earthquakes and to monitor the tsunami warning activities.

6 A full text of the address is presented in Annex V.

7 Dr. I. Oliouline, the Technical Secretary of the Session, Senior Assistant Secretary IOC, thanked the Government of France and the local authorities for hosting the Meeting and providing excellent facilities. He emphasized the important input of the Laboratoire de Géophysique located in Papeete to the tsunami warning system and to ensuring the maximum preparedness of the population of the Pacific to face natural disasters and to mitigate their consequences. He reminded the participants that the system was established 30 years ago and that at this Session the Group will have an opportunity to summarize achievements, identify problems and formulate new tasks in order to respond effectively to the Recommendations of the IOC Governing Bodies and to the objectives of the International Decade on Natural Disaster Reduction (IDNDR). He expressed satisfaction and acknowledged all the continuous efforts put into the tsunami warning system by the IOC/ITSU Member States.

8 In closing his welcome address, Dr. Oliouline stressed that there is no country in the Pacific which can isolate itself from inevitable dangers and effects of tsunami and it is vitally important to concentrate efforts with a view to achieve an ultimate noble goal of saving people lives and property. He called on the participants to identify and raise the necessary resources without which there will be no effective tsunami warning system, no matter how high the need is for one.

9 Dr. I. Oliouline, on behalf of the Executive Secretary IOC, Dr. G. Kullenberg, wished all the participants a productive Session and a nice stay in Tahiti, washed by the sun of the South Pacific and by the hospitality of its local people.

10 The Chairman thanked the speakers and invited the Group to adopt the Provisional Agenda, as dated of 12 January 1995. The Group adopted the Agenda as presented in Annex I.

11 The Group accepted the proposal of Canada to designate Mr. W. Sites (USA) as Rapporteur of the Session.

MAIN TSUNAMIGENIC EARTHQUAKES SINCE 1992

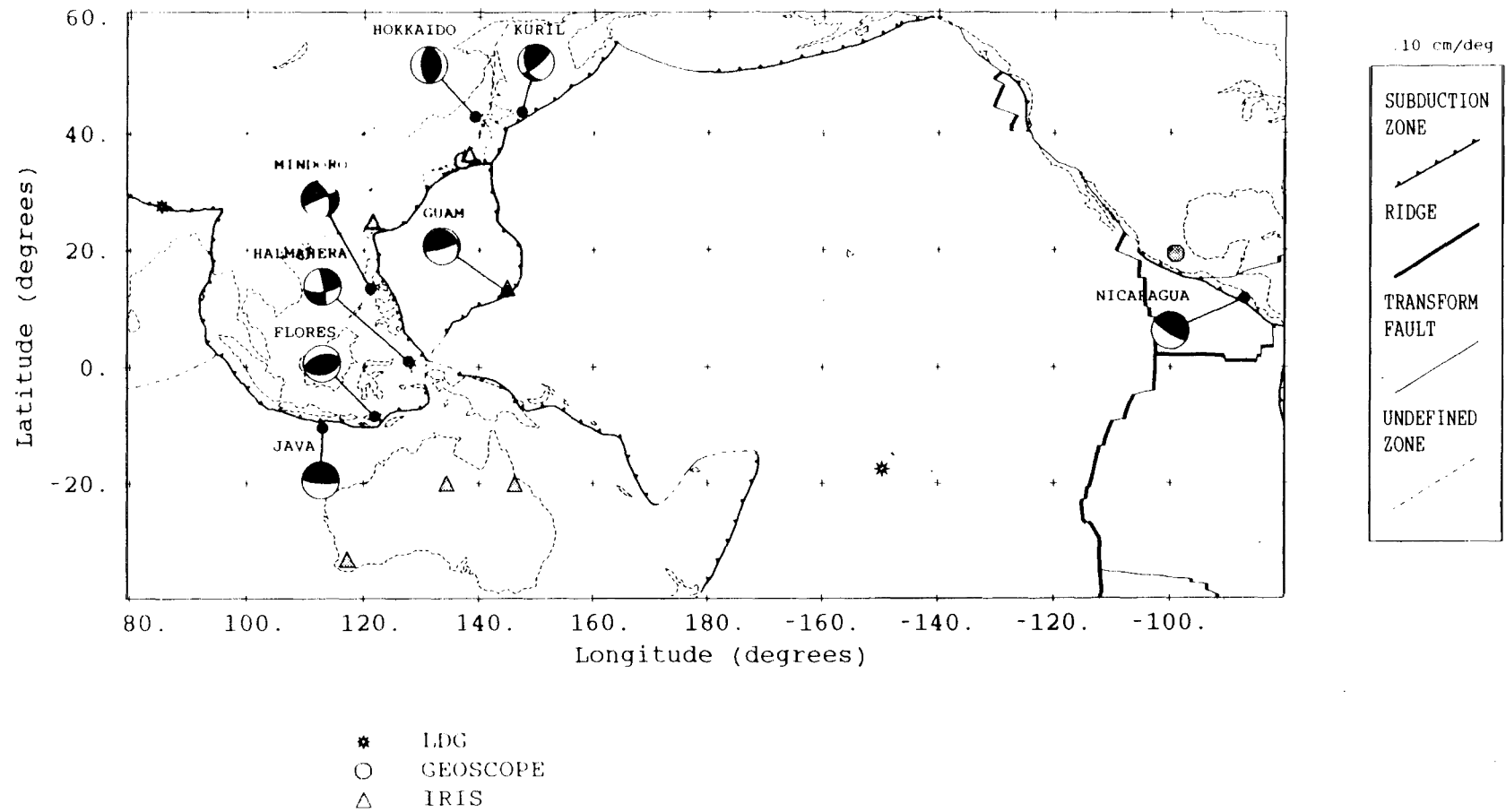


Table 1. Tsunamigenic Events - Intersessional Period September 1993. through July 1995

Date	Location	Time UTC	Epicenter		M,	M _w (Har- vard)	M _m (PTT Real- time)	Tsunami Type
			Lat.	Long.				
Nov. 13, 1993	East Kamchatka, Russia	0118Z	51.9N	158.6E	7.0	7.0	6.6	Very Small Local
Jan. 21, 1994	Halmahera, Indonesia	0224Z	01.0N	127.7E	7.2	7.0	6.9	Damaging Local
Apr. 08, 1994	East Honshu, Japan	0110Z	40.6N	143.7E	6.3	6.4	5.6	Small Local
Jun. 02, 1994	Java, Indonesia	1813Z	10.5S	112.8E	7.2	7.8	7.4	Damaging Regional *
Sep. 01, 1994	Northern California, USA	1516Z	40.4N	125.6E	7.0	7.0	6.7	Very Small Local
Oct. 04, 1994	Kuril Islands Region	1323Z	43.7N	147.3E	8.1	8.3	8.3	Pacific-wide, local damage
Oct. 08, 1994	Halmahera, Indonesia	2144Z	01.2S	128.0E	6.8	6.8	6.6	Damaging Local
Oct. 09, 1994	Kuril Islands Region	0756Z	43.9N	147.9E	7.0	7.3	7.1	Small Regional
Nov. 04, 1994	Skagway, Alaska, USA	0410Z	59.5N	135.3E	Non	seismic	event	Damaging Local Landslide
Nov. 14, 1994	Mindoro, Philippine Islands	1916Z	13.5N	121.1E	7.1	7.1	7.3	Damaging Local
Dec. 28, 1994	North Honshu, Japan	1219Z	40.5N	143.5E	7.5	7.7	7.5	Small Local
Jan. 16, 1995	West Honshu, Japan (Kobe)	2047Z	34.5N	135.0E	6.8	6.9	6.8	Subsidence Recorded by Tide Gauge
Apr. 07, 1995	Tonga Islands, Samoa	2207Z	15.2S	173.6W	8.0	7.5	7.0	Small Regional
Apr. 21, 1995	West Sama Is., Philippines	0010Z	12.0N	125.5E	7.0	6.9	6.5	Very Small Local
May 14, 1995	Timor, Indonesia	1133Z	08.5S	125.4W	6.9	6.9	6.9	Possible Damaging Local
May 16, 1995	Loyalty Islands Region	2013Z	22.9S	169.7E	7.7	7.7	7.4	Small Regional
May 27, 1995	Sakhalin Island, Russia	1304Z	52.5N	142.9E	7.6	7.0	6.7	Possible small Local

* Occurring near Java Island, Indonesia, this Indian Ocean tsunami caused extensive damage along the south coast of Java with lesser damage reported along the northwest coast of Australia.

Table 2. Destructive Tsunami 1992-19942

Date	Eq Mag (Ms)	Location	Run-up Height (m)	Tsunami Damage	Deaths
Sep. '92	7.2	Nicaragua	9.7	Extensive	170
Dec. '92	7.5	Indonesia	26.0	Extreme	1,000
Jul. '93	7.6	Japan Sea	19.7	1.5×10^9	330
Jun. '94	7.2	Indonesia	3.0	2.2×10^6	250
Oct. '94	8.1	Kuril Islands	9.0	Some	11
Oct. '94	6.8	Indonesia		Local	1
Nov. '94	Landslide	Alaska	10.0	21×10^6	1
Nov. '94	7.0	Philippines	10.0	25×10^6	62

12 The Technical Secretary introduced the documentation and the timetable of the Session. The Group adopted the working procedures and accepted the documentation with slight modifications as presented in the List of Documents reproduced in Annex IV. It was decided to make the necessary modifications to the timetable while the Session is progressing. The List of Participants is given in Annex HI.

13 **The Group noted with satisfaction** the good representation of the IOC/ITSU Member States and warmly welcomed a new Member of the Group: the Cook Islands. **The Group expressed regret** that due to different reasons New Zealand, the Philippines, Fiji and some other countries were not able to attend the Session.

14 Finally, the head of the local organizing Committee, Dr. F. Schindeleé, informed the participants of local arrangements.

2. GENERAL REVIEW OF INTERSESSIONAL ACTIVITIES, LESSONS LEARNED FROM RECENT TSUNAMI

15 The Chairman started the presentation of his report on intersessional activities (Document IOC/ITSU-XV/6) by expressing his thanks to all the colleagues who helped him with advice and contributed to the implementation of actions agreed upon at the previous Session of the Group.

16 He stated that the intercessional period was very productive and the contributions from Japan and the USA to the TIME project, from Russia to the development of the expert tsunami database for the Pacific, and from France to the wide. utilization of the TREMOR System were specially mentioned.

17 Efforts have been made to look for financial support of the programme from other than IOC international organizations, funding agencies and Member States. Some of these attempts were successful and additional resources were allocated to the IOC Trust Fund for different projects of the tsunami programme, such as TIME, training and publication activities.

18 The Chairman expressed satisfaction that in response to his address to national contacts to request their heads of delegations at the Eighteenth Session of the IOC Assembly in June 1995 to raise their voices in support of the programme, many delegates supported the programme and gave it a high priority among other IOC programmes.

19 The Assembly *"considered the programme as one of the most effective activities of the IOC providing practical results and expressed satisfaction of its successful implementation."* (Document SC/MD/106, para. 350).

20 **The Group expressed satisfaction** with the Chairman's efforts, accepted the report on the intersessional activities and requested the Technical Secretary to include the Action Sheet presented as

² From an article "NGDC monitors frequency of recent destructive tsunami events" by Mrs. P.A. Lockridge published in Earth System Monitor, Vol. 5, N° 4, June 1995.

Annex III to the ITSU Officers Meeting Summary Report (IOC/ITSU-Officers/3 of 10 April 1995) after the necessary modifications resulting from the deliberations of this Session as Annex VI to the ICG/ITSU Summary Report.

- 21 In response to the IOC Circular Letter N° 1445 of 8 February 1995, national reports on tsunami-related activities were received from Australia, Canada, Chile, Colombia, France, Japan, Korea (Republic of), Indonesia, Mexico, New Zealand, Russian Federation and USA. All these reports were made available to the participants (Document IOC/ITSU-XV/7) and additional comments-on national activities were provided by several countries.
- 22 The Delegate of Australia presented the project for the establishment of an improved Australian Tsunami Warning System (ATWS). The new system would extend tsunami warning coverage to Australia's coastline along the Indian Ocean and would augment the warning capabilities provided by PTWC to Australia's Pacific coasts. The Representative stated that the tsunami risk in Australia is perceived to be greater along the Indian Ocean Coast than along the Pacific Coast. Details of the project were distributed in a written report which is attached hereto as Annex VII. In addition, under the IDNDR programme, a compilation of the historical tsunami events in Australia is being carried out. Also, numerical modelling studies are in progress to assess tsunami inundation and impacts. Australia requested assistance obtaining tsunami travel time software so that travel time charts may be developed for the Indian Ocean.
- 23 **The Group strongly supported** the plans of Australia to improve and update a national tsunami warning system and agreed that if established, it will constitute an important component, not only of the Pacific wide system but also will create the basis for a tsunami warning system in the Indian Ocean.
- 24 Mr. R. Hagemeyer (USA) stated that the USA would gladly provide the tsunami travel time software to Australia. He noted that water-level (tide) data available to PTWC could also be distributed to Australia. The data would include the event-driven data provided by the National Ocean Service Next Generation Water-Level Measurement System (NGWLMS) gauges.
- 25 **The Group also recalled** that the Russian experts have developed software for the construction of the tsunami travel time charts which was used for the development of the tsunami travel time charts atlas. It was recommended to contact the Russian experts and discuss ways for acquiring the necessary software. The Technical Secretary was requested to provide Australia with all the information needed for establishing these contacts.
- 26 The Delegate of Chile reported that they were completing preparations for the implementation of the TREMORS capability in September 1995. He also informed of the plans to transfer the tsunami inundation modelling technology from CICESE, Mexico to Chile.
- 27 The Delegate of Colombia reported that a draft national tsunami education textbook was recently completed. He informed the Group that Colombia is giving much attention to the development of plans for resettlement of the population from the tsunami affected areas on a scientific basis and using a tsunami inundation zone modelling technique created under TIME by Prof. N. Shuto's Group. As a result of these studies, resettling families from the community of Tuamaco to higher ground outside of previous tsunami inundation zones have been started. Colombia is involved in a co-operative tsunami programme with Ecuador and they are preparing for the establishment of the TREMORS by 1996.
- 28 The Delegate of the Cook Islands requested the delegates to provide assistance in mitigating the tsunami hazard in his country. He was particularly interested in obtaining tide/water-level data from the Pacific basin.
- 29 **The Group requested** its Chairman and the representatives of France and Australia to help the Cook Islands in obtaining the necessary information and in providing advice on the infrastructure required for the establishment of a reliable and up-to-date system of seismic and sea-level measuring stations.
- 30 The Delegate of Japan noted that the Japan Meteorological Agency (JMA) completed installation of a network of 150 seismic stations in 1994. In March 1995, the computer processing system in Tokyo was replaced with a new one. As a result, the prompt issuance of information was achieved and the estimated arrival time of near-field tsunami was added as a new item into the revised tsunami information forms. He

also noted that the satellite-based information dissemination system was established to back up the possible functional disorder on the land line based communication system caused by natural disasters and to insure another route for prompt dissemination of tsunami forecast to local governmental authorities and terminal users. He then provided details on intersessional earthquake/tsunami events that impacted Japan recently. The Delegate noted that in order to cope with the tsunami hazards more adequately, a quantitative tsunami forecast for limited areas should be required. JMA initiated development of the quantitative tsunami forecast for practical use for prevention or mitigation of tsunami disaster. JMA expects that in 2 or 3 years, the new tsunami forecast procedure will become operational.

31 The Delegate of the Republic of Korea inquired if Japan's tsunami warnings could be disseminated to the Republic of Korea and other neighboring nations in real-time via the GMS communications system. Japan agreed to provide details to the Republic of Korea regarding the GMS coverage area (satellite footprint) and its warning dissemination capabilities.

32 The Delegate of the Republic of Korea expressed the opinion that Member States where earthquakes and tsunami occur should be responsible for disseminating relevant information as soon as possible to other Member States and the related organizations.

33 **The Group noted** that, as far as possible, Member States should disseminate warnings to neighbors directly and urgently, as well as to delivering them to PTWC for further distribution.

34 The Delegate of France provided details on the evolution of the TREMORS and its improvements during the intersessional period.

35 **The Group noted** with great interest that 7 TREMORS had been installed to date and 4 more are planned for 1996 (Figure 2). The TREMORS appears to offer a greater capability to identify tsunamigenic earthquakes than the traditional short and long period seismic instruments.

36 The Delegate of Indonesia briefly reviewed the major tsunami/earthquake events that impacted Indonesia during the intersessional period. He noted the planned establishment of two new seismic stations and an automatic data processing system by the end of 1995. The country is also pursuing the acquisition of the TREMORS.

37 He expressed the continued interest of his country in the establishment of a Southwest Pacific Tsunami Warning System and pointed out that tsunami generated in the Indian Ocean affect the Indonesian coasts in addition to those generated in the Pacific, and that plans exist to extend a national tsunami warning system to their Indian Ocean coastline.

38 The Delegate of Mexico reported that the Seismological Service of Mexico has set in operation 7 broad-band seismic stations including one on the coast of Oaxaca, and in Guerrero and Jalisco. The CICESE has 2 broad-band stations, one in Bahia de los Angeles and the other in La Paz, Baja California, SUR. The stations do not yet have the capability to process data in real-time. The data can be retrieved via telephone dial-up and processed manually at this point. Mexico is also working on expanding their tidal network.

39 **The Group welcomed** the efforts made by Mexico in the establishment of a national tsunami warning system and in the expansion of its seismic and tidal networks, development of automated data processing capabilities and improved warning dissemination techniques. **The Group requested** the Chairman ICG/ITSU to be responsive to the Mexican needs, taking into account that the tsunami warning system in Mexico may be beneficial not only to the Member States of the Pacific but also of the Caribbean Region.

40 The Delegate of Peru informed the Group that in his country important logistic and human efforts have been made, both to improve the national tsunami warning system, as well as to modernize the sea-level stations network (acquiring digital recording). The Peruvian Navy has started a strong and wide campaign to alert and educate the population about tsunami. Furthermore, the Directorate of Hydrography has acquired maps showing the inundation areas in the main national harbours.

41 The Delegate of Russia reviewed the Russian Tsunami Warning System, recent seismic and tsunami activity and performance of their service. He expressed concern that Russia recently has lost funding for several seismic and tidal stations. He noted that the data collected by the Russian submarine monitoring

system could be made available for application to monitor geophysical phenomena in real-time. The Member States were invited to pursue use of the system's capabilities.

42 **The Group invited** other Member States to investigate the possibilities of using these data for tsunami mitigation.

43 On behalf of the Delegate of the USA, Dr. E. Bernard reviewed the US National approach to tsunami hazard mitigation. He presented the plan which could be easily applicable to any natural hazard worldwide. The plan has 3 main components: warning guidance, response and hazard assessment (Figure 3).

44 Dr. Bernard remarked that the 3 responsible groups need to exchange information in order to develop an effective tsunami hazard mitigation plan. The plan will be most effective if all 3 elements work in harmony. Dr. Bernard emphasized that a method for measuring the tsunami wave directly is needed, as it has not proven effective enough to measure the tsunami wave indirectly through analysis of seismic and shore-based tide/water-level data. He described a way to measure tsunami directly. The method involves deep ocean tsunami measurement instruments, surface buoys to transmit the data to communication satellites and real-time distribution of the data to tsunami warning centers. A prototype system was presented that successfully measured tidal changes in real-time off the Washington coast in May 1995.

45 **The Group requested** Dr. Bernard to provide a summary of recommendations for the national tsunami hazard mitigation plan. These recommendations are included in Annex VIII of the Summary Report.

The Group expressed its gratitude to the Member States for their informative reports and **recommended** that each Member State provide abbreviated report summaries to ITIC by 1 October 1995, preferably via Internet e-mail or on computer diskettes, in any of the most commonly used PC word processor formats, for inclusion in the January 1996 issue of the ITIC Tsunami Newsletter.

3. IMPLEMENTATION OF ITSU-XIV DECISIONS

3.1 REAL-TIME EXCHANGE OF TELEMETRY, SEISMIC AND TSUNAMI DATA

46 The Chairman of the Task Team on Real-Time Telemetry, Seismic and Tsunami Data Exchange reported on the intersessional activities of various members of the team (Document IOC/ITSU-XV/8). The Task Team had no meetings during the intersessional period. However, individual members of the team accomplished a number of actions that contributed to improvements in real-time data exchange.

47 The Pacific Tsunami Warning Center (PTWC) installed new pressure transducer water-level instruments on Niue Island and at the existing station in Legaspi, Philippines. The US National Ocean Service (NOS) upgraded a number of their NGWLMS stations to be more responsive to tsunami signals, as well as to be more accessible to the warning system. Also, the Director PTWC participated in a tsunami workshop in Australia where he stressed the importance of having regional or national tsunami warning centers to augment the Pacific Warning Tsunami System (PTWS). Dr. T. Murty from the Australian Delegation noted that Japan has enabled Australia to relay data from a number of their water-level stations located on the Southwest Pacific islands through its GMS satellite.

48 Mr. M. Blackford noted that PTWC would continue to disseminate tsunami warnings to several nations in the Pacific who were not yet members of ITSU. The Representative of the Cook Islands noted that several South Pacific fora existed in which ITSU membership could be encouraged. He recommended the Summary Report be made available to Regional Committees and Organizations in the Pacific where some of the non-ITSU members are represented. These committees include the Tropical Cyclone Committee for the Southwest Pacific and Southeast Indian Ocean, and the South Pacific Regional Environmental Programme. The issue of warning dissemination should be highlighted in meetings of these groups to obtain feedback from ITSU members and especially non-members.

TREMORS Installed and programmes Stations

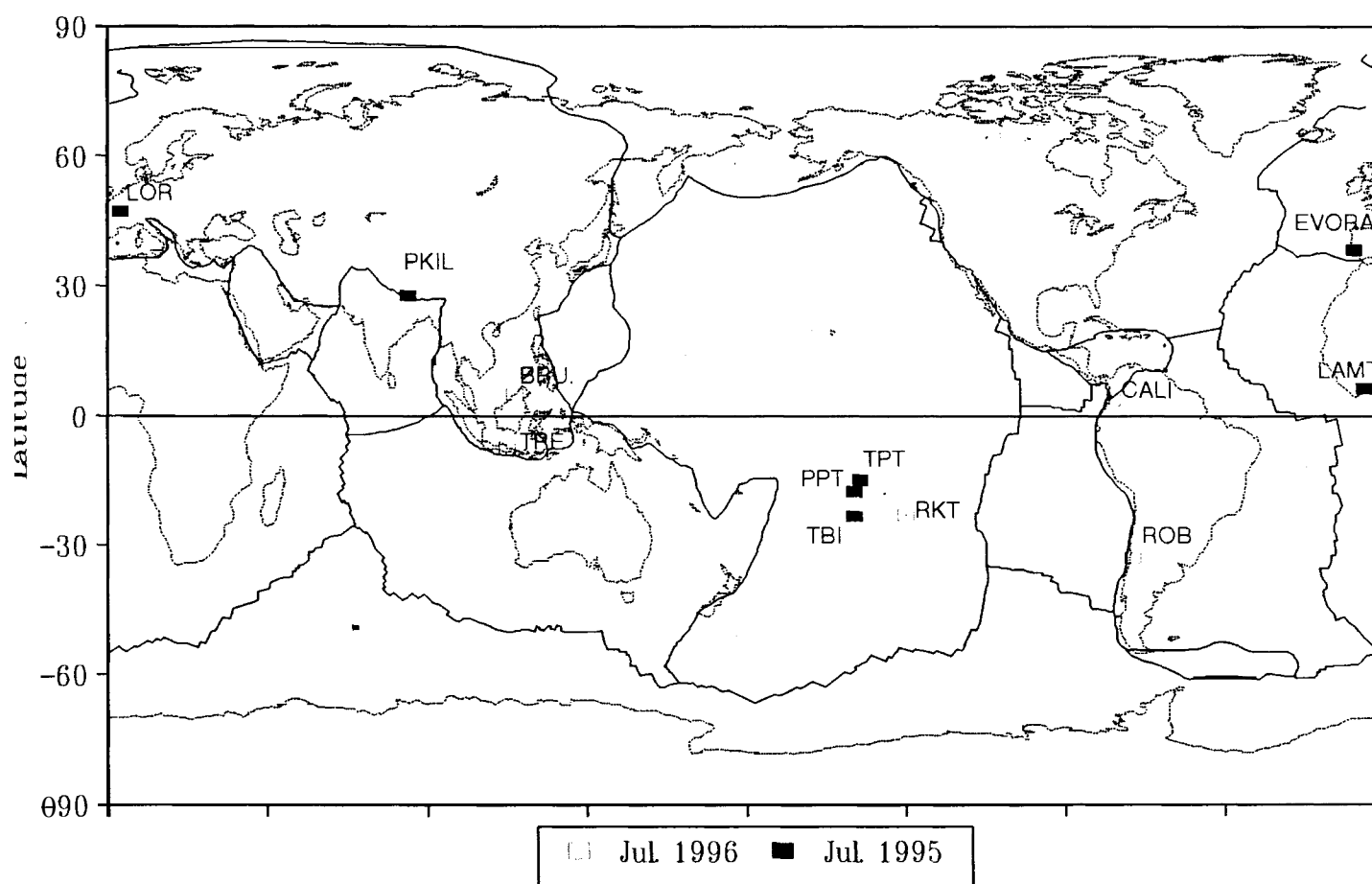


Figure 2

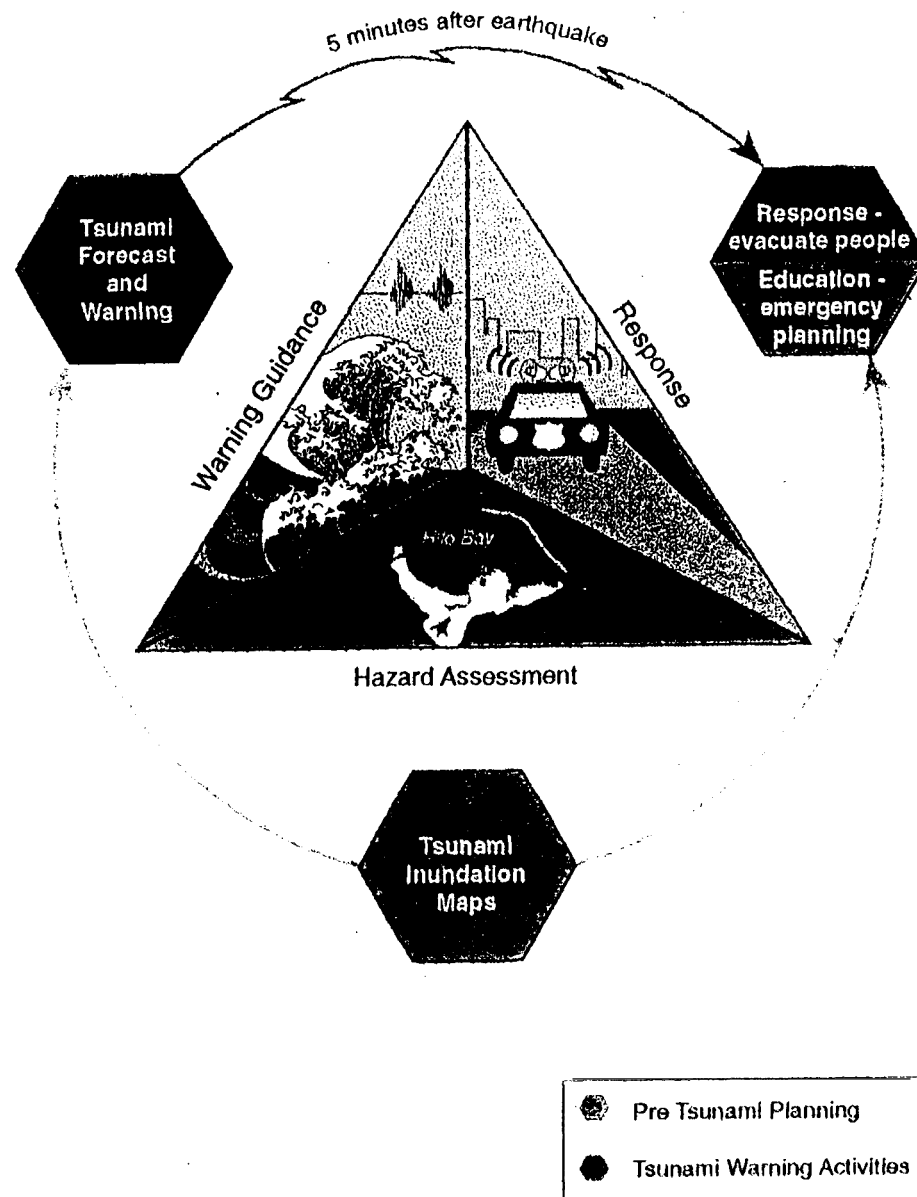


Figure 3

NOAA Tsunami Hazard Mitigation Plan. Each element requires the participation of NOAA, USGS, FEMA, and the states' emergency agencies and universities.

49 The Task Team met during ITSU-XV to discuss potential activities for the next intercessional period. In order to make progress toward having a complete tsunami and earthquake monitoring system in place by the end of the International Decade of Natural Hazard Reduction, the Task Team decided to conduct a survey of countries, dependencies and other political divisions of the Pacific affected by the Tsunami Warning System, to determine the extent of their existing tsunami and earthquake monitoring capabilities and to ascertain their existing procedures for dealing with local or regional tsunamigenic events. The Team shall conduct this survey during the next 6 months and distribute the results to the Member States. The purpose of this survey is to identify areas where work must be done to improve seismic and tsunami monitoring capabilities.

50 **The Group noted** the report with interest and **recommended** that the Task Team continue its work and that the Terms of Reference established at ITSU-XIV be maintained. The Team will work by correspondence and through off-line technical meetings during ITSU sessions. **The Group also recommended** that the ICG/ITSU Chairman conduct a survey to ascertain the status of plans for the establishment of national and regional tsunami warning systems.

3.2 TSUNAMI INUNDATION MODELLING EXCHANGE (TIME) PROJECT

51 Dr. E. Bernard, in his capacity as the Representative of the IUGG Tsunami Commission, presented the report on the TIME Project prepared by the Project Leader Prof. Shuto from Japan. The implementation of the project progressed successfully. Due to the generous contribution from IOC, a Manual of Numerical Simulation of Tsunamis was finalized and submitted to the Session for consideration (Document IOC/ITSU-XV/9 and 9 Add.), conditions for transfer of the TUNAMI code formulated. A few numerical models have been transferred free of charge to leading institutions involved in the tsunami mitigation and research, and the description of the characteristics of a work station and peripherals necessary for tsunami simulation and computer graphics animation have been drafted and distributed. Plans are now in progress to provide training for two experts from the Pacific Region in numerical tsunami modelling under the TIME Project.

52 **The Group appreciated** highly the efforts of Prof. Shuto and his group in the project implementation and **expressed** thanks to the USA, Japan and the IOC for the financial support to the project. **The Group strongly recommended** continuation of this important activity and, after noting that available funds will be exhausted by the middle of 1996, **requested** Member States to seek funds to support the project.

53 **The Group noted** that Japan and Chile, jointly with Mexico, plan training courses on TIME for 1996 (see agenda item 10) and **recommended** that support for the courses should be sought, not only from IOC, but from other international organizations and funding agencies, such as JICA. **The Group requested** the Chairman to co-ordinate these efforts and provide endorsements to requests. **The Group noted** that it would be of utmost importance to have the TIME Manual widely available and **recommended** that the IOC publish this Manual in the IOC Manuals and Guides Series.

3.3 EXPERT TSUNAMI DATABASE FOR THE PACIFIC

54 **The Group considered** the report on the Expert Tsunami Database (ETDB) Project (Document IOC/ITSU-XV/10) presented by Dr. V. Gusiakov and **concurred** that the work has been done in accordance with the technical specifications of the project.

55 The ETDB area consists of broad Pacific-wide coverage, as well as regional levels, and contains condensed data from about 720 historical tsunami events that have occurred in the Pacific Basin from 684 AD to 1994. However, these data constitute only a small percent of all tsunami-related data in the Pacific. On the regional level, the full dataset is now available only for the Kuril-Kamchatka region, but data from other regions can be easily included in the ETDB, provided that interested regional or national agencies co-operate with the Novosibirsk Computing Center in data collection and preparation.

56 **The Group urged** the Executive Secretary IOC to find possibilities for additional funding of the ETDB project in the direction of further data collection and refinement on both Pacific-wide and regional levels and the development of an interface with the World Data Centre-A for Solid Earth Geophysics.

57 **The Group also requested** all Member States to develop and maintain the national tsunami data catalogues updated, and keep the ITIC Director and the IOC Secretariat informed of the progress. This will

be very helpful, not only for different ICG/ITSU projects, but also to the WDC-A for Solid Earth Geophysics which possesses the largest data bank of historical tsunami data now available on CD-ROM.

3.4 TSUNAMI COMMUNICATION NETWORKS - STATUS AND WAYS OF IMPROVEMENT

58 The Acting Director ITIC presented a summary report on the existing communications networks used for dissemination of tsunami warnings, watch and information bulletins (Document IOC/ITSU-XV/11). His discussion included mention of internationally certified communications systems, educational systems, those of the private sector and brief mention of some nationalized networks.

59 For the most part, the TWS uses internationally certified systems like those of the WMO's Global Telecommunications System and the International Aeronautical System. He made special emphasis of the general availability, low cost and capability of these systems to send messages to many users at one time. However, it was noted that these systems depend on intermediate relay points that, on occasion, have not performed to expectation.

60 A detailed report on the Inmarsat-C system using global satellites and moderate-cost receivers was presented and discussed. Although the Inmarsat system is highly reliable and widely available, it can be expensive to send a typical tsunami warning bulletin to a single user. However, using the data reporting channel capability of this system, the cost per message can be reduced dramatically but there are strict limitations on message length.

61 **The Group was advised**, based on the overall cost considerations of Inmarsat-C, that every effort to exploit and utilize low-cost systems already in place should be pursued. Representatives from Canada, France and the USA expressed a knowledge of promising new and less-expensive satellite communications systems with world-wide coverage that should be available for commercial use in the near future. **The Group agreed** that an *ad hoc* Working Group, headed by the Director ITIC, with members from Australia, Canada, France, and Russia, continue to stay abreast of developing communication technologies during the intersessional period and report on such activities during the next session of the ICG/ITSU. Although the present time is too early, these forthcoming systems may provide the technology to dramatically improve (with little or no extra cost) the overall performance of warning message dissemination to the Member States. **The Group noted with interest** information of the Russian-USA discussions on the usage of space vehicles for natural disaster mitigation and **requested** to be informed of the progress.

62 The Delegate of the USA reported on his activities during the intersessional period in attempting to improve communications between the PTWC and the appropriate organizations in Pyongyang, Democratic People's Republic of Korea and Beijing, People's Republic of China. It had previously been determined that the PTWC messages were reaching Pyongyang, however, their receipt has not been acknowledged. The US Permanent Representative of the WMO had written to his counterpart in the People's Republic of China asking for his assistance in resolving the problem. Contacts between the USA and China were also held at the 1995 WMO Congress. Recent correspondence from the China Meteorological Administration (CMA) indicated that successful communications have been established between the CMA and the US National Oceanic and Atmospheric Administration. The USA is attempting to arrange for an "end-to-end" test of the relay per message from PTWC to Beijing and return.

63 The Delegate of Russian Federation confirmed communications problems with the Russian Far East Tsunami Center using the GTS. The other members of the Group reported that they were generally pleased using the capabilities of the existing communications networks. The Associate Director ITIC proposed, and **the Group agreed**, that ITIC should contact the other ITSU Member States, not present at the Session, to solicit their comments on the capabilities and response time of existing communication networks that support the TWS. The *ad hoc* Working Group, previously mentioned, will report on these survey results at the next Session of ICG/ITSU.

64 The Delegate of Japan made special mention of the tsunami warning message dissemination capability available on the Japanese GMS satellite. The Delegate from the Republic of Korea expressed interest in obtaining the receiver hardware that would allow receipt of these messages in the Republic of Korea. Similar interest in this capability was expressed by the Delegate of Russia.

65 The Director of the Pacific Tsunami Warning Center reported briefly that a preliminary draft of a new edition of the Communications Plan (CommPlan) of the Tsunami Warning System has been completed and that the final version will be published and distributed to members and others before the end of 1995.

66 The Director also presented a short summary of the current status of message dissemination based on information in the CommPlan and on a listing of countries, dependencies, and other political entities affected by the Tsunami Warning System (Table 3). He noted that 9 of the 40 entities listed in the CommPlan as receiving PTWC messages are not members of ITSU. He further noted that 3 countries, Costa Rica, Singapore and Thailand, who are ITSU members, do not receive messages. Finally, he noted that 6 other entities in the Pacific, not listed in the CommPlan, do not receive messages.

67 **The Group was of a strong opinion** that all potential entities of the Pacific, regardless whether they are members or non-members of the ICG/ITSU, should receive tsunami warnings and requested the Director PTWC to ensure that this is accomplished.

4. ITIC ACTIVITIES

68 Mr. D. Sigrist, Acting Director ITIC, provided his report on ITIC'S intercessional activities, highlighting the important accomplishments that are discussed in detail (Document IOC/ITSU-XV/12). He made special mention of the continued high level of tsunami activity that during the last intercessional period has claimed numerous lives and/or has caused significant property damage in Indonesia (1994 -3 damaging tsunami), Japan (1994), Russia (1994), USA (1994) and the Philippines (1994). Many other tsunami, although not damaging, were reported during the period that provided invaluable data for the tsunami research community. **The Group was saddened** by the devastating earthquakes (although not tsunamigenic) that occurred in Kobe, Japan (1995) and Sakhalin, Russia (1995) that claimed thousands of lives. The summary is presented in the Tables 1 and 2 and Figures given above under Agenda Item 1. Detailed information on devastating tsunami and earthquakes, as well as results from post-disaster filed surveys of the affected areas are reported on a timely basis in the ITIC Tsunami Newsletter. Mr. Sigrist reported that the Tsunami Newsletter continues to be published semi-annually and is distributed to some 800 subscribers world-wide.

69 Of interest to the Group, the Acting Director reported on ITIC's continuing involvement in tsunami education activities. During the intersessional period, ITIC prepared and published a supplemental guidebook on tsunami for teachers, a revised edition of the booklet, '*Tsunami - the Great Waves*', and with financial support from the IOC, an updated version of the ITIC Brochure in English, Spanish and French. The ITIC-developed poster on the 1993 Hokkaido (Japan) tsunami and subsequent survey was shown along with tsunami education materials at the IDNDR Conference in Yokohama, Japan. ITIC actively maintained liaison activities with the Member States using the electronic Tsunami Bulletin Board, routine correspondence and fax, and arranging individual member visits to ITIC and PTWC by taking advantage of their travels through Honolulu. The ITIC Visiting Experts Programme, discussed in detail further on in this Summary Report (under Agenda Item 10.2), was recognized as a resounding success for the two scientists that trained at ITIC for a 4-week period in November 1994. Detailed instruction and information about the Pacific and national tsunami warning systems, tsunami education and research activities and the importance of historical tsunami data were covered.

70 **The Group was advised** that ITIC provided the necessary Member States co-ordination amongst the Philippines, Japan and the USA that culminated in the enhancement of the existing TWS tide gauge at Legaspi, Philippines, with a satellite telemetry capability in April 1995. Working with Inmarsat communication providers, ITIC collected pertinent information on the Inmarsat-C satellite-based communications system that could help improve tsunami warning message distribution to the Member States. **The Group noted with interest** the Acting Director's discussion of the Tsunami Bulletin Board system and the enhanced capabilities (for distributing information) using a tsunami Homepage on the World Wide Web.

Table 3. Countries, Dependencies, and other Political Divisions of the Pacific affected by the Tsunami Warning System

Entities currently listed in the CommPlan that are supposed to receive PTWC warning/watch and information messages:

America, United States of
American Samoa (USA)
Australia
*Belau
Canada
Chile
China, Peoples Republic of
China, Taiwan
Colombia
Cook Islands
Ecuador
*El Salvador
Fiji
French Polynesia (France)
Guam (USA) ‘ ‘
Guatemala
Hong Kong (United Kingdom)
Indonesia
Japan
Johnston Atoll (USA)
Korea, Democratic Peoples Republic of
Korea, Republic of
Kwajalein (USA)
*Marshall Islands, Republic of the
Mexico
*Micronesia, Federated States of
*Nauru
New Caledonia (France)

New Zealand
Nicaragua
*Niue
*Northern Marianas Is., Commonwealth of
*Papua New Guinea
Peru
Philippines, Republic of the
*Pitcairn Island (United Kingdom)
Russian Federation (CIS)
*Tuvalu
Wake (USA)
Western Samoa

Members of ITSU that are not listed in the CommPlan and apparently do not receive PTWC messages:

Costa Rica
Singapore
Thailand

Other entities in the Pacific that are not listed in the CommPlan and do not receive PTWC messages:

*Kiribati
*Solomon Islands
Tokelau (New Zealand)
*Tonga
*Vanuatu
Wallis and Futuna (France)

* Non-Member States of ICG/ITSU

71 The Acting Director ITIC was pleased to mention to the Group that Mr. S. Farreras, ITIC's new Associate Director, reported to Honolulu in late April 1995 for a one-year posting in the position. The Group acknowledged the secondment of Mr. Farreras and thanked Mexico, as well as IOC, for providing supplemental living expenses. Although Mr. Farreras has been posted at ITIC for only a short time, he has already made significant contributions (such as the document on standardizing tsunami survey measurements and as co-Editor of the July 1995 Tsunami Newsletter) to the ITIC mission which **the Group recognized** with appreciation. The Technical Secretary invited Member States to consider locating a follow-up Associate Director prior to the end of the incumbent's term in April 1996. Mr. Farreras suggested that the Associate Director need not be physically present in Honolulu and could actually perform the duties in his regular place of work (in his own country) using the capabilities of electronic communications such as the Internet, fax, tele-conferencing, and with regular spaced travel when personal working visits are required at ITIC. This concept is similar to the positions of ICG/ITSU Chairman and Vice-Chairman who hold their respective posts but continue to work in their home countries. **The Group agreed** that this option is attractive and may help secure a follow-up Associate Director in a timely manner. The **Group requested** the Chairman, the ITIC Director and the Technical Secretary to further explore this option. Furthermore, **it was the opinion of the Group** that the workload and the continued responsibilities imposed on the ITIC require both adequate financial and personnel support.

72 The Delegate from the USA noted that the Acting Director ITIC is leaving the position at the end of August 1995 as part of a career move to the US mainland and that the ITIC Director-designate, Dr. C. McCreery, has been selected and will be recommended to the Executive Secretary IOC for approval. The Group acknowledged with great appreciation the accomplishments of the Acting Director, Mr. Sigrist, since his posting to ITIC in July 1993.

4.1 STANDARDS FOR SURVEY MEASUREMENTS OF TSUNAMI RUN-UP AND DAMAGE

73 In response to the decisions of ITSU-XIV, the ITIC Associate Director presented Document IOC/ITSU-XV/13 rev. prepared by the *ad hoc* Working Group which contained recommended guidelines to establish tsunami field survey teams, procedures to conduct the field investigations and identified simple and efficient field survey equipment. The document also included some recommendations from the July 1995 Estes Park (USA) Tsunami Measurements Workshop, as well as components for a post-tsunami eyewitness interview questionnaire. The results of the study are presented in Annex IX.

74 **The Group discussed and agreed** that international survey teams should be organized and dispatched as quickly as possible, if an invitation from the host country affected by a tsunami is extended.

75 **The Group recommended** that the Executive Secretary IOC allocate necessary funds in the IOC budget for emergency operations immediately after the occurrence of tsunamis. The IOC Member States were invited to give the names of the candidates which have the merit to qualify for a survey of an international team, and invited the IOC Member States to consider financial support using extra-budgetary mechanisms of funding (e.g., the IOC Trust Fund).

76 **The Group noted** that the ICG/ITSU National Contact of the country to be surveyed should be made available through a real-time accessible address to arrange in advance on the procedures to allow access to the affected area, set the procedures to expedite the survey and co-ordinate the main aspects of the survey.

77 **The Group expressed** thanks to the members of the *ad hoc* Working Group and **recommended** that this item continue to be pursued by the development and completion during the intersessional period, of a draft of a Field Guide for Post-Tsunami Surveys, to be presented for discussion at ITSU-XVI.

78 **The Group recommended** Mr. Farreras, the present Associate Director ITIC, to chair the *ad hoc* Working Group which will include experts from Australia, Canada, Colombia and Mexico.

5. THE WORLD CONFERENCE ON NATURAL DISASTER REDUCTION - FOLLOW-UP ACTIONS REQUIRED FROM ICG/ITSU

79 The Technical Secretary informed the Group of the contribution made by IOC to the IDNDR objectives and to the implementation of the Yokohama World Conference on Natural Disaster Reduction which took place from 23 to 27 May 1994.

80 **The Group recalled** that since its establishment, IOC is engaged in the assessment and mitigation of risks arising from natural hazards, such as tsunami, storm-surges, sea-level changes and harmful algal blooms. The purpose of IOC in these fields is to set up reliable early warning systems, to protect people's lives and property, to enhance preparedness and public awareness through education and training, communication and information, and to foster post-disaster investigation.

81 The World Conference undertook a 5-year review of the progress made by Member States and organizations in meeting the Decade's objectives. The Conference was attended by over 2,000 individuals representing almost 150 countries and different international organizations. During the week-long course of the meeting, poster sessions and exhibits provided an in-depth view at a broad range of research projects, technology and policy implementation.

82 The ICG/ITSU was well represented at the Conference: a presentation on the Pacific Tsunami Warning System was made by a Chilean expert at one of the Technical Committees, two informative posters were displayed by experts from Mexico and Japan on national tsunami vulnerability reduction activities; a week-long exhibition and video films demonstration was conducted depicting the Group's activities in tsunami mitigation.

83 The Technical Secretary then presented to the Group the main findings of the Conference, such as the Yokohama Message and Yokohama Strategy and Plan of Action and called on the delegates to express their views on possible follow-up actions.

84 **The Group emphasized** that the Yokohama Plan of Action and main Conference decisions provide an opportunity to move ahead with implementation of many ICCJ/ITSU activities such as the establishment of regional warning systems, enhanced education programmes, inundation mapping for developing countries, establishment of databases and other priorities, which have been identified in the past and at the present Session.

85 **The Group supported** the view of the Conference that disaster prevention and preparedness are of a primary importance in reducing the need for disaster relief. The **Group noted with satisfaction** the recommendation that disaster prevention and preparedness should be considered as integral aspects of development policy and planning, at national, regional, bilateral, multi-lateral and international levels, and called on the ITSU National Contacts to bring this principle to the attention of national authorities and use it widely in the tsunami preparedness exercises.

86 **The Group recognized** that the United Nations has set aside the second Wednesday of October each year for the International Day for Natural Disaster Reduction (IDNDR Day) and **recommended** that the ICG/ITSU Member States should contribute to its objectives and to the 1995 theme '*Women and Children-Key to Prevention*', through organizing lectures in schools, distribution of textbooks and children's cartoon-books on tsunami developed by the ICG/ITSU, circulating information through local media on the effects of tsunami and measures to be taken for saving lives and property.

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87 **The Group requested** Member States to keep the IOC and IDNDR Secretariats (address of the IDNDR Secretariats is given below) informed on all actions taken by them for celebrating IDNDR Day.

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IDNDR Secretariat
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6. **RESULTS OF THE IT SU MASTER PLAN REVISION AND PLANS FOR FUTURE ACTIONS**

88 The ITIC Acting Director reported to the Group on the results of the ITSU Master Plan Revision (Document IOC/ITSU-XV/14). He acknowledged with appreciation the support provided by the members of the Task Team, representatives of France and Mexico, in implementing this task. The conclusion of the revision was that since 1987, when the Master Plan was first published technological innovations such as enhanced communication networks, improved seismic analysis techniques and low-cost, high-power desktop computers have added greatly to the expectation that improvements recommended in the Plan can be realized for the benefit of the Member States. However, it was recognized that the Plan continues to be a useful, living document that can be modified and revised to capture benefits associated with technological improvements, undiscovered funding opportunities and collaboration amongst the Member States.

89 **The Group agreed** that the Master Plan requires thorough review and a subsequent re-write, and adopted Recommendation ITSU-XV.1.

7. **ESTABLISHMENT OF NEW REGIONAL TSUNAMI WARNING SYSTEMS**

7.1 PACIFIC

90 The Chairman ICG/ITSU informed the Group of the efforts made to seek support to the Tsunami Warning System in the South Pacific Project which is in the pipeline of the UNDP projects since 1989. In response to the request of the Fourteenth Session of the Group, Indonesia, Papua-New Guinea and the Philippines have formally supported the project through UNDP Resident Representatives. The tsunami which occurred and damaged these countries during the last two years demonstrated a need for launching the project without delay. PTWC is not in a position to issue and deliver warning messages quickly enough to prevent losses when local tsunami occur. Regional systems may help to diminish the effects of disasters.

91 The Chairman then referred to the decision of the Eighteenth Session of the IOC Assembly (June 1995) relevant to the issue. The Assembly requested that efforts in starting the project should continue, the project be updated, interest of Member States in the project be reiterated and other sources of financial support, rather than UNDP, should be investigated.

92 The Delegate of France and the Technical Secretary informed the Group of the plans to approach the European Community Humanitarian Office (ECHO) of the European Commission in order to find out their interest in supporting the project. The Delegate of France expressed his readiness to update the project by the middle of September 1995.

93 **The Group expressed** thanks to France for offering assistance and **requested** the Technical Secretary to keep the Member States informed of the developments. **The Group also requested** its Chairman to continue efforts in gaining support from the UNDP and other funding agencies.

94 The Delegate of Mexico, Mr. M. Martinez, informed the Group of the efforts being made to implement a regional tsunami warning system for Central America. The CICESE Research Center in

Ensenada is installing two broadband seismic stations around the Gulf of California to monitor earthquakes. Each station is equipped with 3 component long-period seismometers and 3 component accelerometers. These stations will become part of a national network of broadband stations installed by the National Seismological Service of Mexico. Real-time transmission via satellite will be considered in the near future. He also advised the Group that Mexico will soon be in the position to offer numerical modelling of inundation technology transfer for other countries in the region. He expressed the view that these developments will help the nations of Central America to develop a regional tsunami warning system. He requested the help of Colombia in contacting the Member States of Central and South America for advertising the idea of a regional warning system and in identifying their interest to participate in the system. His request was welcomed by the Delegate of Colombia who offered to contact Ecuador and have their interest to be involved in the project.

95 **The Group expressed** its appreciation for the efforts made by Mexico in the pursue of this item and **encouraged** Member States of the region to continue activities targeted to the establishment of the regional tsunami warning system.

96 **The Group received** the comments of the Delegate of Japan relative to the proposal made by the Delegate of the Republic of Korea at ITSU-XIV, regarding the establishment of a Far East Tsunami Warning Centre and its possible location at the Japan Meteorological Agency. There were a number of concerns open for discussion: the area of responsibility of the Centre, communications for warnings and the need for additional seismic and tidal data which would be required to support the operations of the Centre.

97 Considering that the establishment of the Centre could benefit not only Japan but also other interested Member States, **the Group encouraged** Japan to continue considering the possibility of establishing and hosting the Far East Tsunami Centre and to further improve the quality of information disseminated through the GTS.

7.2 EUROPE

98 The Delegate of France speaking on behalf of the Co-ordinator of the CEC Project on Genesis and Impact of Tsunamis on European Coasts (GITEC) made a presentation on the history of the European tsunami which are classified amongst the largest and the most disastrous ever observed in the world. Tsunami in Europe affected the shores of Greece, Italy, Portugal, Spain and countries of northern Africa. The development of modern research on tsunami in Europe started about 35 years ago and its promoting element was a large tsunamis involving the entire Aegean sea in 1956. In 1988, in Italy, the first scientific meeting specifically devoted to tsunami was held in the framework of the 13th General Assembly of the European Geophysical Society. The interest on tsunami has been materialized in an international European Project - GITEC, that is being financed by the European Community. Dr. Y. Caristan then described to the Group the main objectives and topics of the project which include: tsunami generation, tsunami potential, tsunami propagation and end-effects and tsunami warning and risk mitigation. He stressed that the motivation for launching the project was the mature awareness that the tsunami in Europe deserve special attention today and that the main present concern is the prevention of a future disaster.

99 **The Group concurred** with the view that the time is ripe to consolidate the co-operation between the European experts and those working in the Pacific. **The Group decided** that this can be achieved by exchanging regularly, information on the activities, by undertaking common projects and by providing stable links for exchanging experiences.

100 **The Group recommended** that the ICG/ITSU and ITIC will establish a more robust and close relationship among researchers from Europe and the Pacific nations.

101 **The Group encouraged** the Chairman ICG/ITSU and the Executive Secretary IOC to explore the ways of co-operation in transferring know-how and in helping European countries in establishing the regional tsunami warning system by sharing knowledge and experience.

7.3 OTHER REGIONS

102 **The Group considered** the potential possibility of establishing regional warning systems in the Indian Ocean and Caribbean Basin. It was noted that both geographical areas are affected by tsunami and there

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will be a need to provide advice and assistance to the Member States of the regions in establishing the systems and increasing awareness of population in tsunami dangers.

103 **The Group noted and welcomed** the actions taken by Australia and Indonesia in this regard and requested the Director ITIC to keep contact with the representatives of these countries and investigate possible ways of assistance.

104 Mr. J. Lander informed the Group of the plans to have an International Conference on Hazards in the Caribbean from 9-12 October 1996, in Kingston, Jamaica, where tsunami mitigation will be one of the topics for discussion. The Group agreed that the Conference might be a good opportunity to make the people of the Caribbean aware of the tsunami danger and investigate, with the representatives of countries from the region, possible ways of co-operation. Noting that this area is very poorly covered by historical data, the Group recommended to use the Conference for acquiring data from the region and invited the representatives of Mexico and Colombia to help in this activity.

8. CO-OPERATION WITH OTHER INTERNATIONAL BODIES IN TSUNAMI MITIGATION

105 Dr. E. Bernard (USA), past Chairman of the IUGG Tsunami Commission, reported on the Commission's activities for the past two years. They included the publication of a book entitled, '*Tsunami: Progress in Prediction, Disaster Prevention and Warning*', of selected papers from the Wakayama Tsunami Symposium edited by Prof. N. Shuto and Y. Tsuchiya. Another book is scheduled to be published in 1996 containing selected papers from the Seventeenth IUGG Tsunami Symposium held in Boulder, Colorado, USA from 3-4 July 1995.

106 The Seventeenth International Tsunami Symposium was held in conjunction with the IUGG General Assembly. Sixty-seven papers were presented by 55 tsunami scientists orally or in a poster form. New developments in run-up modelling were reported. New data sets were collected from the tsunami in Fiji, Russia, Indonesia and the Philippines. The 4 October 1994 Shikotan tsunamis was recorded at over 100 tide gauges throughout the Pacific, including 4 deep-ocean gauges.

107 Several papers were concerned with warning improvements. Prof. Shuto reported on the "*sounds of tsunami*" as they are breaking on Japan's coastline. Another Japanese paper dealt with the effectiveness of underwater barriers in reducing tsunami impacts. Dr. Gonzalez from the USA reported on a prototype, real-time, deep-ocean tsunami detection system that holds promise for improving tsunami forecasts.

108 Dr. E. Bernard informed the Group that new officers of the IUGG Tsunami Commission were elected at the business meeting including: Chair - V. Gusiakov (Russia), Vice-Chair - S. Tinti (Italy) and Y. Tsuji (Japan) and Secretary - J. Lander (USA). The Commission recommended the maintenance of strong affiliations with IOC ICG/ITSU.

109 **The Group recognized** the great value of co-operation with the IUGG Tsunami Commission and other international bodies dealing with the tsunami problem. **The Group reiterated** its interest to see, as far as possible, the IUGG Tsunami Symposiums collocated with ICG/ITSU Workshops and Sessions.

110 **The Group applauded** Dr. Bernard's efforts in fostering co-operation between the IUGG Tsunami Commission and ICG/ITSU during his 8-year term as Chairman and **expressed** hope that his knowledge will continue contributing to the implementation of the tsunami programme.

111 Mr. J. Lander provided a briefing on the International Tsunami Measurements Workshop held in Estes Park, Colorado, USA, June 28-30/1995 (Document IOC/ITSU-XV/19). The Workshop was attended by 45 tsunami scientists from 10 Nations. He thanked the IOC, the National Science Foundation, and the National Geophysical Data Center for their support. Publication of the Workshop proceedings is planned for the end of 1995. Mr. Lander then outlined the 4 main topics discussed: international tsunami disaster surveys, instrumentation, modelling and mitigation. He noted that there were a number of Workshop recommendations relevant to ITSU and ITIC, including: co-ordinating disaster surveys, developing a field survey guide, using models for real-time wave height forecasting, training (TIME Project) and providing continued support for further development of the expert tsunami database.

112 **The Group noted** with satisfaction that some of these recommendations have already been discussed under previous agenda items and received deep consideration and positive responses. **The Group recommended** to continue efforts in implementing them during the intercessional period. The recommendations were included in the Summary Report as Annex X.

113 **The Group noted** that though numerous international meetings are planned for the next year where the tsunami issue is in the Agenda, there were only a few fully devoted to consideration of tsunami. In this regard, **the Group welcomed** the kind invitation from Russia to have a joint 10 C-Russian Academy of Sciences Workshop on Tsunami Hazard Mitigation in August 1996 in Russia and **adopted** Recommendation ITSU-XV.2.

9. **DISSEMINATION OF INFORMATION**

9.1 E-MAIL AND ELECTRONIC BULLETIN BOARDS

114 The Acting Director ITIC, Mr. D. Sigrist, presented a report on the status of the electronic Tsunami Bulletin Board (TBB) system that was developed in 1992 by the USA NOAA/PMEL and operated since that time as an experimental e-mail notification system for the international tsunami community (Document IOC/ITSU-XV/15).

115 It was noted that the utility of this system has been proven, and that the time has come for ITIC to assume responsibility for the continued operation and maintenance of the TBB. Mr. Sigrist was careful to note that the TBB system requires a robust connection to the Internet, as well as a computer (server) workstation. Neither of these capabilities exist at ITIC presently. The Representative of the USA remarked that ITIC will have greatly improved access to the Internet when it moves (along with the office of the Pacific Region of the National Weather Service) to a new location in September 1995. It was further noted however that, though the USA provides substantial financial and in-kind support to ITIC, no extra funds will be available to support the purchase of a computer workstation for ITIC.

116 **The Group recommended** that the request for financial support for the purchase of the computer workstation be included in the Programme of Work and Priorities for 1996-1997.

117 Mr. Sigrist provided additional information on the proposed enhancements to the TBB that will include a World Wide Web home page with access to a broad range of tsunami information at ITIC and other WWW sites already available or under development by other users in the tsunami community. Connectivity to other W sites that are maintained by Member States should be established. He reported on a prototype home page that was developed by researchers at the University of Washington (USA) that will be modified and turned over to ITIC for continued upkeep and operation (Annex XI).

118 **The Group agreed** that this is an important activity which should be pursued actively by ITIC and supported. **The Group adopted** Recommendation ITSU-XV.3.

9.2 HISTORICAL TSUNAMI DATABASE

119 The Acting Director ITIC reported on the status of the historical tsunami database and the database format. He indicated there has been limited work on actual maintenance of the database (adding new records on recent tsunami) due to lack of financial and staff resources. He also noted that the existing database format should be modified and does not contain fields that include important seismic parameters not available when the database was originally configured.

120 The Delegate from France, Dr. Schinde1é, indicated that the database should at least include such important information as seismic moment, moment magnitude, and other seismic source parameters.

121 The Delegate from the USA noted that the tsunami database maintained at the World Data Center A for Solid Earth Geophysics in Boulder, Colorado, on a regular basis is probably the most complete Pacific-wide tsunami dataset. However, historical tsunami databases located and maintained by other Member States in total, comprise a much larger dataset. However, these data are distributed amongst many sites and are in different formats.

122 The Group discussed ways to improve the database format and the continuing necessary activities associated with data collection, cataloging and documentation. The Group recognized that the magnitude of this task requires, not only financial and manpower support, but the assistance of the Member States by providing historical tsunami data that have not yet been cataloged in the database. The Group agreed that there is a need to review the existing database format, suggest improvements, establish guidelines for updating the information and consider suggestions to develop the tsunami database as a distributed set of data rather than as a single database maintained at ITIC.

123 The Group agreed that a Working Group be formed that will review existing tsunami database standards and formulate ways to improve existing data collection and dissemination procedures. The Working Group will also formulate recommendations on the tsunami database format and on the actual availability of tsunami datasets. It will report its findings to the next Session of the ICG/ITSU. This Group will be initially composed of the Director ITIC, Mr. Lander, Dr. Schindel , Dr. Gusiakov, and Mr. Farreras. The preliminary results of their studies will first be brought to the attention of the Workshop on Tsunami Mitigation and Risk Assessment, planned to be held in the summer of 1996 in Russia.

9.3 PUBLICATIONS

124 The Chairman informed the Group that the textbooks and teachers' guidebooks on earthquakes and tsunami, that were previously under development in Chile, have now been published in Spanish by Chile and are being used in schools. The books have also been translated into English by Canada, with the assistance of Chile, Japan and New Zealand, but have not yet been published. IOC has prepared the camera-ready copy and Canada has offered to investigate the possibility of covering the printing costs. The detailed discussion of this issue took place under Agenda Item 10.1.

125 The Acting Director ITIC informed the Group about the ITIC publications completed during the intersessional period including: (i) an updated ITIC brochure in English, French, and Spanish, (ii) a supplemental teacher's guide to the children's cartoon book on tsunami, and (iii) "*Tsunami - The Great Waves*", a colour booklet describing tsunami and tsunami safety guidelines. The text of the booklet is available in digital format and can be provided to all Member States for their use. He thanked Mr. Farreras (Mexico) and Dr. Schindel  (France) for their efforts in translating the ITIC brochure into Spanish and French, respectively. The French-language version of the ITIC and ITSU brochures have been published by IOC and widely distributed. The Associate-Director ITIC offered to translate the children's cartoon book into Spanish during the intersessional period and present it for publication to ITSU-XVI.

126 The Technical Secretary IOC requested that a new, high-quality brochure be developed to describe the activities of ITSU and ITIC, particularly their efforts in international tsunami hazard mitigation. The Delegate from France expressed his willingness to head this development effort. The Technical Secretary suggested that France would develop an outline of the brochure's sections that could be distributed to Member States for their contributions and comments. France agreed to explore opportunities for publishing the brochure before ITSU-XVI.

127 The Group expressed its appreciation to all Member States participating in the development, printing and distribution of ITSU publications. The Group emphasized the importance of continued publication of information about tsunami, tsunami hazard mitigation, and the activities of ITIC and ICG/ITSU, and encouraged all members to participate in those efforts.

128 The Group expressed the opinion that sufficient time has elapsed since the publication of the "Tsunami Glossary" in 1991 to justify the publication of an errata sheet and an updated version to reflect the changes in definitions, etc., that have taken place. The Group recommended that the IUGG Tsunami Commission jointly with the ICG/ITSU will start revision of the Tsunami Glossary and report on the progress to ITSU-XVI.

10. TRAINING, EDUCATION AND MUTUAL ASSISTANCE IN REGARD TO THE ITSU PROGRAMME

129 Training is always considered a key component of the ICG/ITSU programme. The last few years showed a new increase of interest in TEMA, in response to the decisions of the Yokohama Conference and

to IDNDR in general. Training courses, publication of textbooks, development of education strategy were discussed and evaluated by the Group under this agenda item.

10.1 IMPLEMENTATION OF RECOMMENDATION ITSU-XIV.1

130 The Chairman of the *ad hoc* Working Group for the Tsunami Public Education and Awareness presented Document IOC/ITSU-XV/16 containing a proposal on general public education strategy. The general objective of the strategy was to recommend basic measures of risk prevention that should be taken against earthquakes and/or tsunami, and finally to achieve a change in the attitude of the population in relation to risk prevention when natural disaster occurs.

131 The **Group acknowledged** the efforts of the Working Group in developing the strategy and concluded that, though the strategy contains many interesting ideas, it cannot have a regional-wide application as it is based primarily on the experience of a single country and represents local problems. It was not recommended to accept the strategy for the Pacific-wide usage. However, **the Group agreed** that many ideas presented in "the document could be embedded and useful in national and regional public education strategies.

132 **The Group thanked** the Chairman of the *ad hoc* Working Group for his efforts, considered that its existing Terms of Reference have been fully implemented and **decided** to disband the Working Group.

133 **The Group was then informed** on the actions taken by the Chairman and the Technical Secretary for publication of the Earthquake and Tsunami textbooks in languages, other than Spanish. The **Group thanked** Canada, Chile, Japan and New Zealand for the preparation of an English language master copy of a complete set of books. **The Group noted** the high interest expressed in the textbooks at the Yokohama Conference and **acknowledged** that this product constitutes a valuable contribution to the IDNDR Action Plan. **The Group expressed** concern that in spite of all efforts, the publication of the textbooks in English and Russian have not yet been implemented.

134 The **Group requested** the Chairman and Member States to continue efforts, and the Executive Secretary IOC to secure the necessary funds for the publication of the textbooks. **The Group appreciated** the interest of Canada to investigate the possibility of publishing the textbooks in English and **advised** the Canadian Delegate to keep the Chairman and the Executive Secretary IOC informed of the progress.

135 The **Group invited** the Delegate of Japan to explore further the interest of national authorities to see the textbooks published in Japanese and to assist through contributions to the IOC Trust Fund, the publication of the material in English.

10.2 VISITING EXPERTS PROGRAMME AND OTHER TRAINING ACTIVITIES

136 The ITIC Visiting Experts Programme resumed in November 1994 after a two-year break when two scientists (Ms. Seung-hee Sohn - Republic of Korea and Ms. Melanie Deocampo - Philippines) attended the 4-week programme in Honolulu. Mr. Sigrist stressed the importance of continuing the programme in future years as it provides significant benefits to the Member States. One immediate, positive outcome from the recent programme session was the satellite telemetry upgrade to the Legaspi, Philippines tide-gauge that would not otherwise have occurred without the on-site training of the visiting expert from the Philippines. As a reminder to the Group, Mr. Sigrist noted that nominations for the 1995 programme are due by 15 August 1995 at which time a selection of two trainees will be made. The Member States were urged to submit names of candidates without delay for consideration.

137 The Delegate of Chile informed the Group that his country, jointly with Mexico, plans to conduct a two-month course related to the TIME Project and usage of the TREMORS in March-April 1995. The Course will be arranged for up to 8 experts (5 from outside of Chile) for Spanish speaking countries of South and Central America. The Course will give an advantage to increase knowledge in modern methods of tsunami modelling and earthquakes and tsunami detection. A modest level of support will be required from IOC.

138 The Delegate from Colombia announced that a Seminar on tsunami hazard evaluation and mitigation in South and Central American countries is planned for April 1996 (Observatorio Sismologico del

Suroccidente - OSSO, Universidad del Valle). The countries of this region share high levels of local tsunami threat, the same language and similar socio-economical conditions, but different approaches to the tsunami problem. The event shall include presentations of the state-of-the-art and national and sub-regional programmes and projects. It is aimed at fostering initiatives and promoting regional integration.

139 It is envisaged that the Seminar will bring together participants from all countries, from Mexico to Chile. Details of the programme of the Seminar will be available in the next two months. He invited Member States and IOC to support the Seminar.

140 **The Group recommended** IOC to consider support through the IOC/UNESCO Regional Office for both training activities after the programmes are available, objectives identified and the list of candidates studied.

11. NATIONAL PROPOSALS FOR FUTURE PROJECTS AND OTHER BUSINESS

141 The Delegate of Russia presented two proposals to the Group for consideration and comments (Document IOC/ITSU-XV/17).

142 The first proposal was on the "Automatic Determination of the Tsunamigenic Earthquake Precursor on the Single-Station Observations" (prepared by Dr. Levin and Dr. Sassorova). The proposal contains information on the studies carried out by Russian scientists for determining the new component of the seismic process in real-time mode which can be used to provide information on the quick determination of earthquakes. **The Group noted** with interest the preliminary results of these studies and recommended that the work continue.

143 The second proposal was on the "Development of Aeromethods for Mapping of Centers of Earthquakes at the Offshore Areas, Compilation of Terrestrial and Air Nets for Monitoring and Warning of Tsunamis". The purpose of the proposal was, among other things, to develop airborne measurement technologies to enable aerial investigation and collection of geophysical parameters overland and marine long-the-fault epicentral and tectonic zones, to study the phenomena of seismic electromagnetic events at offshore areas and to develop earthquake and tsunami hazard monitoring system using airborne magnetic and electromagnetic surveys.

144 **The Group felt** that though the concept is interesting, the sphere of application lies primarily beyond the direct interests and responsibilities of the Group and are more related to seismological interests and particularly to the long-term earthquake prediction.

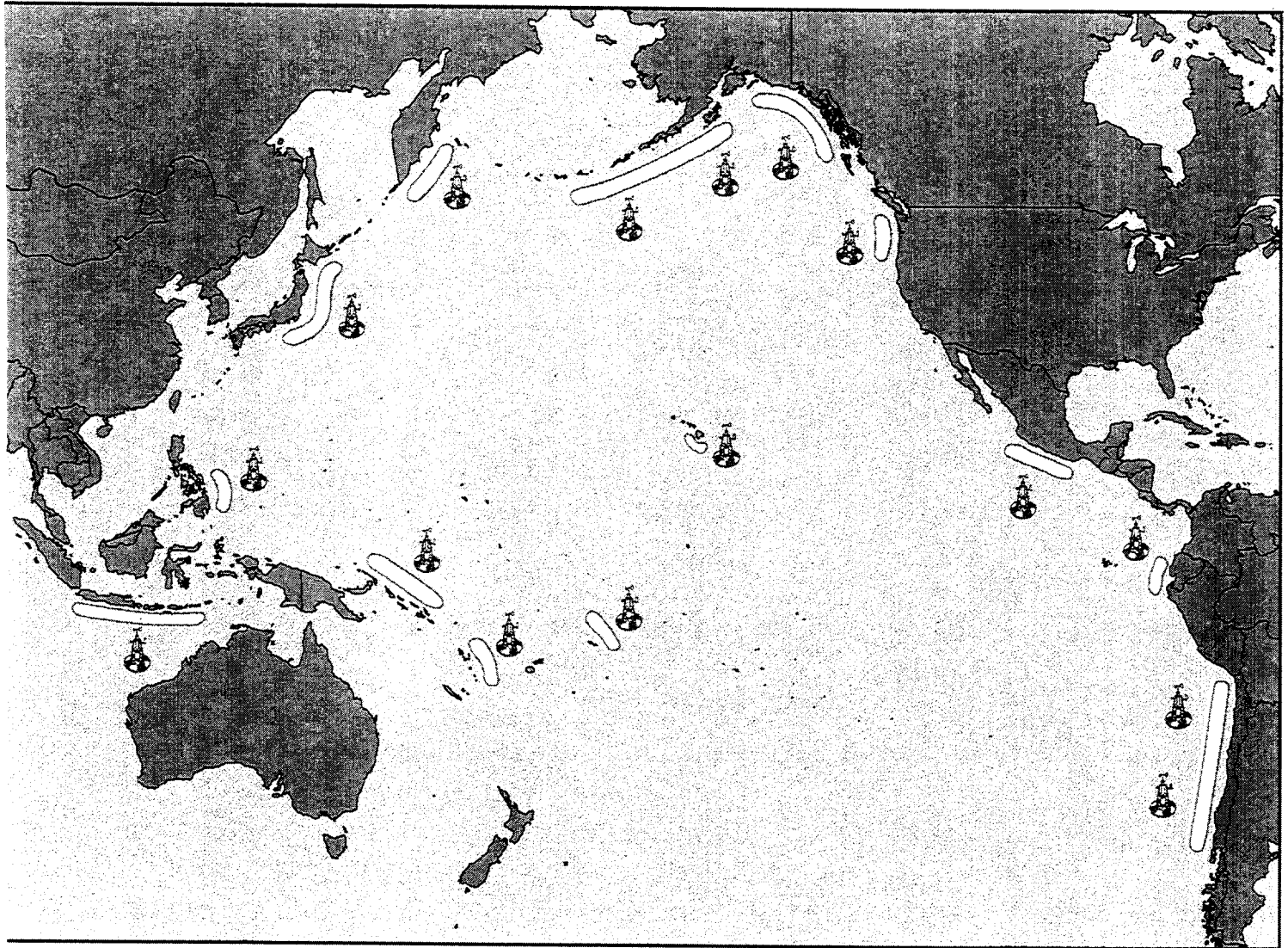
145 The Director PTWC requested the Group permission to modify the frame of reference used to establish the limits of the warning area and the watch area in warning/watch messages. The modification is to change the reference from the earthquake origin time to the issuance time of the message. This will give the recipients of the message a better understanding of the amount of time they have before a tsunami is expected to arrive in their area. The Group agreed to this modification.

146 The Director also requested that he be able to modify the messages sent to ITSU and other recipients, following a review, comment and acceptance process during the intersessional period. The Group also accepted this request.

147 Dr. E. Bernard, Past Chairman of the IUGG Tsunami Commission, on behalf of the Delegate of the USA, proposed a concept for Tsunami Hazard Reduction for the Pacific Nations. The concept utilizes tsunami inundation technologies to identify risk areas and tsunami detection technology based on real-time offshore surface buoys to measure tsunamis in the open ocean for forecasting coastal impacts. This technology will help mitigate the local tsunami hazard near the earthquake zone and help mitigate the distant tsunami hazard by providing deep ocean measurements of the tsunami (Figures 4 and 5).

148 **The Group enthusiastically adopted** the concept and directed Dr. Bernard to prepare a proposal for the ITSU Officer's Meeting, planned for January 1997 for evaluation. Australia and Russia volunteered to help in the preparation of the proposal.

Protecting People of the Pacific



A Tsunami Hazard Reduction Program for the Pacific Nations



Figure 4

Design for Tsunami Real-Time Reporting System

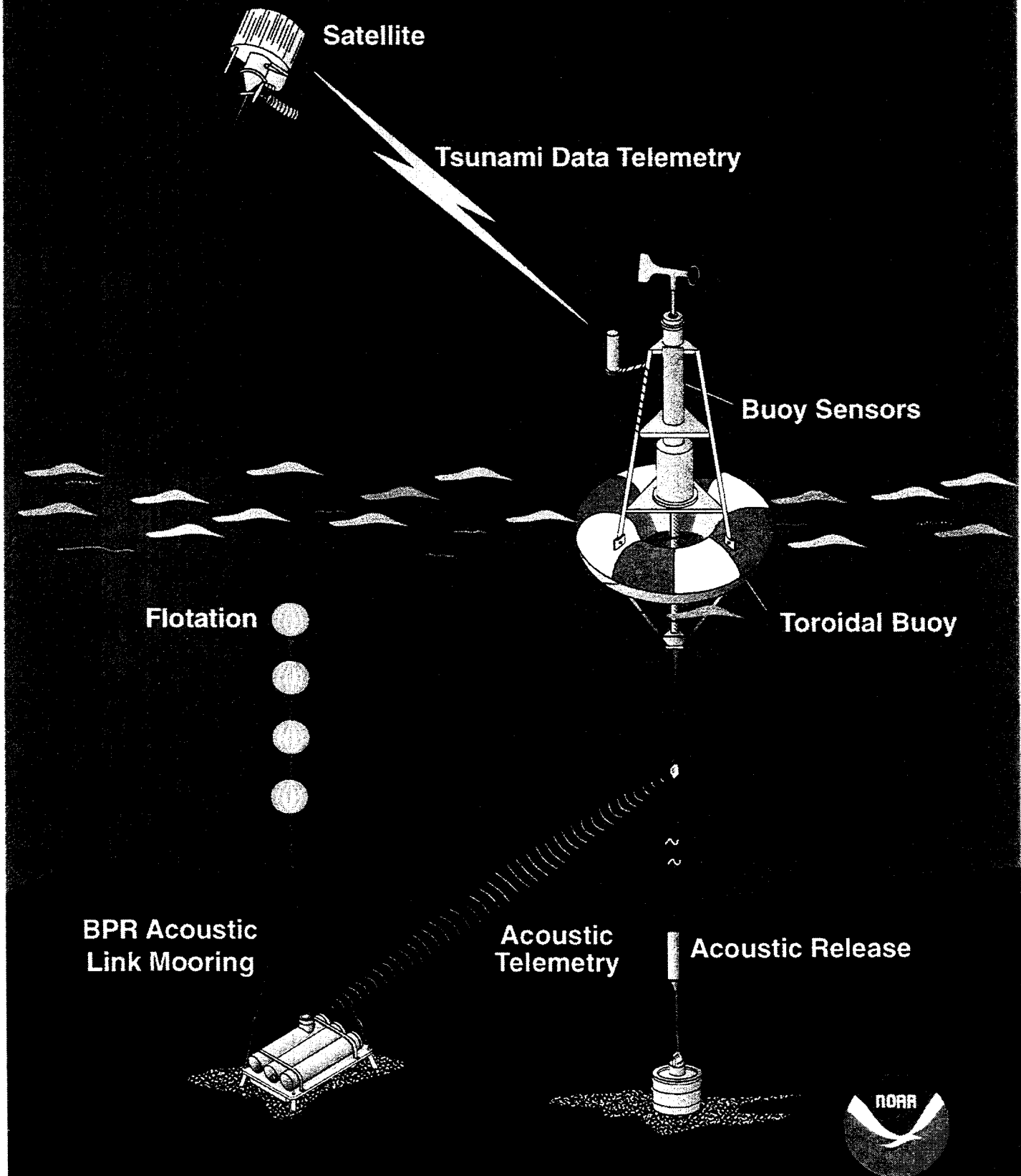


Figure 5

149 The Delegate of Russia informed the Group of the present state of the national tsunami warning system in the Kuril Islands which were strongly affected by the Shikotan earthquake and tsunami of 4 October.

150 Tsunami waves of up to 10 meters high, seriously damaged many ships in harbours and devastated coastal facilities. Three of 5 existing regional mareograph stations were totally destroyed.

151 Buildings and instruments of seismic stations in Malo-Kurilsk, YuzhnoKurilsk and Kurilsk which constituted a part of the Far-East regional tsunami warning system were seriously damaged and are still unrecovered. All this destruction may hinder the effectiveness of the Russian Tsunami Warning system in the Kuril-Kamchatka region and threaten the effectiveness of the International TWS in the entire north-western Pacific Region.

152 Russia is ready, in spite of all financial difficulties facing the country now, to provide personnel, experience and knowledge, as well as part of the instruments for these stations. Also, Russia will be ready to cover the current expenditures for maintenance of the stations. However, for the complete reconstruction of the system there will be a need for additional support from the international community and from the ICG/ITSU Members.

153 **The Group** felt that for saving lives and property in the Pacific, there is an urgent need to renovate stations and upgrade instrumentation.

154 **The Group noted with** satisfaction the decision of the Eighteenth Session of the IOC Assembly to invite *"the Executive Secretary IOC and Member States to consider ways to supped Russia in reconstructing the warning system in the tsunami affected area"* (Kuril Islands) (Document SC/MD/106, para. 354) and expressed a strong belief that if the project is implemented, it will considerably improve the reliability of the entire Tsunami Warning System in the north-western Pacific and will help the governments to diminish the destructiveness of tsunami if a tsunami occurs.

155 **The Group called** on its Member States to bring their efforts and resources together for rebuilding the system and **requested** the Executive Secretary IOC to take all necessary actions for implementing the Assembly decision.

12. ELECTION OF THE CHARMAN AND VICE-CHAIRMAN OF THE ICG/ITSU

156 The Technical Secretary reminded the delegates of the procedures for the election of the Chairmen and Vice-Chairmen of the IOC Main Subsidiary Bodies as they are presented in the IOC Manual Part I, March 1989, and invited the delegates to elect the Chairman and Vice-Chairman of the Group.

157 The Group appraised the energetic, constructive and most helpful contributions of the present Chairman to the activities of the Programme, and noting that he served only one intersessional period, recommended him to continue maintaining his Chairman's duties and responsibilities. The Group enthusiastically re-elected the incumbent Chairman, Mr. Gorziglia, by unanimous acclamation.

158 The Group was informed that the present Vice-Chairman, Mr. H. Uchiike from Japan, has already served two intersessional periods and that France officially offered the services of Dr. Schindel   as a candidate to the post of the Vice-Chairman of the ICG/ITSU.

159 The Group noted the role of France in promoting the principles of international co-operation in the implementation of the tsunami warning system and in providing technical support to the Member States of the Pacific in upgrading their technical facilities for tsunami mitigation. The Group also noted that the professional knowledge and experience of Dr. Schindel   in seismology and his personal qualities will be an important contribution to the programme and recommended to support the offer of France. Dr. Schindel   was elected as the new Vice-Chairman of the Group.

160 Mr. H. Gorziglia thanked the Group for his re-election and extended his thanks and appreciation to Mr. Uchiike whose support and wise advice were always helpful and friendly. The Delegate of Japan,

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speaking on behalf of Mr. Uchiike, expressed his sincere appreciation for the confidence and co-operation extended to him during his tenure as the Vice-Chairman of the ICG/ITSU.

161 **The Group also appraised** the contributions made by Mr. Sigrist, Acting Director ITIC, to the programme during the last two years and **wished** him every success in his new position.

162 **The Group requested** the Technical Secretary to arrange the despatch of letters of acknowledgement to Mr. Uchiike and Mr. Sigrist under the signature of the Executive Secretary IOC.

13. **PROGRAMME AND BUDGET FOR 1996-1997**

163 **The Group was informed** of the discussions held at the Eighteenth Session of the IOC Assembly in June 1995 on the programme and budget of IOC for 1996-1997, and on the decisions taken by the Assembly relevant to the level of support to the tsunami programme.

164 **The Group appreciated** the increased IOC contribution to the ICG/ITSU activities in 1994-1995 and the most positive attitude of the Executive Secretary IOC to the importance of the programme, not only for Member States of the Pacific, but for many other countries of the world. **The Group expressed a** strong desire to see a continuing high level of support to the programme from IOC and Member States, and taking into account the deliberations and findings of the Session **formulated** the programme of activities of the Group for 1996-1997 **and identified** priorities as they are presented in Recommendation ITSU-XV.

14. **DATE AND PLACE OF THE NEXT SESSION**

165 The Delegate of Peru reiterated his country's offer to host the Sixteenth Session of the Group in Lima in the second half of 1997. The Technical Secretary informed the Group that this offer has also been presented by the Peruvian Delegation at the IOC Assembly. The **Group accepted** the offer with thanks and **requested** the Chairman and Technical Secretary to make the necessary arrangements with the local authorities for a successful Session. The Technical Secretary pointed out that there will be a need for an official letter from Peru addressed to the Executive Secretary IOC, expressing their willingness to host the Session and offering the necessary facilities. This letter should be dispatched not later than the middle of 1996 and will be used as a basis for the official agreement between Peru and UNESCO.

166 The Delegate of the Republic of Korea invited the Group to have the Seventeenth Session in Seoul, in 1999. The **Group acknowledged** this kind invitation and decided to keep this in mind when the issue of the dates and place for ITSU-XVII are discussed at the Sixteenth Session.

167 **The Group reiterated** the importance of the ITSU's Officers Meeting as an important intercessional activity and **invited** the Chairman to consider having the next meeting in Honolulu well in advance of ITSU-XVI, in order to evaluate programme implementation and finalize arrangements for the Group Session.

15. **ADOPTION OF THE SUMMARY REPORT**

168 **The Group adopted** the Summary Report and Recommendations of the Fifteenth Session, and requested the Technical Secretary to undertake the necessary editing to ensure accuracy and correctness.

16. **CLOSURE**

169 The Chairman closed the Session at 16.00 on 28 July 1995.

ANNEX I

AGENDA

- 1. OPENING AND ARRANGEMENTS FOR THE SESSION**
- 2. GENERAL REVIEW OF INTERSESSIONAL ACTIVITIES, LESSONS LEARNED FROM RECENT TSUNAMI**
- 3. IMPLEMENTATION OF ITSU-XIV DECISIONS**
 - 3.1 REAL-TIME EXCHANGE OF TELEMETRY, SEISMIC AND TSUNAMI DATA
 - 3.2 TSUNAMI INUNDATION MODELLING EXCHANGE (TIME) PROJECT
 - 3.3 EXPERT TSUNAMI DATABASE FOR THE PACIFIC
 - 3.4 TSUNAMI COMMUNICATION NETWORKS - STATUS AND WAYS OF IMPROVEMENT
- 4. ITIC ACTIVITIES**
 - 4.1 STANDARDS FOR SURVEY MEASUREMENTS OF TSUNAMI RUN-UP AND DAMAGE
- 5. THE WORLD CONFERENCE ON NATURAL DISASTER REDUCTION - FOLLOW-UP ACTIONS REQUIRED FROM ICG/ITSU**
- 6. RESULTS OF THE ITSU MASTER PLAN REVISION AND PLANS FOR FUTURE ACTIONS**
- 7. ESTABLISHMENT OF NEW REGIONAL TSUNAMI WARNING SYSTEMS**
 - 7.1 PACIFIC
 - 7.2 EUROPE
 - 7.3 OTHER REGIONS
- 8. CO-OPERATION WITH OTHER INTERNATIONAL BODIES IN TSUNAMI MITIGATION**
- 9. DISSEMINATION OF INFORMATION**
 - 9.1 E-MAIL AND ELECTRONIC BULLETIN BOARDS**
 - 9.2 HISTORICAL TSUNAMI DATABASE**
 - 9.3 PUBLICATIONS**
- 10. TRAINING, EDUCATION AND MUTUAL ASSISTANCE IN REGARD TO THE ITSU PROGRAMME**
 - 10.1 IMPLEMENTATION OF RECOMMENDATION ITSU-XIV.1**
 - 10.2 VISITING EXPERTS PROGRAMME AND OTHER TRAINING ACTIVITIES**
- 11. NATIONAL PROPOSALS FOR FUTURE PROJECTS AND OTHER BUSINESS**
- 12. ELECTION OF THE CHAIRMAN AND VICE-CHAIRMAN OF THE ICG/ITSU**
- 13. PROGRAMME AND BUDGET FOR 1996-1997**
- 14. DATE AND PLACE OF THE NEXT SESSION**
- 15. ADOPTION OF THE SUMMARY REPORT**
- 16. CLOSURE**

ANNEX II

ADOPTED RECOMMENDATIONS

Recommendation ITSU-XV.1

MASTER PLAN FOR THE TSUNAMI WARNING SYSTEM IN THE PACIFIC

The International Co-ordination Group for the Tsunami Warning System in the Pacific,

Acknowledging that the Master Plan is the guiding publication for the ICG/ITSU,

Recognizing that the Master Plan has the value for ICG/ITSU Members in encouraging them to improve national tsunami mitigation capabilities and establishing national and regional tsunami warning systems,

Noting that it is necessary due to many technological developments and scientific findings, to update the plan after nearly 10 years since it was first published,

Recommends that a small Editorial Group headed by the Chairman ICG/ITSU and composed of the Director ITIC, the Director PTWC, an expert from Australia and a representative of the IUGG Tsunami Commission be established to update the Master Plan of 1987 and to present a new version for adoption at the ICG/ITSU XVI Session;

Urges that the first draft of the revised Master Plan be circulated before 31 July 1996 to all ICG/ITSU Members for comments; that these comments should be received at ITIC before 30 November 1996 and that the final draft be sent to ICG/ITSU Members and the Executive Secretary IOC at least 3 months in advance of ITSU XVI;

Requests the Executive Secretary of IOC to secure provision of financial assistance for the implementation of this task in the 1996 contract with ITIC.

Recommendation ITSU-XV.2

WORKSHOP ON TSUNAMI MITIGATION AND RISK ASSESSMENT (Russian Federation, August 1996)

The International Co-ordination Group for Tsunami Warning System in the Pacific,

Being informed of the plan of Russia to organize the Workshop on Tsunami Mitigation and Risk Assessment on the Lake Baikal in August 1996,

Being aware of the importance of this issue for the reduction of tsunami damage in the Pacific region,

Taking into account that the Workshop's objectives correspond fully to the IDNDR objectives, and will help the implementation of the ICG/ITSU recommendations,

Recommends that this Workshop be co-sponsored by IOC in the form of travel support for a few Workshop participants;

Requests the Director ITIC to assist the organizers of the Workshop in formulating the Workshop programme.

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Recommendation ITSU-XV3

TSUNAMI BULLETIN BOARD AND WORLD WIDE WEB SITE

The International Co-ordination Group for the Tsunami Warning System in the Pacific,

Acknowledging the success of the electronic Tsunami Bulletin Board system developed by NOAA/PMEL for the international tsunami community,

Recognizing the need to accept the responsibility for the continued operation and maintenance of the system within the framework of the ICG/ITSU,

Expressing thanks to the Government of the USA for making reliable Internet links available to ITIC,

Noting the need to enhance the capabilities of the system by including a World Wide Web (WWW) Homepage and arranging links to other WWW sites possessing tsunami-related information,

Noting further the need to move ahead quickly with these enhancements as they will improve greatly the visibility of the IOC tsunami programme and ICG/ITSU,

Requests the Member States and IOC provide financial support for the operation of the Tsunami Bulletin Board and the development of the WWW site, and in particular for the purchase of a computer (server) workstation for ITIC, as noted in the Programme of Work and Priorities for 1996- 1997.

Recommendation ITSU-XV.4

PROGRAMME OF WORK AND PRIORITIES FOR 1996-1997

The International Co-ordination Group for the Tsunami Warning System in the Pacific,

Recalling the view of the IOC Governing Bodies on the IOC Tsunami Programme as a programme of high priority which is targeted to saving human lives and reducing the impact of natural disasters,

Recognizing that the sustainable development of the programme cannot be achieved without adequate resources,

Noting with thanks the support by IOC to the programme through the regular programme budget and trust funds arrangements,

Being informed of the IOC Programme and Budget for 1996-1997, adopted by the Eighteenth Session of the IOC Assembly,

Emphasizing the need for all Member States of the Pacific to share the burden of operational costs of the tsunami warning system and of the resources required for implementation of agreed upon actions in 1996-1997,

Adopts the following ICG/ITSU Work Programme for 1996-1997, in the following order of priority:

- (i) Provision of increased assistance for the continuing activities of the International Tsunami Information Center (ITIC), including the purchase of the computer workstation.
- (ii) Provision of support to the Visiting Experts Programme (4-6 trainees) and to other training activities which will help Member States of the region increase their capacity in preventing or diminishing effects of tsunamis, giving priority attention to developing States.
- (iii) Provision of financial support to the operation of the Tsunami Bulletin Board and to the development of the Tsunami Homepage and Web Server.

- (iv) Provision of assistance for the revision and updating of the Master Plan for the Tsunami Warning System in the Pacific.
- (v) Provision of funds for publication of tsunami and earthquake textbooks in English and Russian, and to assist in the distribution of copies to users.
- (vi) Provision of funds for the organization of meetings of the Group (ITSU-XVI, in the second half of 1997 in Lima, Peru and the ITSU Officers Meeting in January 1997, in Honolulu), for the implementation of project proposals and the hiring of consultants as recommended at ITSU-XV.
- (vii) Provision of funds for publication of a coloured brochure on tsunami and activities of the IOC ICG/ITSU.
- (viii) Provision of funds for the participation of ITSU Officers/Experts in the meetings of other organizations dealing with relevant problems, and of the ICG/ITSU Chairman at the meetings of the IOC Governing Bodies.
- (ix) Co-sponsoring scientific conferences and symposia of other international bodies related to the IOC Tsunami programme by providing support for participation of experts from developing countries.
- (x) Provision of support to the development of the interface with the WDC-A for Solid Earth Geophysics data bank within the ETDB project.
- (xi) Provision of support to the activities of the Associate-Director, ITIC.
- (xii) Provision of funds upon request for the assessment of tsunami damage and inundation.

Invites all Member States to support the programme in funds through contributions to the IOC Trust Fund and in-kind, through national and regional efforts; and ITSU National Contacts to make national authorities aware of the programme and of the potential benefits of tsunami disaster reduction and preparedness by paying attention to the issue, making commitments and allocating resources;

Requests the Executive Secretary IOC to take all necessary measures for providing support to the programme by allocating the necessary funds and staff;

Expresses a strong hope that all activities mentioned in the programme for 1996-1997 above, will receive the necessary funding.

ANNEX III

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ANNEX IV

LIST OF DOCUMENTS³

Document Code	Title
IOC/ITSU-XV/1	Agenda
IOC/ITSU-XV/1 Add.	Timetable
IOC/ITSU-XV/2	Annotated Agenda
IOC/ITSU-XV/3	Summary Report
IOC/ITSU-XV/4	List of Documents
IOC/ITSU-XV/5	List of Participants
IOC/ITSU-XV/6	Report of the Chairman of ICG/ITSU on Intersessional Activities
IOC/ITSU-XV/7	National Reports on Tsunami-related Activities
IOC/ITSU-XV/8	Report of the Chairman of an Ad hoc Task Team on Real-time Telemetry, Seismic & Tsunami Data Exchange on Intersessional Activities
IOC/ITSU-XV/9	TIME Project
IOC/ITSU-XV/9 Add.	Report of the Project Leader on the TIME Implementation
IOC/ITSU-XV/10	Report on the Expert Tsunami Database (ETDB) for the Pacific & ETDB Software
IOC/ITSU-XV/11	Tsunami Communication Networks - Today & in the Future
IOC/ITSU-XV/12	Report of the ITIC Director
IOC/ITSU-XV/13 rev.	Standards for Tsunami Survey Measurements (as of 24.07.95)
IOC/ITSU-XV/14	Status of Implementation of the Master Plan for the Tsunami Warning System in the Pacific
IOC/ITSU-XV/15	E-mail & Electronic Bulletin Board Capabilities & Ways to Use Them
IOC/ITSU-XV/16	General Public Education Strategy
IOC/ITSU-XV/17	National Proposals for Future Projects
IOC/ITSU-XV/18	Work Plan 1996-1997
IOC/ITSU-XV/19	Preliminary Report of the International Tsunami Measurements Workshop (Estes Park, USA, June 28-30, 1995)

³ This list is for reference only. No stocks of these documents are maintained, except for the Summary Report.

ANNEX V

WELCOME ADDRESS OF DR. R. BAGNIS

Dear Colleagues,

In charge of the questions of research and technology for the French Minister of National Education, Superior Teaching, Research and Professional Insertion, and as the representative of Mr. P. Ronciere, High Commissioner of the French Republic in French Polynesia, I would like to welcome you on his behalf. Mr. Ronciere wants to apologize and express his regrets not to be present at the opening of the Fifteenth Session of ITSU, kept away by professional duties.

Even if the word "Tsunami" is still not very familiar to the populations of our territory, some effects of the phenomenon, are well known and still present in the collective memory of natives, mainly in Tuamotu after the earthquake in San Francisco in 1906 and most recently in the Marquesas Islands, after the earthquakes at the Aleoutian Islands in 1946 and 1957, and in Conception, Chile, in 1960.

I had the opportunity to hear from old natives, the terrific stories about the loss of lives and property caused by waves cresting to heights of more than 30-50 meters and striking coastlines with devastating force.

I could see with my own eyes in several Marquesas islands, the traces of the 1960 tsunami run-up when the swell entered the most exposed valleys deep into the land at Hanavave in the famous Bay of the Virgins, Fatuiva Island. These traces are marked on the land forever.

The participation of the Colloquium on the Protection of the Environment of the South Pacific organized this year by the French Ministry of Higher Education and Research, stressed the need for the development of warning systems and observational networks to monitor natural disasters and disaster effects of natural hazards. I appreciate the international co-operative scientific efforts made by so many states of the Pacific region, under the auspices of IOC, to improve knowledge on tsunami, to evaluate potentially tsunamigenic earthquakes and to co-ordinate the tsunami warning activities in the area.

I congratulate all the scientists and technicians involved in this work with the achievements and particularly the ICG/ITSU, ITIC and PTWC, of the US National Weather Service.

I am sure you will excuse me if I pay special tribute to the important contribution made by the Polynesian Tsunami Warning Center of Pamatani, CEA, the Geophysics Laboratory in Tahiti, in developing an automatic system for real-time detection, location and measurement, of the strong earthquakes magnitude and seismic moment, which has a direct application to tsunami warnings.

I do not doubt that your biennial ITSU Meeting will be studious. I suppose it will be successful and I wish you a good stay in French Polynesia.

ANNEX VI

ACTION SHEET - STATUS OF IMPLEMENTATION OF ITSU-XIV DECISIONS

Para. of ITSU-XIV of Sum. Rep	Action	Status of Implementation
12	Find reasons for absence of Australia, China, Dem. People's Rep. of Korea, Russia at ITSU-XIV.	Done. IOC allocated funds to support few experts from developing countries to attend ITSU-XV. Australia & Russia were present.
25	Communication with Russia.	Done. Past Chairman wrote letter to Russia on communication problems. Ambiguities resolved.
30	Publication of abstracted texts of Nat, Reports in Tsunami Newsletter	Done. Vol. XXV, N° 2, Dec. '93
35	Include summary of Hokkaido Nansei-Oki earthquake & tsunami survey in Dec.'93 ITIC Newsletter.	Done. Vol. XXV, N° 2, Dec.'93
38	Implementation of real-time tsunami data exchange issues. (<i>Chairman of an Ad hoc Task Team on Real-time Telemetry, Seismic & Tsunami Data El-change</i>).	Continuing; Usage of Inmarsat for data collection & Internet for data exchange under study. Progress reported in Dec. IOC/ITSU-XV/8.
39	Seek financial support for implementation of project.	Continuing; 1 st & 2 nd phases of project have been implemented through national contributions.
42	Seek financial support from Member States to implement TIME Project.	Done. US\$50,000 contribution from USA.
43	Explore possibilities to secure funding for TIME from JICA. .	In process. ITSU contact point from Japan will study possibilities.
50	Make communications system more effective & report on progress at ITSU-XV.	Continuous. Dec. IOC/ITSU-XV/11.
54	Arrange for participation of ICG/ITSU experts at 1995 Tsunami Commission Mtg.	IOC was represented & support for 4 experts provided.
55	Develop standards for survey of tsunami run-up & damage, & report to ITSU-XV.	Dec. IOC/ITSU-XV/13 rev.
62	Prepare an addendum of additions and/or corrections to ITSU Master Plan.	Dec. IOC/ITSU-XV/14.
66	Establishment of a Regional Tsunami Warning System in the Southwest Pacific.	Continuous. Draft letter will be prepared & sent under ICG/ITSU Chairman & Secretary IOC's signature to UNDP & World Bank. Progress is very slow.
68	Start working with other Member States in Central America on formulation of design for regional tsunami warning system in Central America.	Ways to implement this decision have been explored & progress was reported to ITSU-xv.
69	Include updated list of ITSU nat. contacts in Dec.'93 ITIC Newsletter.	Done, New update will appear in Jan.'96 issue of Newsletter.

Para. of ITSU-XIV of Sum. Rep	Action	Status of Implementation
71	Compose international team of experts in earthquakes & tsunami for quick-response missions in tsunami affected areas.	Director ITIC assisted Chairman in making draft list of experts, taking into account needs for interdisciplinary geographical rep. & knowledge of languages. Procedures for operating such teams have been discussed at Tsunami Workshop in Estes Park & ITSU-Xv.
71	Allocate funds to support team financially in cases of emergency.	Upon request on case to case basis.
71	Develop inundation maps & emergency plans for countries with limited technical capabilities & propose plan for implementation of other recommendations from mission report "Post Tsunami Survey (2-7 Nov. '92) of Run-up & Inundation in Coast of Nicaragua" .	In process.
72	Increase support to ITIC activities.	Continuing. At present only USA, Mexico & Chile provide support to ICG/ITSU activities, including ITIC, through Trust Fund & in-kind arrangements.
73	Fill post of ITIC Associate-Director.	Done. Expert from Mexico with support from IOC started his job from mid-Apr.'95 until mid-Apr.'96.
77	Continue efforts to publish English version of earthquake & tsunami textbooks.	In process. Canada is considering possibilities of publication of Russian & Japanese versions.
81	Regularly send tsunami radio & TV spot announcements to ITIC.	No progress. Director ITIC will send reminder.
82	Implement annual visiting experts programme, starting from Oct.'94.	Done. Visiting experts programme for 1995 planned for 23 Oct-17 Nov. Letter of invitation sent Apr.' 95.
88	Secure funds for implementation of ETDP project.	Done. Contract signed for development of system. Results were reported at ITSU-XV.
91	Consider possibility of establishing Far-East Tsunami Warning Centre.	In process. Progress was reported to ITSU-XV.
95	Provide Sec. IOC with concrete ideas & proposals on IOC participation at World Conference on Natural Disaster Reduction.	Done. Report on IOC participation at World Conf. on Natural Disaster Reduction available as Dec. IOC/EC-XXVII/Inf.4 of 27 Jun.' 94.
95	Secure funds for participation of ICG/ITSU experts at Conference.	Done. See Dec. IOC/EC-XXVII/Inf.4 mentioned above. 4 experts were supported.
98	Preparation & publication of French & Spanish translation of ITIC brochure.	French version has been published. Translation provided by France. Spanish version in progress.
107	Provision of funds for participation of ITSU Officers/Experts in mtgs of other organizations dealing with tsunami problems.	Done. ITSU Officers Mtg. (3 exp.) Yokohama Conf. (4 exp.) Workshop & IUGG Tsunami Commission Mtg, USA (4 exp.).
109	Make arrangements for ITSU-XV to be held in fall of '95.	Done.

Para. of ITSU-XIV of Sum. Rep	Action	Status of Implementation
110	Negotiate with Peru & USA on dates & place for ITSU-XVI.	Chairman ICG/ITSU sent letter to Peru to find out their interest in hosting ITSU-XVI. Peru reiterated their invitation.
111	Hold ITSU Officers mtg prior to ITSU-XV.	Done. Mtg. held in Honolulu, 24-27 Jan.'95. SR available as Inf. Doc. IOC/ITSU-Officers/3.

ANNEX VII

PROPOSAL FOR AN IMPROVED AUSTRALIAN TSUNAMI WARNING SYSTEM



A joint project of the

Australian Bureau of Meteorology
Australian Geological Survey Organisation
National Tidal Facility
Emergency Management Australia

July 1995

Proposal for an Improved Australian Tsunami Warning System

Purpose

This paper describes how an improved Australian Tsunami Warning System (ATWS) could be established, how it would operate and the benefits that it would provide for Australia and potentially for neighboring countries in the southwestern Pacific and southeastern Indian Ocean basins.

2. The Bureau of Meteorology provides Australian representation on the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) but the Australian role has been confined to relay and distribution of Pacific tsunami warnings and the distribution of information. With growing scientific interest in the tsunami question and heightened awareness of potential impacts, for example of tsunamis generated by Indonesian seismic disturbances in northwestern Australia, there is a significant requirement to upgrade national arrangements.

3. This proposal outlines roles, responsibilities and functions of the national agencies which have expressed interest in contributing to the creation and operation of the ATWS. These agencies are:

- Australian Bureau of Meteorology (BoM);
- Australian Geological Survey Organisation (AGSO);
- National Tidal Facility (NTF); and
- Emergency Management Australia (EMA)

4. The highly successful National Tsunami Workshop held in Brisbane, Australia in August 1994 pointed to the need for an integrated approach at the national level for improved tsunami warning and information services to the community. The ATWS would integrate and coordinate existing expertise, responsibilities and interests of the lead agencies presently involved in monitoring tsunamigenic seismic activity, detecting seismic waves in the ocean, preparing and disseminating warnings to the community and organizing and managing emergency response activities.

5. The ATWS would establish for Australia's vulnerable northwest coasts a service similar to that currently provided by the Pacific Tsunami Warning Centre (PTWC) for its Pacific Ocean coastlines. The PTWC in Hawaii provides Australia with early warning of tsunamigenic events in the Pacific basin, and the likely arrival time and severity of a tsunami that could impact on Australia or its territories. It does not provide this service in the Indian Ocean, so the ATWS would be the only source of information for the western coasts of Australia and territories such as Christmas and Cocos Islands.

Objectives of the ATWS

6. The overall objective of the ATWS is to provide Australia and its inhabited island territories with a timely and accurate warning service for tsunami events which occur in both the Pacific and Indian Oceans, using state of the art scientific techniques and communications systems.

7. The specific objectives for the ATWS are to:

- Augment the warning capabilities presently provided by the Pacific Tsunami Warning Center (PTWC) in Hawaii for Australian Pacific coastal areas;
- Establish a warning capability for Australia's Indian Ocean coasts, including seismic detection, sea level monitoring, and promulgation and dissemination of warning advices;
- Interface with emergency and community response organisations to enhance tsunami preparedness, including education, liaison with the media, assessment of warning effectiveness and tsunami risk and impact studies; and
- Develop strong links to other tsunami warning centres, such as the PTWC, other relevant and interested agencies within Australia and in neighboring countries, and with scientists and scientific communities who can contribute to the development of the national warning system in areas such as training, development of scientific and decision support, applications of technology and raising community awareness of tsunami issues.

Proposed Operation of the ATWS

8. The ATWS would be operated by the three lead national agencies currently involved in monitoring or providing warnings of tsunamis, or which have specialist skills that would contribute significantly to improving national capabilities in the area, in conjunction with the national emergency response coordination agency.

9. The role of the three agencies providing operational components of the ATWS, and EMA would be:

- *Bureau of Meteorology (BoM)*: Providing communications and round-the-clock operational coverage for dissemination of information, warnings, data, etc. and which has the responsibility of composing warnings for use by responsible community response agencies and the media. The BoM's Regional Forecasting Centres (RFCs), through which tsunami warning operations are conducted are shown in Figure 1;
- *National Tidal Facility (NTF)*: Providing expert assessment of sea level response to, seismic events, through on-line access to tide gauge networks in Australia and neighboring regions, and the expertise to provide inundation prediction for the formulation of warning advices for emergency response agencies. The Australian Baseline Sea level Network, which is operated by NTF, is shown in Figure 2;

- *Australian Geological Survey Organisation (AGSO)*: Providing on-line access to national seismometric networks and interpretation of events which would be used in the early stages of detection and warning of tsunamis, especially in the Indian Ocean. Figure 3 shows the Seismograph Network operated by AGSO; and
- *Emergency Management Australia (EMA)*: Providing emergency response expertise for shaping interfaces with, and networking to, the broad range of need-to-know and interested response and community-based organisations, and to the general public.

Operational framework

10. The arrangements for monitoring tsunamis are proposed as the following:

For the Indian Ocean area:

- (i) AGSO detects a seismic event and informs BoM and NTF
- (ii) NTF acknowledges receipt of AGSO advice to BoM
- (iii) NTF interrogates tide gauges for evidence of tsunami
- (iv) NTF uses inundation model data where possible
- (v) NTF provides prognostic tsunami height and timing information to BoM
- (vi) Bureau composes warnings and advices for the media and community response agencies
- (vii) Media liaison could be shared between BoM and NTF, which has already established a "media profile" in that area. NTF would be happy to provide media release information to BoM for incorporation into public release material.

For the Pacific Ocean area:

The chain would be similar but PTWC advices would be used for steps (i) to (iii) but there would be additional interrogation of gauges by NTF (and also providing this data to ITWC) to enhance advice from PTWC.

Maximizing the Effectiveness of the ATWS

11. The effectiveness of the warning system is a key issue for the success of the ATWS, particularly given the tripartite operational arrangements, and the importance placed on interfacing to community response agencies and human communications factors in dealing with the general public. In this context EMA will play an important role. The design of interfaces, warning formats, customisation of warning information for key client agencies and ongoing assessment of how well the system is performing in meeting the needs of client groups will all benefit from EMA's close involvement. Training programs for BoM forecasting staff and public

education and media liaison will also benefit.

Management Arrangements

12. A Committee of Management would be set up, comprising Bureau of Meteorology's Assistant Director Services (currently National Representative on the International Coordinating Group) as Chair and Directors of NTF and AGSO (or their nominated representatives) and an appropriate manager from EMA. operational managers from the Bureau and scientific experts on tsunamis would also be invited to attend meetings as required.

Communications Arrangements

13. Because of the rapid response times required and the multi agency nature of the proposed national warning system, Internet may be the most promising means of linking BoM, NTF and AGSO, providing low cost bulletin board, e-mail and data transfer facilities. Mobile communications would be needed to provide round the clock access to staff from NTF or AGSO who would not ordinarily work out of hours.

Operations Arrangements

14. Detailed investigation is still required but a number of operational issues will need to be addressed, for example:

- New operational and funding arrangements could be needed for call out of staff from NTF and AGSO;
- Success of initiatives of BoM and NTF to secure funding to produce inundation/run-up scenarios for the Australian coast (NTF to undertake these studies) will be required if the ATWS is to function effectively; and
- Access to high quality real-time sea level data must be ensured, with upgrading of existing obsolescent equipment, especially in key locations such as Cocos Island, a priority.

15. The internal disposition of resources and responsibilities in BoM will remain much as they **are at** present, with each Regional Forecasting Centre being responsible for interfacing information and warnings to the media, public and emergency response agencies in its State or Territory. Each would receive decision support from NTF and AGSO and/or PTWC. The concept of the System in the eastern States would be somewhat more of an augmentation of the existing arrangements, being essentially Regional (in the Bureau sense) in operation but coordinated centrally through the Coordinating Committee.

Development of the Indian Ocean Capability

16. During discussions with NTF on Sea Frame gauges installed or being planned for Indonesian locations, the Indonesian operators have expressed interest in becoming involved on the Indian Ocean component which is of immediate interest to them also.

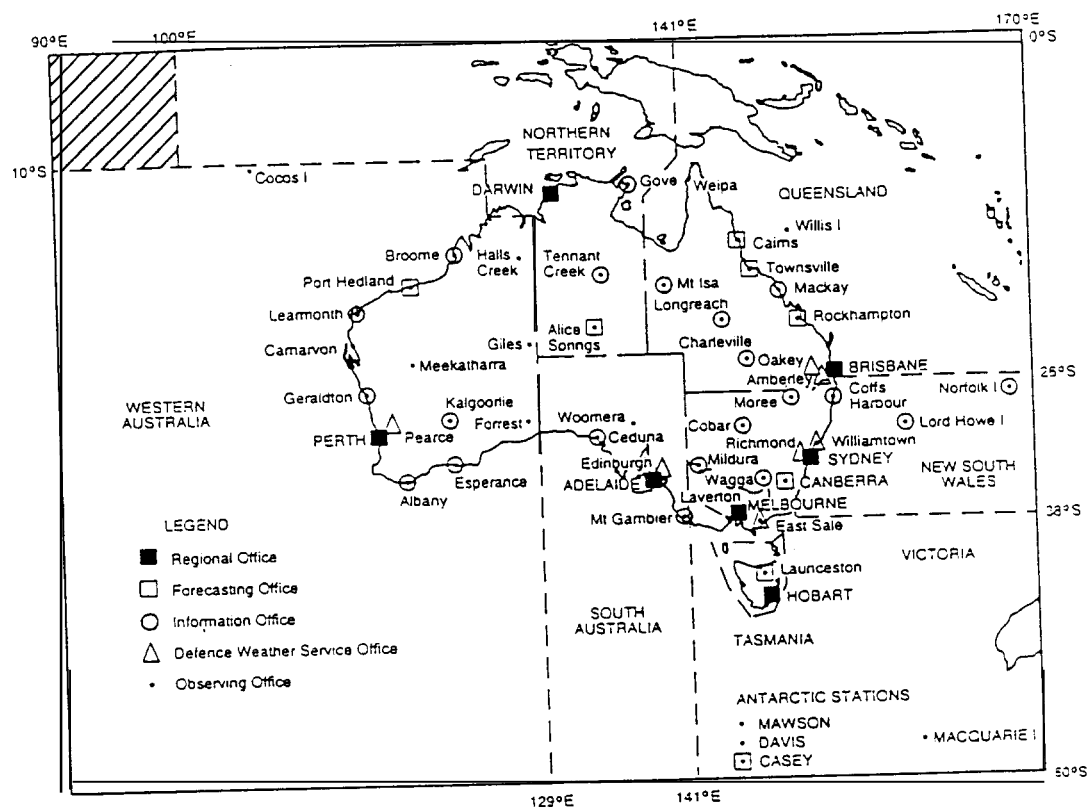


Figure 1. Regional Forecasting Centres of the Australian Bureau of Meteorology.

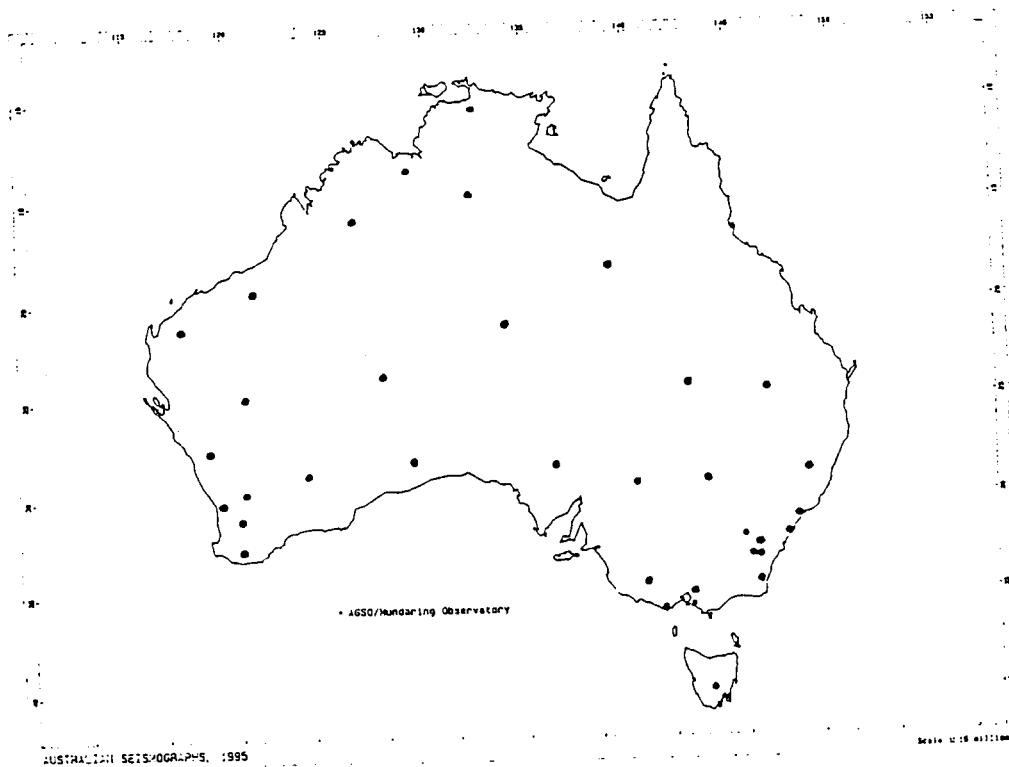


Figure 3. Seismographs operated by the Australian Geological Survey Organisation.

Australian Baseline Sea Level

Monitoring Project - Monitoring Sites

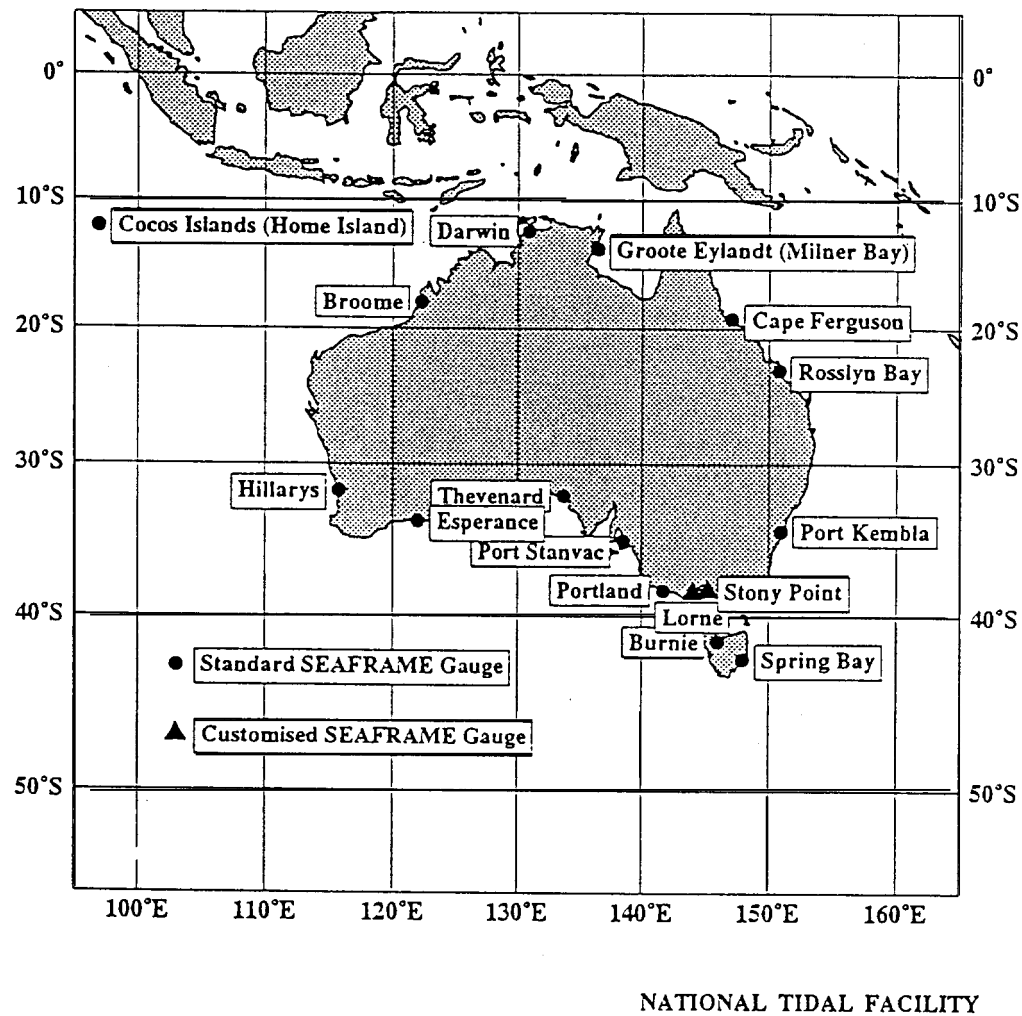


Figure 2 The array of 16 SEAFRAME stations that comprise the Australian Baseline Array, including the station on the Cocos Islands.

South Pacific Sea Level and Climate Monitoring Project

Monitoring Sites

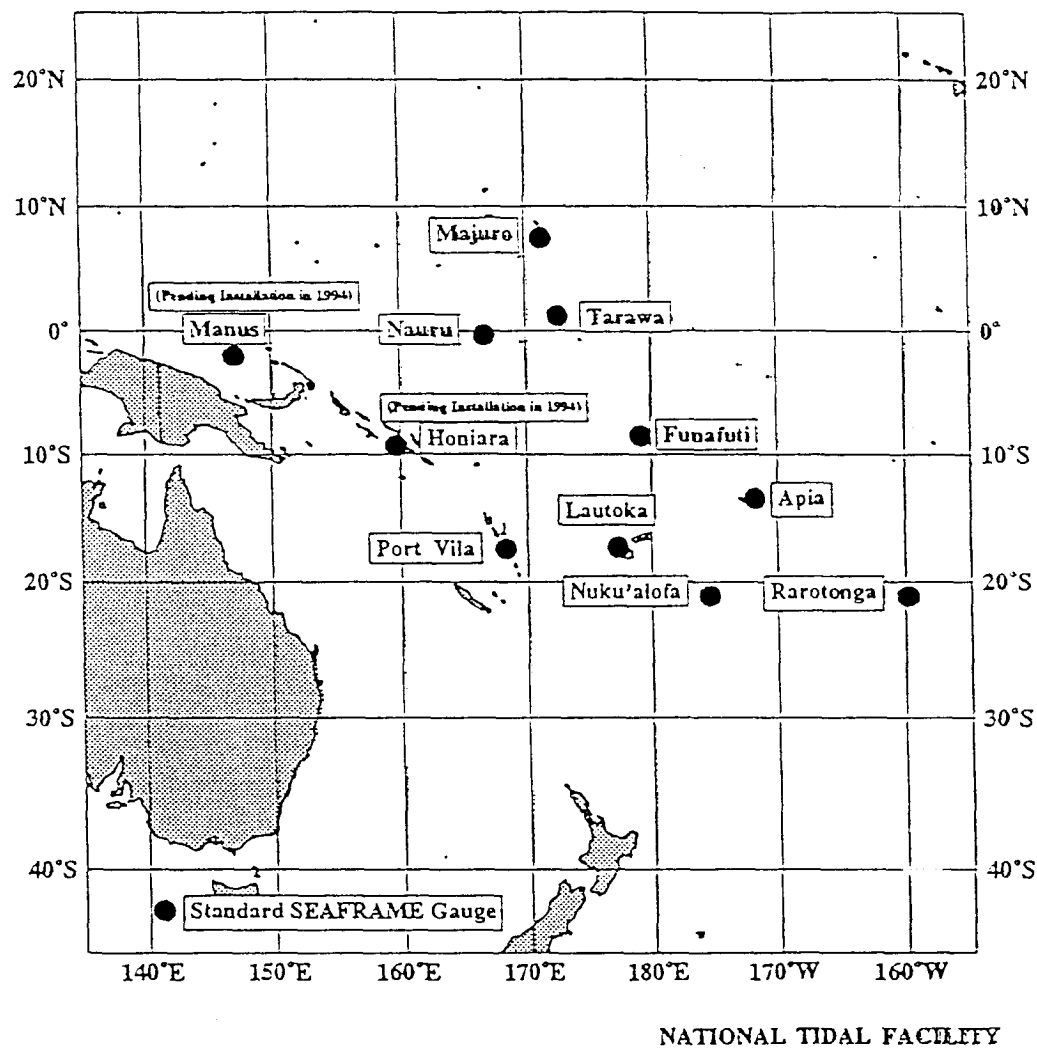


Figure 1 The array of 11 SEAFRAME stations in the South Pacific Sea Level and Climate Monitoring Project.

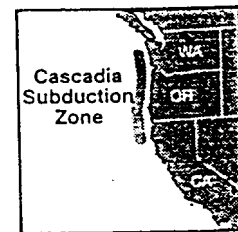
ANNEX VIII

TSUNAMI HAZARDS MITIGATION PLAN OF THE USA

Prepared by the National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory, Seattle, Washington, 31 March 1995

Executive Summary

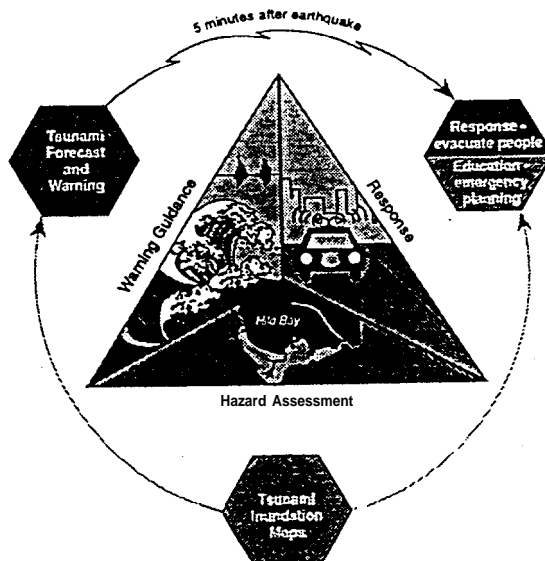
- **Senate Concern.** The threat to West Coast communities from destructive tsunamis generated by earthquakes in the Cascadia Subduction Zone.



- **NOAA Response.** Lead the first coordinated, comprehensive effort by Federal and State agencies, academia, and local communities to
 - identify needs of at-risk communities
 - inventory existing national resources
 - review recent technological advances
 - develop specific, practical recommendations



- **Tsunami Hazard Mitigation Plan.** Modernize and integrate existing national capabilities by exploiting recent technological advances. Focus on at-risk coastal communities. Provide each with effective
 - Tsunami Hazard Assessment
 - Tsunami Warning
 - Tsunami Educated Response



- **First Step.** Create necessary Federal/State partnership to examine each recommendation and oversee implementation of the agreed plan. Broad-based membership should include Federal, State, local and academic participation.

I. Background

The Senate Committee on Appropriations has expressed its concern about the destructive potential of a major tsunami to U.S. coastal communities and has issued the following directive to the National Oceanic and Atmospheric Administration (NOAA):

“The Committee directs NOAA to prepare a plan for a tsunami warning system that could reduce risk to coastal residents. The plan should evaluate sites for a tsunami warning system that would assist States in the mapping of possible tsunami inundation. The Committee expects such a report no later than March 31, 1995.” (Report on FY95 Budget, July 1994)

In response to this directive, NOAA has developed a plan to reduce the risk of tsunamis to coastal residents on U.S. coastlines. The strategy involves the use of new technologies along with better coordination of existing activities to reduce tsunami risk through an integrated program that focuses on:

- A. Hazard assessment (identify and map tsunami flooding potential)
- B. Real-time tsunami monitoring and warning systems (alert the people)
- C. Public education (population awareness and community response)

Intensive workshops to develop each component have been held with broad-based participation that included tsunami scientists, Federal, State, and local emergency planners and emergency operators. Workshop participants focussed on evaluation of new hazard assessment and mitigation technology. NOAA technical reports were published on each workshop. This document summarizes and synthesizes these workshop recommendations into a coherent plan.

II. The Problem

U.S. coastal communities are threatened by tsunamis that are generated by both local earthquakes and distant earthquakes. Local tsunamis give residents only a few minutes to seek safety. Tsunamis of distant origins give residents more time to evacuate threatened coastal areas but increase the need for timely and accurate assessment of the tsunami hazard to avoid costly false alarms. Thus, U.S. residents in Alaska can experience a local earthquake and tsunami while residents of Hawaii and the west coast may experience this disaster as a distant tsunami. Similarly, west coast residents can experience a local tsunami that may also have an impact on the distant states of Alaska and Hawaii. Of the two, local tsunamis are more devastating. The challenge is to design a tsunami hazard mitigation program to protect life and property from two very different types of tsunami events.



Figure 1. Tsunami hazard for the United States is defined by the earthquake zones capable of generating tsunamis in the Alaska-Aleutian Seismic zone, the Cascadia Subduction Zone, and Hawaii. The populations at risk from tsunami are identified as population centers.

1. The Greatest Threat—Local Tsunamis Generated Off the U.S. Coast

The Cascadia Subduction Zone threatens California, Oregon, and Washington with devastating local tsunamis (Figure 1) that could strike the coast within minutes. There is increasing geological and seismological evidence that: earthquakes of Richter scale magnitude 8 and more have previously occurred in this region; at least one segment of the subduction zone may be approaching the end of a seismic cycle culminating in such an earthquake; and, these earthquakes have generated tsunamis that have caused extensive flooding along the coastlines of Washington, Oregon, and California (Heaton and Hartzell, 1987; Weaver and Shedlock, 1992). Recent articles (Waethrich, 1994) indicate that the probability of a Cascadia earthquake occurring is comparable to that of large earthquakes in southern California (i.e., 35% probability of magnitude of 8 or above between 1995–2045). The Alaska and Aleutian Seismic Zone also has been recognized as a region with very high seismic

potential. Respected U.S. seismologists have predicted the occurrence (84% probability between 1988–2008) of a major earthquake with magnitude greater than 7.4 in Alaska (Nishenko and Jacob, 1990). When this earthquake occurs, Alaska's coastlines can be expected to flood within 15 minutes.

A reminder of this threat occurred in April 1992 when a small tsunami was generated at the southern end of the Cascadia Subduction Zone by a large (7.1 M_s) earthquake near Cape Mendocino, California (González and Bernard, 1992). This tsunami arrived at Eureka, California only 15 minutes after the earthquake origin time. No tsunami warning was issued because the instruments used to determine earthquake magnitude were outdated. During a post-earthquake scientific meeting on the Cape Mendocino earthquake/tsunami, sponsored by the Federal Emergency Management Agency (FEMA), one of the two most urgent recommendations suggested was the production of local tsunami inundation maps for Northern California coastal communities at risk. Tsunami preparedness was deemed to be of such high importance and urgency that the project was funded by FEMA and NOAA to produce tsunami inundation maps for Eureka and Crescent City, California. FEM also funded an earthquake scenario study of Northern California. The combined study

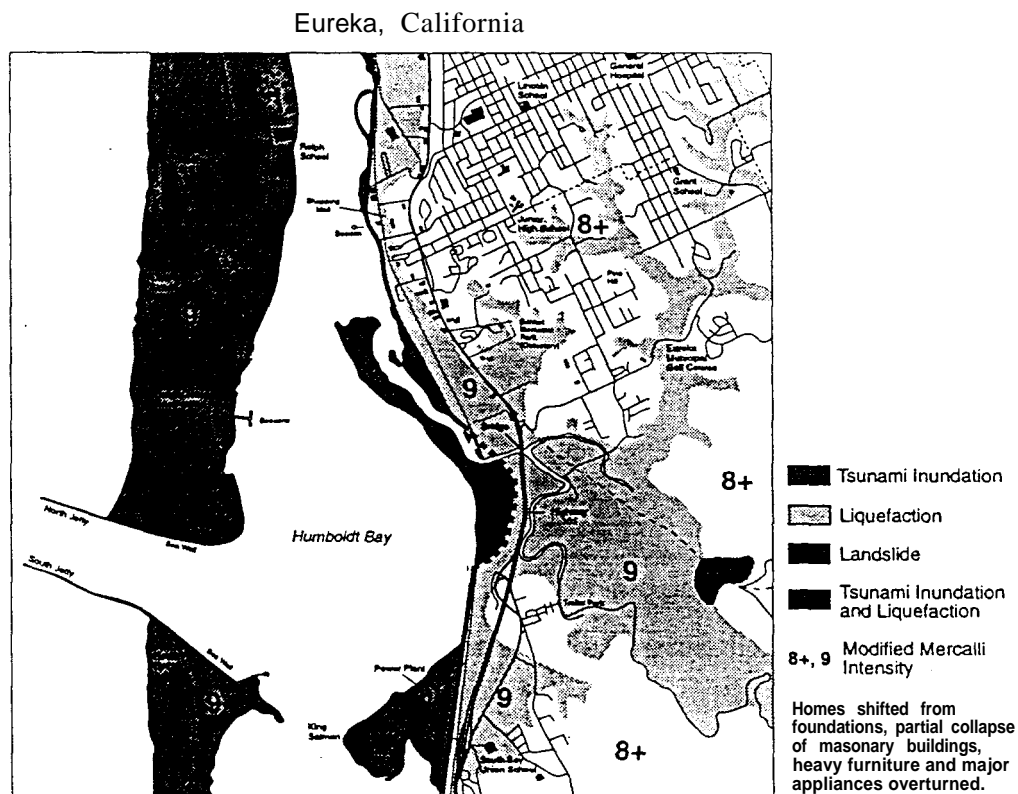


Figure 2. This map identifies areas of tsunami flooding, areas of liquefaction, landslides, and intense ground shaking. If the tsunami is generated by a local, major earthquake near Eureka, then highway 101 probably will be damaged by the liquefied soils to the south. Evacuation then would be feasible only to the north on highway 101. It is important to evacuate to safe areas.

produced the first comprehensive assessment of the nearby earthquake and local tsunami risk to a coastal community (Bernard *et al.*, 1994, and Toppozada *et al.*, 1995). The first-of-a-kind map is illustrated in Figure 2, which clearly shows areas susceptible to tsunami flooding, earthquake shaking intensity, earthquake-induced liquefaction, and earthquake-triggered landslides.

The Eureka tsunami study can be considered the prototype and model for the application of existing technology to local tsunami hazard assessment. These local tsunami hazard maps will be incorporated into the emergency plans of Eureka, California. This process, which starts in March 1995, will provide an opportunity for NOAA, FEMA, the State of California, and local Eureka emergency planners to set the standard for emergency procedures for other coastal communities threatened by local tsunamis.

2. The Silent Threat—Tsunamis Generated at a Distance

The U.S. has suffered major damage from tsunamis originating in Chile, Japan, Russia, and Alaska. If an earthquake in Alaska generated a major tsunami, Alaskan shores would be flooded within 15 minutes, while the coasts of Hawaii, Washington, Oregon, and California would be hit within 5 hours after the event. Under present conditions, the Alaskan and Pacific Tsunami Warning Centers (ATWC and PTWC) would issue warnings, based on seismic data alone, covering a limited area as soon as the earthquake is detected, located, and sized. It then would take about an hour for the Centers to receive conflation from Alaskan coastal tide gauges that a major tsunami had been generated. With conflation, the ATWC would expand its warning area to include the entire west coast of the United States, and the PTWC might issue a Pacific Basin-wide warning. Even at this time, the Centers would have only a rough idea of the potential size of the tsunami. They would receive no further information until the tsunami reached Midway Island (about 3 hours after the earthquake) or the west coast of the United States (4 to 5 hours after the earthquake). At that point, it would be too late for Washington and Oregon emergency managers to change their plans of operation, and Hawaii emergency managers would have only about an hour and a half to adjust their plans. Recently, the development of a method to detect, in real time, the passage of a tsunami in the open ocean could provide additional lead time to evacuate coastal residents.

For the Alaska earthquake/tsunami scenario, it is important to recognize that only Hawaii possesses a set of evacuation maps for the distant tsunami scenario. These maps were derived from tsunami inundation models and are published in local telephone directories. Once a warning is received in Hawaii, residents are evacuated from potential tsunami inundation areas. The other affected states have no similar maps. Lack of evacuation maps and timely tsunami wave information gives rise to confusion on how to respond to a NOAA tsunami warning. Lack of evacuation maps and timely tsunami wave information certainly contributed to the confusion caused by the October 4, 1994 distant tsunami warning. (See the Tsunami Education Workshop report (Good *et al.*, 1995).)

3. Conclusions

Local tsunamis are the greatest threat to U.S. coastlines, but distant tsunamis are also a constant threat. Technologies now exist to identify areas at risk from both types of tsunamis and to detect the passage of a tsunami in the deep ocean in real time.

III. Tsunami Hazard Mitigation Plan

Eventually, tsunamis will strike all U.S. Pacific Ocean coastlines. To mitigate any rapid onset natural disaster, it is critical to accurately assess the nature of the hazard, design an alerting technique, and prepare the at-risk area for appropriate reaction to reduce the impact of the hazard. Applying the conceptual model—hazard assessment, warning, and educated response—to the tsunami hazard is a way to reduce the inevitable impact of tsunamis. One way to think about the application of this model to the tsunami hazard is illustrated in Figure 3. The three interdependent pieces of the conceptual model are shown as a triangle.

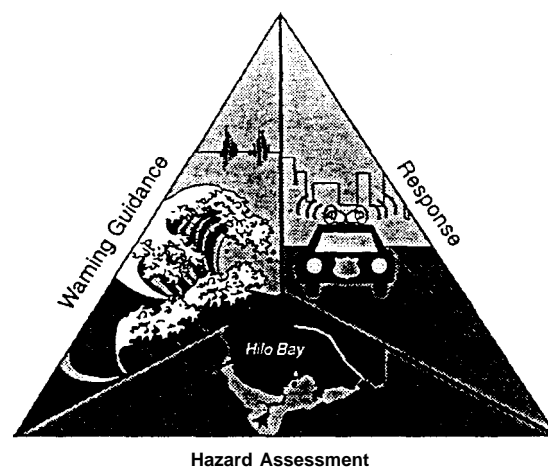


Figure 3. Tsunami Hazard Mitigation Model.

NOAA conducted the first comprehensive evaluation of existing tsunami hazard mitigation technology and user needs through a series of three workshops (hazard assessment, warning, educated response) held from November 1993 to October 1994. (For details about the workshops see Appendix A.) The process of involving Federal, State, and local representatives yielded a rich diversity of ideas and suggestions. The main theme that emerged was that the hazard affects local populations, so the solutions should be developed with input from these people. Below is a summary of the major findings and recommendations from each workshop. These major recommendations

form the basis of the NOAA plan to mitigate the U.S. tsunami hazard. Agencies involved in the mitigation plan at the Federal level include NOAA, United States Geological Survey (USGS), FEMA, and the Army Corps of Engineers. At the State and local level, emergency planning and operations are involved as well as universities.

A. Tsunami Hazard Assessment

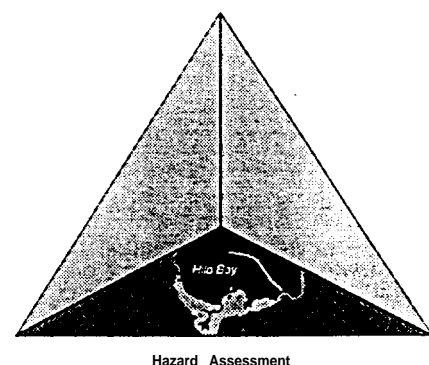
The base of the triangle in Figure 3 and the first element for designing appropriate warning and education systems is **hazard assessment**. For each coastal community, an assessment of the tsunami hazard must be carried out to identify at-risk populations and areas. For some communities, data from earlier tsunamis provide an empirical method for identifying hazardous areas. For most communities, however, little or no data exist. For these areas, tsunami inundation numerical models can provide estimates of areas that could be flooded in the event of a local or distant earthquake. The accuracy of this technology is appropriate to design the other two elements of the model—warning and educated response systems. Our first workshop found that existing technologies are adequate to produce tsunami inundation maps for emergency preparedness and documented several technical methods (Bernard and González, 1994). Participants were of the strong opinion that the production of these maps should be guided by local experts who had detailed knowledge of that geographical area. The participants also wanted these maps to be as accurate as possible, so they felt that the models should be tested and validated with observed data.

Major Finding:

- Technology exists to produce tsunami inundation maps for emergency preparedness.

Major Recommendations:

1. Establish a group of scientists to produce tsunami inundation maps for coastal towns in Alaska, California, Hawaii, Oregon, and Washington.
2. Tsunami inundation map production should be guided and implemented by State and local users.
3. Test and validate models with observed data.



B. Tsunami Warning

The second element of the conceptual model (Figure 3) is the appropriate warning system to alert coastal communities that danger is imminent. Three types of tsunami warning systems exist to alert populations of the occurrence of an earthquake that has high potential to generate a tsunami. The Pacific-wide system warns populations in about 1 hour (>750 km from the source); regional systems warn in about 10 minutes (100-750 km from the source); local systems warn in about 5 minutes (<100 km from the source). Three warning systems exist today. There is one Pacific-wide system-the Pacific Tsunami Warning Center; five well-established regional systems (U.S.-2, Japan, Russia, French Polynesia), and local systems exist in Chile and Japan (Bernard *et al.*, 1986). All three systems use earthquake magnitude as the trigger for warnings and use coastal tide stations as verification that a tsunami exists and as a guide to announce that the danger has passed. Because these systems are activated by earthquake magnitudes, and because not all earthquakes generate tsunamis, there are false alarms.

In the tsunami hazard mitigation model, warning systems are designed according to the local hazard assessment. For the U. S., the earthquake areas shown in Figure 1 subject California; Oregon, Washington, Alaska, and Hawaii to the local tsunami hazard and all coastal areas are exposed to the distant tsunami hazard. The tsunami warning system for the U.S. should provide local and distant tsunami warnings for coastal communities. Our second workshop found that the national effort to detect earthquakes in the states of California, Oregon, Washington, Alaska, and Hawaii consists of seven seismic networks with about 1000 real-time reporting seismometers at a capital cost of \$23 million and annual operating costs of over \$9 million. The participants of the workshop found that this extensive network could be utilized, with some modifications, to provide tsunami warnings within five minutes for any earthquake occurring along U.S. coastlines. Those modifications include 1) the inclusion of more real-time seismometers which can be used to quickly determine the magnitude of a large earthquake (broad-band seismometers); 2) the agreement that these data plus other real-time seismic data should be exchanged among the existing networks; and 3) the implementation of 24-hr/day in-office operations at the two existing tsunami warning centers.

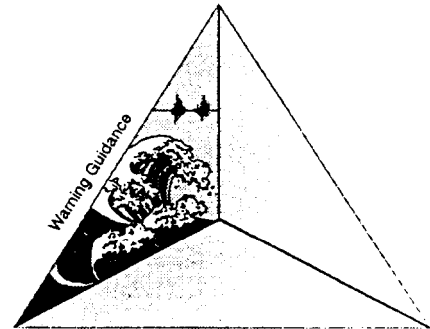
Participants felt that making better use of existing networks was preferred over the siting of a new tsunami warning center. If their recommendations are implemented, there is no need to create another traditional tsunami warning center on the West Coast.

They also found that the existing water level network of 12 real-time tide gauges in Alaska and Hawaii was inadequate to detect local tsunamis for forecasting local tsunami impacts. Participants recommended the modification of coastal gauges to detect large tsunamis. They recognized that the new technology to detect tsunamis near the source offers an improved approach to early detection and forecasting of tsunamis. With this realization, they recommended the installation of deep water tsunami gauges and the use of the resulting data for forecasting tsunami wave heights. Details of the

discussions and recommendations can be found in the tsunami warning workshop report (Kanamori and Blackford, 1995).

Major Findings:

- Technology exists to issue local tsunami warnings within five minutes for earthquakes occurring along U. S. coastlines.
- Existing water level system is inadequate to track large tsunamis in a timely manner.



Major Recommendations:

4. Upgrade existing seismic networks to include real-time instruments that provide more accurate earthquake magnitudes.
5. Implement a plan to coordinate the exchange of data among existing seismic networks.
6. Implement 24 hr/day in-office operations at two tsunami warning centers.
7. Install network of deep water tsunami gauges and modify existing coastal network to survive large tsunamis.
8. Develop procedures that incorporate water level data for forecasting local tsunami impacts.

C. Tsunami Response/Education

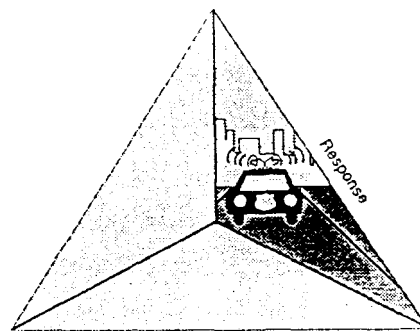
The third element of the tsunami mitigation model (Figure 3) is the educated response which is based on hazard assessment and warning systems. The appropriate response to impending danger from a tsunami requires knowledge of areas that could be flooded (tsunami inundation maps) and knowledge of the warning system to know when to evacuate and when it is safe to return. Without both pieces of information the response could be inappropriate and fail to mitigate the impact of the tsunami. Our third workshop found that the residents of Oregon, Washington, and California were unaware of hazard assessment and warning procedures. A FEMA survey of 14 coastal communities' response to the October 4, 1994 NOAA tsunami warning found the information unusable by 30 percent of the communities surveyed and not timely for 71 percent of the affected communities.

Workshop participants recommended the formation of an educational network to exchange existing information and keep abreast of new educational material being developed. Participants, recognizing that lack of tsunami inundation maps was a major obstacle in education of local residents, recommended the production of tsunami inundation maps as soon as possible. Workshop participants were concerned that each state may create different signs for guiding people out of

tsunami hazard areas, so they recommended that standardized signs for tsunami hazard zone and evacuation be used in all affected states. They were also concerned that too many “experts” were being used by the media during tsunami warnings, which led to public confusion. Participants recommended that each state establish a tsunami advisor to provide expert guidance to the media, decision makers, and emergency planners. A summary of this workshop can be found in the tsunami education workshop report (Good *et al.*, 1995).

Major **Finding:**

- Tsunami education for local and distant tsunami is deficient for West Coast decision makers and residents.



Major Recommendations:

9. Establish an educational network among local, State, and Federal agencies to promote communication and coordinate the exchange of existing and new information and assist in improving tsunami warning messages.
10. Produce preliminary tsunami inundation maps to aid in local educational process.
11. Develop standardized tsunami hazard zone and evacuation signs for use in Alaska, California, Hawaii, Oregon, and Washington.
12. Establish each state's single-point tsunami expert contact for media decision makers, and emergency planners.

D. The Plan

By combining the three elements—hazard assessment, warnings, and response—we have a context for implementing the workshop recommendations. A schematic summary of the plan is illustrated in Figure 4.

The tsunami hazard mitigation plan (Figure 3) uses hazard assessment to design appropriate warning systems and appropriate response by affected populations to reduce the impact of the tsunami. These three components must be highly interactive and well coordinated to mitigate the effects of a tsunami. Thus, a coordinating body of appropriate scientists, emergency managers, emergency planners, and warning center operators, with representations from each affected state, should be created to ensure this coordination.

NOAA Tsunami Hazard Mitigation Plan

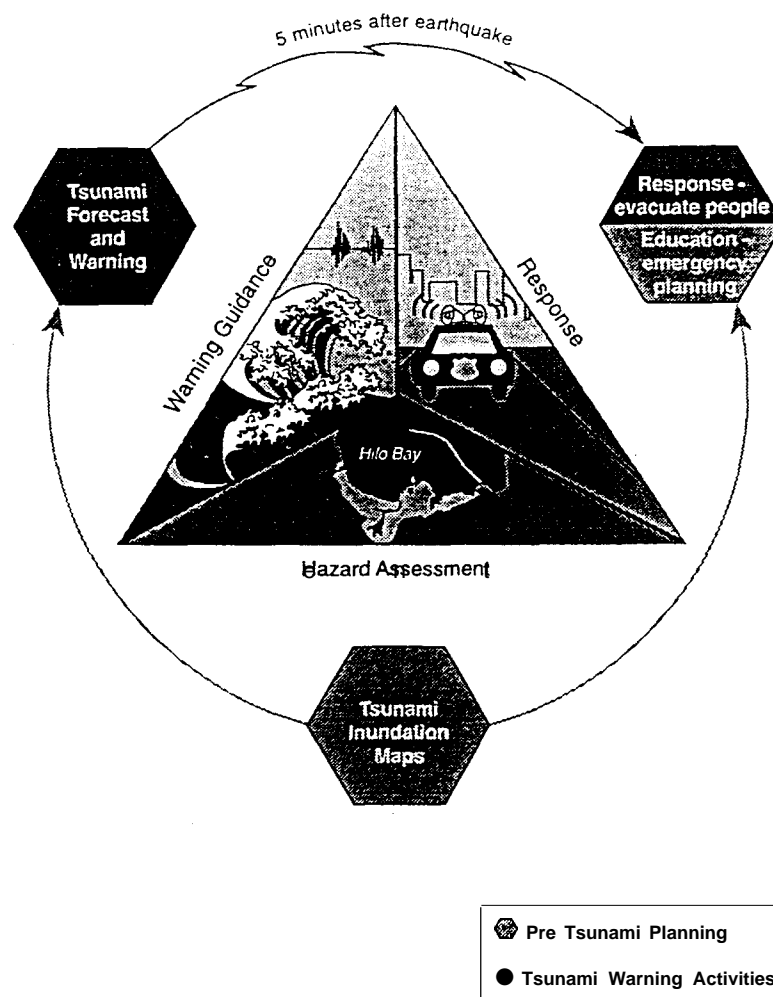


Figure. 4. NOAA Tsunami Hazard Mitigation Plan. Each element requires the participation of NOAA, USGS, FEMA, and the states' emergency agencies and universities.

IV. The First Step—A Federal/State Partnership

To implement the plan requires three phases:

1. Coordination
2. Planning
3. Implementation

The coordination phase is essential to form a coherent plan of action with time milestones. The three workshops provide a technical basis for identifying techniques and needs, but they represent only the first step in coordination. The next step is to form a Federal/State partnership to convert these recommendations into an action plan. The Federal side of the partnership should include NOAA, USGS, FEMA, and the Army Corps of Engineers. Since NOAA has Federal responsibility for tsunami warnings, NOAA should be the lead agency. The State side of the partnership should include Alaska, California, Hawaii, Oregon, and Washington. Each state should have a representative that could become the expert for that state (Recommendation #12). Through this process, a plan can evolve in which the Federal role to protect life and property is appropriately applied at the local level. The plan should outline what recommendations can be implemented at various resource levels. We must recognize that each state has a different emergency planning/operational structure and that the Federal government is downsizing. These two facts force us to use our existing resources as wisely and productively as possible.

The planning phase should emerge as soon as possible. The present document contains 12 recommendations that could be the essential elements of the plan. Coordination is required to establish a process to rank the recommendations. Once the ranking of recommendations is agreed upon, then the implementation phase can begin. The process of implementation will be controlled by resources available from all sources—the Federal sector, the State sector, and the private sector.

V. Conclusions

The three workshops on tsunami hazard assessment, warning guidance, and educated response have provided a set of recommendations that can reduce the impact of local tsunamis on West Coast residents. The next step is to rank these recommendations through a coordinating group composed of Federal/State partners and formulate a plan of action. The recommendations do not call for the siting of a new warning center, but rather the use of existing seismic networks through focused upgrades of instrumentation, telemetry, and processing. The recommendations provide for inundation mapping for all Pacific coastal communities through a process that involves local governments, including affected coastal residents.

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.ANNEX IX

STANDARDS FOR THE TSUNAMI SURVEY

by the ICG/ITSU ad hoc Working group for Standardizing Tsunami Survey Procedures
(including recommendation from the Field Survey Group Report of the Estes Park Tsunami
Measurements Workshop, as compiled by Jody Bourgeois and Costas Synolakis)

Introduction

With what seems to be an unprecedented number of locally destructive tsunamis occurring during the last three years in the Pacific, the need to develop systematic procedures for the collection and utilization of post-disaster survey data has become apparent. The international tsunami research community has been actively involved in collecting time-critical data sets that include field surveys, mareographic records, anecdotal reports, aerial reconnaissance surveys (by plane and satellite) and geodetic/bathymetric information. This collection of data has been helpful in verifying and refining numerical generation and run-up models with the purpose of mitigating the loss of life and associated property damage from future tsunami events.

The period of time immediately following a destructive tsunami can be an agonizing ordeal for local communities and their citizens. People have been killed or lost, buildings and homes are damaged, transportation and lifeline infrastructures may be wiped out and people are in a state of shock. Clearly the first order of business for any country and affected community following a tsunami is a period of grieving and rehabilitation. Recognizing these important human needs, post-disaster tsunami surveys must be conducted with sensitivity to these cultural requirements and with complete coordination with the host country. Every effort should be made to fully involve the host country in any post-disaster tsunami survey field work. Coordination through the ICG/ITSU (national contact) provides an excellent mechanism to ensure that field surveys will be sanctioned at the national and local levels.

A tsunami monitoring program must be organized in advance to plan for the post-tsunami measurements. For small to medium tsunamis, the after-event information is quickly perishable, especially for "unprepared observers". Water level measuring devices to detect and measure the presence of substantial water on land beyond the normal limits must be in place, and observers in target locations must be trained to note and preserve the effects before their disappearance, in all regions susceptible to tsunami attack.

Tsunami Field Surveys and the ICG/ITSU

PURPOSE: Improve post-tsunami surveys.

PROCEDURE: Establish standards for observations, measurements, and assessments on how to properly collect the data in a timely manner, and decide on the data to be collected. Develop guidelines for the conduct of the field investigation so as to enable the consistency of these data. Set procedures to organize survey teams, and dispatch them quickly and effectively, that is, almost immediately following the tsunami. Identify the needs to facilitate such surveys. Identify simple and efficient field survey equipment. Establish policies to manage and distribute post-tsunami survey data.

FINAL PRODUCT: Field Guide or Manual for Post-Tsunami Surveys, targeted -to scientists, engineers, government officials, planners, and field survey personnel in general, to whom copies should be distributed as soon as possible at low cost or free of charge. This Field Guide should be simple-easy to carry, read and understand, be translated into the languages of potentially affected countries, and be periodically updated. A prototype interview format, translated also into the local languages, must be included in the Guide. Appendix I contains components for a post-tsunami eyewitness interview, as recommended by Y. Tsuji and V. Kaistrenko, during the June 1995 Estes Park International Tsunami Measurements Workshop.

TOPICS (ISSUES):

1. Before the Field Survey

Selectivity

Develop a criteria to judge on a case by case basis, which tsunamis have the merits (based on preliminary information of the severity or accountable size of their effects, or the new scientific knowledge that might be learned, or the accessibility of the affected area, or availability of enough field personnel and funding) to qualify for a survey of an international team of experts. Define who is going to make the decision on the above.

Financial Support:

Allocation of a reasonable amount of money (US\$50,000 to \$100,000 per tsunami event) in the regular IOC budget for emergency operations immediately after the occurrence of each tsunami, to be assigned on a case by case basis, should be sought. Voluntary contributions from other national sources (governmental or private) such as the SGER program of the U.S. National Science. Foundation or international agencies are welcomed, and should be identified as soon as possible so that surveyors are prepared to act quickly in seeking such funding immediately after tsunami events.

Funding from the IOC should in particular be made available to enable participation of scientists without direct access to funding in their own countries, as well as to ensure that the necessary expertise be represented in any survey.

Funds should also be made available for training scientists and students from countries vulnerable to tsunami attack, both in field survey techniques and in principles of hazard mitigation.

Make-up of the Survey Teams:

Multidisciplinary composition (specialists in oceanography, engineering, land surveying seismology, geology, soil liquefaction, sedimentology, sociology, urban planning public health, and community leaders). From a previously made list of potential field survey personnel, indicating their field of expertise, previous experience, special skills, and time of the year when they are available, a selection of interested and capable persons, according to the specific needs of each case, should be made. Team members in target locations must be trained to note and preserve the effects before their disappearance, in all regions susceptible to tsunami attack. Training sessions may be needed.

In response to a request by the ICG/ITSU Chairman, after a recommendation of ITSU-XIV Session, the following Member States: Colombia, Fiji, Indonesia Japan, Mexico, New Zealand, Nicaragua, Philippines, Russian Federation, and the USA, provided a total of 51 names as a preliminary, potential list of field survey experts. The participation of more experts can be enhanced by a blanket call to all Tsunami Bulletin Board (TBB) members at the time of each event. ITIC should enhance and maintain current the list of scientists and use the TBB to develop and disseminate this information.

Basic training for the team to help in disaster relief efforts, first aid, communications, and public education, may be needed; although it should be stressed that these activities are not the main purpose of the field survey.

It is highly desirable that at least one of the team members represents the affected country and speaks the local language of the survey area. The local scientist's and authority's expertise and invaluable knowledge should be recognized in their participation in the survey. A limit on the size of the team, based on the availability of funds and the efficiency in operating under the difficult conditions of the affected area, should be set. Who is going to make the selection of the members of the team, needs to be defined.

Pre-Travel Procedures:

Consider ways to facilitate the access of the teams to the survey area. Visa arrangements, immunizations, letters of introduction or other identification documents, permits to access the affected area, transportation, accommodation and food for the team should be arranged **in advance with the help** of ICG/ITSU National Contacts in-place to expedite the surveys. Accident, health, and life insurance's should be arranged by the participants themselves. Contact with national academic institutions, International Organizations (ITIC, etc.), Consular officers, relief agencies (UNDRO, Red Cross), etc. may also be helpful. Agreements should be reached in advance on the procedures for the admission of the teams and custom clearance of the survey equipment and sediment samples, as well as other logistical matters.

Local authorities should not be overwhelmed with requests of visas, invitations, databases or reports at a rather inopportune time. International agreements should be arranged now between or among different countries to enable the rapid issuance of visas and invitation letters as necessary, in case of an event occurrence.

Communication and Coordination:

A national authority of the country to be surveyed (i.e. the ICG/TISU National Contact) should be named and made available through a real-time accessible address (e-mail, telephone, FAX) to the international community to coordinate the main aspects of the survey. Establish also the necessary links with the academic and operational community of the affected nations, who will be involved in the surveys, to help recruit local members for the team, and agree on how the information to be obtained will be shared, eventually the development of joint research activities. The electronic Tsunami Bulletin Board may be useful for this purpose. Those participating international experts *must work* hand-in-hand with the local survey experts.

Determine also the communication and logistical support needed from local sources, like: photocopiers, FAX and telephone lines, Internet accessibility, modems, cellular telephones, etc. Select a common meeting site adjacent to the stricken area. Coordinate with other groups who are performing similar surveys in the same place, so as to minimize or eliminate duplication of efforts and to share the information.

This coordination should not be aimed at excluding any individual from the effort, but rather at maximizing the effectiveness of surveys while remaining sensitive to local communities and cultures.

Instrumentation:

Identify types of instruments that might be permanently available for the infrequent occurrence of tsunamis, specifically sea-water level gauges and current meters, their adaptation to tsunami measurement digital sampling rates and record lengths (i.e. bottom or surface pressure transducers for low frequencies), their calibration, and/or the conversion of their measurements into valid tsunami information. Consider their survivability in the tsunami source and arrival regions.

Simple and reliable water level measuring devices to detect and measure the presence of substantial water on land beyond the normal limits must be in place. In advance to the survey, identify the existing instruments in the site, and collect their information.

Survey Equipment, Baggage, and Documents:

Field equipment Should be as simple and effective as possible for rapid surveying. This equipment should be listed and described in the Field Guide, and periodically updated. Identify and select the most suitable, portable, and easily accessible instruments for the parameters to be measured.

Sources where to buy, rent, borrow, or get them through inter-institutional cooperation. Eventually, stock pile basic equipment (or at least, have a computerized list of what and where to get it) in storage at some facility.

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Optical survey equipment, hand levels, stadia rods, synchronized chronographs, inclinometers, measuring tape, compass, and a small scale maybe essential. Hand pushable piston cores to take sediment samples, and a shovel to dig. A digital survey fathometer coupled to a GPS maybe needed. Do not forget the Tsunami Survey Field Guide. Consider the use of photographic, audio, or video recorders, and carry enough rolls of film, cassettes, tapes and battery supplies.

For remote locations, portable seismographs may provide valuable aftershock data-

Include portable light weight energy sources (i.e. solar panels to recharge batteries, small natural gas tanks, or generators, fuel) as required by the survey equipment and camping needs (stove, lamp, tent, etc.). Flashlights with extra batteries and lamps, matches in waterproof containers. A portable radio, portable (laptop) computers, papers, pens, portable telephones, clipboard, pocket knife, and waterproof packaging for documents should be carried. Appropriate clothing, hat, and shoes or boots for the climate and season of the year. Don't forget sun-screen and insect repellent lotions to complement the protective clothing.

Archives of maps (bathymetry and topography at a scale of 1:25,000 or finer), aerial photos, tidal gauge locations, and tide tables (or computer tide programs) to correct runup measurements for areas of high vulnerability to tsunami attack, should be assembled and maintained. Enlarge the maps by photocopying before embarking, to aid field note taking. In addition, lists of organization names, contact names and addresses of sources for these materials for all tsunami-prone areas of the world, including the Pacific, the Atlantic, and the Mediterranean, should be maintained. If such materials are not presently available for relevant areas, efforts to establish databases should be undertaken as soon as possible.

Design a pre-departure checklist including

- a) personal effects (toilet articles, Kleenex, Wash'n Dry, toilet paper, safety pins, scissors, sunglasses, alarm clock sewing kit, etc.)
- b) non-perishable emergency food and water' supplies to survive (canned mea& poultry, fish fruit, vegetables, and beverages; dry milk, cereals, coffee, tea, creamer, salt, pepper, sugar; disposable plates, cups, and napkins, a can opener, and pills to purify water, and
- c) first aid kit and prescriptions (adhesive tape, sterile cotton, antiseptic solution, aspirin, prescribed antibiotics, bandages, diarrhea medication ear drops, laxative, petroleum jelly, rubbing alcohol, toothache remedy, thermometer, etc.)

Include this list in the Guide.

Credit cards and foreign currency (if you survey outside your country) are also a need.

Education, Training, and Information:

Local scientists in particular have the opportunity for quick-response surveys, before valuable field data may be lost. So, it is important to provide opportunities, means or ways to transfer and disseminate survey technology, standards, and procedures, through training, to as many as possible potential field survey personnel (like: scientists, engineers, government officials, and planners) from tsunami-prone countries (expected to be affected by local or remote source generated tsunamis), so as to become as a common practice for them.

The formulation of a proposal similar to EERI's current LFE Project supported by National Science Foundation, but called "Learning from Tsunamis", with the primary purpose to observe and document the effects of tsunamis and the resulting economic, social, and policy impacts, could be a useful means for training and methodology transfer.

2. While in the Field Survey

Logistics and Generalities:

Set operational procedures in the field, task role, expectations and responsibility assignments to each specialist according to his/her expertise. The team should spend a day in training before breaking up into field parties. Each field party should include at least one local scientist/representative, as well as at least one person with prior surveying experience.

For all kinds of measurements, the field surveyors must know how to evaluate and report on the quality of the collected data. All physical measurements should be located as precisely as possible on maps and/or air photos.

Use of a Log-book as part of or attached to the Field Guide, with outline and diagrams of basic procedures and techniques, checklist and examples of data to be collected, forms to record the data in a way that can be archived and retrieved in a standard fashion during post-processing and free space for sketches and additional notes and comments on unusual observations. Guidelines can be provided in form of a list or a questionnaire. A glossary of terms would be useful. A prototype interview format translated into the local language should be used to conduct interviews (see Appendix I).

Site Selection:

Select specific sites, like small bays, stretches of open coast, estuaries, beaches, to document a complete case history of all the tsunami effects, trying to obtain sets of coherent stand-alone data of the parameters to be measured. Impossible, capture a broad overview of the area with photographs.

Parameters:

Identification of a set of parameters simple and fast to measure or estimate, so as to make them easily comparable and valid for subsequent surveys and research applications. Various measurements should be coupled to enhance their usefulness.

Horizontal Positioning:

Determination with enough accuracy by means of GPS, or map location. Absolute map locations are preferred as GPS positions may not plot accurately due to signal errors or datum irregularities.

Water Upper Vertical Reach:

Measurement by standard line of sight levels, GPS, or other methods to, impossible, 25 cm accuracy.

Runup definition and Reference Datum for runup: agree on a single definition and a unique reference level (i.e. Mean Sea Level, Mean Lower Low Water if referred to a chart datum, or local tide level (LTL) at the time of arrival or during the tsunami). Runups heights measured relative to the local tide level (shoreline elevation) at the place and time of each particular measurement should be corrected to the common Reference Datum selected.

For the above mentioned correction, it is essential that all hand watches used by the surveying personnel should be synchronized and set to a standard time signal, and each runup measurement time be recorded. Find out if standard or daylight savings time was locally used at the time of the tsunami occurrence, during the survey, in the local tide gauge records, and tide tables. Get the nearest tidal gauge records available for the site.

Be aware that a proper correction to a common Reference Datum and a standard time is a critical and important issue for further interpretation of the data.

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Whenever and wherever possible (but at least in one site), a surveying transect should be measured and drawn between the maximum horizontal inundation watermark and the shoreline (or even into the surf zone). At least, at each site, the maximum runup and the maximum water level (which may in some cases be the same measurement), as defined below, should be measured. The two kinds of data should either be plotted on separate diagrams or be distinguished by different symbols. Recommended definitions for these two magnitudes are as follows:

1.- Maximum runup is the difference between the elevation of maximum tsunami penetration and the elevation of the shoreline at the time of tsunami attack (i.e., corrected for the difference in shoreline elevation between the time of measurement and the time of tsunami attack).

2.- Maximum water level is the difference between the elevation of the highest local water mark and the elevation of the shoreline at the time of tsunami attack (i.e., corrected for the difference in shoreline elevation between the time of measurement and the time of tsunami attack).

As many measurements as possible should be made of runup and water level, with precise locations of measurements plotted on maps or air photos (optionally also locate by GPS), and preferably with sketches of the measurements, as well as photos.

Locate existing benchmarks in the area and use them as reference to check datum and measurements. Obtain GPS corrected vertical positions of the benchmarks to detect possible land uplifting or subsidence due to the earthquake.

Be able to identify localized extreme runups due to “funneling” in narrow valleys, channels, and creeks, or “seiches” in semi-enclosed bays. Agree on a criteria when to: a) perform averaging of runup values on beaches of complex topography, where randomness of the flooding process occur, to obtain a single representative value; or b) avoid averaging of runups, but rather report crude observed data.

Use of GPS as compared to Traditional Techniques:

Use of the Global Positioning System (GPS) technology may help in more timely and efficient collection of tsunami runup data following destructive tsunami events, and to identify land subsidence or uplifting due to the earthquake. Where traditional surveying techniques using measuring tapes, parallax distance finders and bubble levels produce satisfactory results, they are not necessarily the most efficient in time and manpower. Traditional techniques are, however, relatively inexpensive. While GPS technology has shown dramatic improvements in accuracy and cost, the equipment remains relatively expensive for the high accuracy systems.

Accuracy and Equipment

Traditional techniques used in past tsunami field surveys yield accuracy in the horizontal and vertical planes on the order of 5% of the total distance or height measured. Equipment requirements are modest. Recording keeping, a running log of measurements, and personnel (at least 3) are the most demanding aspects of traditional survey techniques.

GPS equipment has basically automated the measurement and record keeping aspects of surveying. Unfortunately, to obtain the same level of accuracy requires fairly sophisticated equipment that is easy to use (with appropriate training) but still expensive. Currently good enlarged maps and air photos are more accurate for plotting position locations than the most easily available GPS technology, particularly for vertical measurements. Four price points and hence four levels of accuracy in equipment are available.

1. Lowest Accuracy, +/- 100 meters horizontal & vertical resolution, is available using off-the-shelf consumer equipment priced at less than \$1,000 per hand-held unit. A single hand-held unit by itself provides the position.

2. Meter accuracy equipment, about 1 meter in the horizontal and about 3 meters in the vertical, are the next two price points. Equipment in this category is either hand held or a small back-pack w/antenna. Price varies between \$7,500 to \$20,000. Data logging capability included. A base-station GPS receiver, separate from the hand-held or back pack receiver, is required to obtain GPS corrections used in obtaining and maintaining the high level of accuracy needed for this price-point and better. Telemetry linking the base-station and the roving GPS receiver is required for real-times fixes; without this option the final, corrected fix is obtained after the day's work running a post-processing program.

3. Survey equipment in the submeter accuracy range provides horizontal control of 10 cm or less and vertical accuracy better than 0.5 m. Expect to pay \$40,000 to \$60,000 for this equipment. Data logging capability included Base-station GPS receiver required

4. Geodetic equipment, in the millimeter range, is cumbersome and even more expensive and not appropriate for this application.

Mobilization

Traditional survey equipment is easily mobilized for field work Transportation is generally not a problem to the survey site.

GPS equipment is, even with the more accurate systems, not particularly cumbersome. - It is, however, more delicate and is packed in oversized foam-lined containers for air transport as accompanying baggage. Since it is sophisticated electronic equipment, there may be hassles clearing foreign country customs without some local, on-site help. Once in the field, the equipment is ready to operate; most are powered by rechargeable batteries that are recharged overnight. So, power is required to maintain and operate the equipment for day-to-day operations,

Markings:

To help identify maximum horizontal and vertical runup. Use of high water marks ("bathtub rings") on walls and structures, and other indicators, like: lines of landward limit of sea grass, debris, sediment, or floating garbage deposition (distinguish from deposition due to normal high tides), horizontal boundaries between vegetation killed or damaged by saltwater and surviving vegetation (discoloration after a few weeks is a good indicator), amounts of bark stripped from trees, and levels of seaweed or debris caught in screens or other structures. Notice if upper, middle or lower parts of houses (windows, roofs, etc.) or structures are damaged, semi-destroyed or intact, and identify if this was due to earthquake shaking or tsunami arrival. Clothes, fishes, dead cattle, and/or other objects or animals caught and hanging in upper branches of trees. Be able to distinguish real run up marks from splashes and from damage marks produced by high floating objects or debris. Always draw sketches if it is possible. Trees broken, bent, uprooted, or overturned Vegetation destroyed and transported. Debris transported and deposited inland. Its type, size (boulders, rocks, driftwood, sand, etc.) and weight (or density) should be measured if possible. Overtopping of coastal structures and destruction of existing tide stations maybe an indicator, too.

Horizontal Flooding:

As conventional definition, inundation is the maximum *horizontal* penetration of the tsunami from the shoreline. Determine this maximum intrusion inshore from MLLW line or other reference line. Delineate in a map, and estimate distances by means of tape, laser, radio frequency equipment, or by visual range (parallax) finder, or (exceptionally) with a car odometer or counting paces,

Currents:

Document evidences of flow direction and/or flow strength.

Estimation of magnitudes through their effects (drag, inertia) on fixed sizable objects and structures, and in floating objects (boats, ships) carried inland. Measure grain size and density of the sediments being transported.

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Geological Information:

Identify, locate and estimate the extent of possible coastal uplift or subsidence and its influence in the tsunami runup. GPS vertical positioning of existing benchmarks, as mentioned before, may be useful. Submerged vegetation or presence of green leafy plants growing in the inter tidal zone, or uplifted barnacles, may be also an indicator of subsidence or uplifting, as well as changes in the level of high tides reaches after the tsunami.

Presence of cracks, liquefaction, tilting or warping in the ground should be noticed and documented. Evidences of fault creep and direction of the motion.

Observe and detect the presence of sand, silt or mud sheets eventually deposited by the tsunami beneath tidal marshes, in flat "meadows" shoreward of ponds, above the height of barrier beaches, or in coastal lagoons. Take vertical core samples with plastic tubes on lines perpendicular to the shoreline, across the surfaces of transport and deposition, till the reach of maximum incursion. Dig trenches and photograph the sediments. Measure the thickness and horizontal extent of the sand layer deposits, and their vertical distribution of grain sizes inside them (use settling tube analysis for fine resolution in a range of 1.5 micron to 2 mm, roughly, if it is possible); and detect the presence of wood detritus and rooted plants as evidence of sudden sand coverage by the tsunami. Identify the areas of eventual erosion, motion and settlement of the sediments by the tsunami waves, but distinguish between beach erosion caused by the tsunami itself from long-term ones (appeal to eyewitnesses).

Identify the presence and eventual influence of landslides of earth or ice in water bodies, in the generation of the tsunami.

Seismological Information:

During the survey, at remote areas, obtain aftershock data from portable seismographs

Profile"

Estimate beach slopes with hand-held inclinometers, or other optical survey equipment. To save time, do the profiles in conjunction with other field observations.

Bathymetry: With the help of a fathometer coupled to a GPS or to UHF radio links for positioning perform a survey of the near-shore bottom of those coastal areas not covered with enough resolution by the available charts, or where substantial changes due to sediment transport by the tsunami may have taken place. A small boat or vessel will be needed.

Timing and Other Characteristics, through Eyewitness Interviews:

Interviews can be invaluable in helping distinguish actual effects of the events (earthquake, tsunami) from pre-event conditions and post-event changes Like damage clean-up.

Whenever possible, interviews should be conducted by local representatives, as interviewers should be sensitive to the emotional condition and cultural practices of interviewees. Obviously, a native-language speaker will facilitate the process. Non-technical language should be used, and leading questions (i.e, questions that suggest an answer) should be avoided.

Appendix I contains components for a post-tsunami eyewitness interview, as recommended by Y. Tsuji and V. Kaistrenko, during the June 1995 Estes Park International Tsunami Measurements Workshop.

Document through eyewitness interview, measurement of instruments, or local press reports, the times of arrival and periods of the tsunami waves, their number, time of tsunami arrival after earthquake shaking, and the total

duration of the tsunami. Did the water recede before the arrival of the first wave or not? Were there “noises” heard? Were the waves of a bore type or not? What was the approach direction of the incoming waves? Be aware of eyewitness interviews, which may vary significantly in reliability.

Document the eventual propagation of tsunami *bores* upstream in estuaries. Detect or identify the influence of any local basin resonance amplifying the tsunami response, and the influence of existing islands, offshore rock formations, or other local bathymetric features present in the continental shelf. Consider the width of the continental shelf. Notice any influence of local topographic geometry in the runup patterns, and damping due to bottom friction.

Make an attempt to describe qualitatively or quantitatively the tsunami waves behavior in the beaches, harbors, etc. (i.e. by refraction, diffraction, scattering, trapping or other physical phenomena) and give a preliminary explanation of the observed inundation patterns.

Audio-Visual and Non-Traditional Survey Methods:

Photos, video, and audio should be considered, but only to augment and not to replace field note taking. Photogrammetry, aerial videos, side scan bottom profilers to assess sea bottom ground deformation, and other methods, should be considered if there is a need, and a financial support.

The dimensions of local reference points (e.g., of a remaining house) should be measured in order to calibrate stereo air photographs.

Collect additional information from local newspapers, radio, and TV reports, and other local sources.

Damage Assessment:

Rough (non specialized) classification; estimate of nature and category of the damage, and to what apparent cause is due: a) primary agents: hydrostatic (pressure, buoyancy) or hydrodynamic (surge, drag) or b) secondary impact by debris or driftwood, fires from electrical vaults or oil ignition, explosions, contamination from hazardous materials or toxic fume releases, lack of ground support by scouring torrent of receding waters, etc. Overtopping of breakwaters, decks, or other coastal structures. Sand erosion or deposition in beaches. Distinguish earthquake from tsunami damage.

Ancillary (Auxiliary) Data and Background Information:

Early availability of good resolution bathymetry, coastal topography (scale 1:25,000 or less) including coastal configuration, geological maps, and seismotectonic information (name and strike or slip type of existing main and subsidiary faults, their location, total length and eventual portion ruptured), to help define source region and mechanisms for early model simulation that may identify most probably affected areas and locations for the survey teams to visit.

Availability and use of aerial photographs and satellite images to help locate affected areas to be surveyed.

Social Impact:

Rough estimate towards gaining an overview of the impact of the tsunami on: human behavior, public services, communication lifelines (roads, rail lines, airport runways, utilities, etc.), disruption of everyday activities, casualties and injuries, performance of emergency management agencies and the degree of effectiveness of the response plans in effect, homeless and displaced persons due to the tsunami. Note changes in the water quality due to the tsunami, and possible resulting diseases.

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Response of different segments of the population (elderly, disabled, minors, etc.) to the warnings. Reasons for lives lost: inadequate warning?, inadequate evacuation?, inadequate preparedness? Make general recommendations.

If needed, get involved in seminars or short lectures for community leaders, government officials, and the general public, on tsunami risk, simple mitigation measures, preparedness, and response issues. Take brochures about tsunamis to hand out. Use the survey as an opportunity to train local and/or international scientists and students. Show sensitivity to local needs, culture, and customs.

Computer Modeling:

Type and quality of data to be collected during the survey for modeling requirements.

Purpose and time frame of the simulation: a) to help determine runoff and inundated areas in almost real time to improve the early warnings, or b) for future better understanding of the phenomena in general, or of any particular event, or c) to do risk mapping for preparedness planning.

Ultimately, what to be used for ? : research, or operational warnings, or early estimates of flooding, or for better determination of the source mechanisms by inverse methods, or for engineering design purposes.

Consider the simulation of specifically unusual cases, like tsunamis generated by landslides.

(These are also issues for next Section: 3.- After Field Survey)

Reconnaissance:

The team should be able to assess and report the need for follow-up research and recommend specific areas that merit attention for subsequent surveys. Any new data collection technique which may arise and aid to improve future surveys should be reported too.

3. After the Field Survey

Report:

Write down the basic general information, with enough detail as it might be needed, and report it to the sponsoring agency (IOC) and the International Tsunami Information Center (ITIC). Participants in the surveys are expected to voluntarily, upon request, contribute with brief reports for the Tsunami Newsletter edited by the ITIC. Comprehensive reports may be required by sponsoring institutions or for presentation at international meetings and symposiums. Brief reports submitted on the electronic Bulletin Board can be helpful for other members of the tsunami community, and should be posted as soon as practical after the return of the survey teams.

Gathering, Processing, Sharing and Distribution of Post-Tsunami Data:

Adopt as a policy to share the information for the benefit of all parties (broad dissemination and accessible storage are the key issues).

Establish uniform procedures and guidelines to standardize the collection, formats, processing archiving distribution, dissemination and availability of the data through existing Centers (ITIC, NGDC, JMA, WDC A and B) or new ones. Funding should be requested to establish new or expand the present tsunami repositories.

Examples of data to be managed: a) bibliographic, b) marigrams, c) tables, d) charts and graphics, e) photos and videos, f) audios.

Options of media to store it: publications, reports, cassettes, diskettes, CD-ROM's, etc.

Classical Photocopies, mail, FAX) as well as most advanced electronic superhighway technology to distribute and give access to the community to the information, like the development of interactive multimedia documentation (use of World Wide Web browsers like Mosaic or Netscape for digital images, graphs, interactive maps, computer generated animations in MPEG or Quicktime formats), and on-line Bulletin Board via Internet for text and tables, etc.

Photographs, charts and other forms of visual data should specifically be posted on World Wide Web sites, The WWW can also be used effectively to point to data repositories. WWW sites should be further developed (with funding made available for such development), with attention to levels of interest and access, from general public to community planners to scientists.

Whereas some potentially affected countries (or parts thereof) do not have broad access to these new electronic superhighway technologies, concise written reports should also be made available.

APPENDIX I

Recommended components of a post-tsunami eyewitness interview

As noted above, whenever possible, interviews should be conducted by local representatives, as interviewers should be sensitive to the emotional condition and cultural practices of interviewees. Also, obviously, a native-language speaker will facilitate the process. Interviewers should also be aware of certain pitfalls in collecting eyewitness data. For example, interviewees should be asked to indicate physical location of water levels, rather than to state numerical elevations of water. Non-technical language should be used, and leading questions (i.e., questions that suggest the wording of an answer) should be avoided. In general, questions asking eyewitnesses to describe observations in their own words will elicit more reliable information than yes/no questions, or questions where certain words are suggested to the interviewee.

I. BASIC INFORMATION

- a. Interviewer's name, date and time of interview.
- b. Interviewee's name, address, profession, gender, age,
- c. Collect various possible place names (town, village, colony, topographic), as these may vary from person to person, and may differ from maps; locate information on maps or air photos (GPS only if map not available).
- d. Where was interviewee: 1) before, 2) during and 3) after the event(s)? (Distinguish earthquake, tsunami waves, etc.)

II. EARTHQUAKE INFORMATION

- a. What was the magnitude of the earthquake, as determined from the Mercalli scale--include MMI Table translated into native language.
- b. If earthquake occurred during night, how many people were awake or awakened?
- c. Distinguish main shock from possible fore- or aftershocks.
- d. Identify casualties and damage from earthquake(s) (include damage report form?).
- e. Eyewitness accounts of liquefaction or sand blows? Cracks in ground? Landslides, rock falls, etc. ?
- f. Did well water become muddy? Change level?
- g. Were any precursors to earthquake noticed?

III. TSUNAMI

- a. What was the situation before the tsunami? -meteorological conditions, sea level, light conditions, sounds (noise)
- b. Arrival time of wave(s)?
 - absolute time--from clocks, TV programs, etc.
 - by feeling--time between main shock and wave arrival(note that an aftershock may come between main shock and tsunami arrival time)

c. Nature of first wave arrival? (interviewer may ask, e.g., if water went out first; but this can be a leading question--try to get witness to describe water behavior without leading them on)

d. How many times did water rise (how many waves were there)?

How much time between waves? (did water completely withdraw and come back again? did people return to houses in between?) What was the relative size of waves (which was largest, etc.)?

e. What did the wave(s) look like? e.g., calm, slow flooding (like a fast tide); like a river, like a swell (with white cap, like a breaking wave), like a wall (bore)

f. From what direction did the water come, in which direction did it go? ‘

g. Describe any sounds or noise associated with the tsunami waves--before the arrival? at the time of arrival? e.g., like a drum, like thunder, like an airplane, like rain, like a car, like a river, no sound....

h. What changes in the land surface did the tsunami make? Places where there was erosion? (what did it look like before?), places where it left sediment (deposits)? (what did it look like before?)--identify rocks, debris, houses, ships, etc. moved by tsunami (where were they before?)

i. Damage due to the tsunami?

Casualties: number of deaths, number of missing, number of serious injuries, number of minor injuries.

House damage (due to tsunami): number swept away, number totally destroyed, number partially destroyed, number flooded. Damage to cars, ships, port facilities, roads, agricultural fields, etc. Health effects since the events--diseases, changes in water quality/availability, ‘etc.

j. Area inundated by tsunami?

Indicate physical points (e.g., on houses, trees, fences) to which water rose; maximum distance inland water reached (locate physically)

k. Estimates of how far down/out the water shifted before or between waves (reliability of these answers maybe questionable)

1. Precaution and evacuation

Did they have knowledge/expectation that tsunami would come, before the event? Had they received any education? Experience of or knowledge of previous events? How did they escape? Where there obstacles?

IV. AFTERSHOCKS AND AFTERSHOCK TSUNAMIS

If these occurred, the same basic questions need to be asked, as above, about earthquake(s) and tsunami.

V. CRUSTAL MOVEMENT

These indicators may not be obvious or easy to distinguish in the time shortly following the event--weeks to months till help clarify temporary changes (e.g., flooding) from actual crustal deformation.

a. Has sea level changed since the event(s)?

b. Rocks or coral reefs emerged? By how much? (be careful to distinguish rocks or coral moved by the tsunami from bedrock or attached coral uplifted by crustal deformation).

c. Areas now submerged? By how much? (be careful to distinguish changes due to erosion or temporarily undrained flooding from indications of permanent land level change)

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VI. OTHER INFORMATION/INFORMANTS

- a. Names of other eyewitnesses? In particular, names of others who may have seen events from different perspectives (e.g., from a hill, from a boat, etc.)?
- b. Knowledge of people who took photographs, videos, etc.?
- c. Knowledge of others who have collected interviews, data?

VII. FOR THOSE WHO WERE IN BOATS

- a. (as above, determine where they were, etc., before, during and after ? where is the boat now?)
- b. What did the sea surface look like?
(e.g., boiling shaking, foaming ripples or waves)
- c. How did the boat behave? Was there damage to the ship/boat?
- d. Did you note any other phenomena? (e.g., fish behavior, light, etc.)

VIII. FOR OLDER PERSONS

- a. Have you experienced any other events like this in your lifetime? (when? describe such events)
- b. Did your parents/grandparents experience any such events?
- c. Do you know of stories or legends of such events that have been handed down?

ANNEX X

SELECTED RECOMMENDATIONS FROM THE PRELIMINARY REPORT OF THE INTERNATIONAL TSUNAMI MEASUREMENTS WORKSHOP

(Estes Park, Colorado, USA, 28-30 June 1995)

The following recommendations were made at the International Tsunami Measurements Workshop held in Estes Park, Colorado, USA from 28-30 June 1995 which are of relevance to the ICG/ITSU activities:

1. INTERNATIONAL TSUNAMI DISASTER SURVEY TEAMS

An international body (ITIC) needs to co-ordinate post tsunami disaster teams by:

- (a) Developing and maintaining a list of potential members from relevant specialties and countries. (Addressed in Agenda Item 4.1 of ITSU-XV);
- (b) Preparing a field guide to improve standards and thoroughness of surveys (Addressed in 4.1);
- (c) Providing support to the team with information on histories of previous events, bathymetry, available marigraphic gauges, locations, maps, contacts, etc., (Addressed in 4.1).

The Intergovernmental Oceanographic Commission needs to co-ordinate post tsunami disaster team by:

- (a) Securing entry into the disaster area with the agreement of the affected country, (Addressed in 4.1).

2. INSTRUMENTATION

- (a) Encourage the development and deployment of modern, multi-user, digital, broadband water-level sensors (Addressed in 3.1, 11);
- (b) Encourage the deployment of instruments in priority gap areas and to gather research and operational data in deep sea, exposed coasts, harbours and the inundation zone.

3. MODELLING

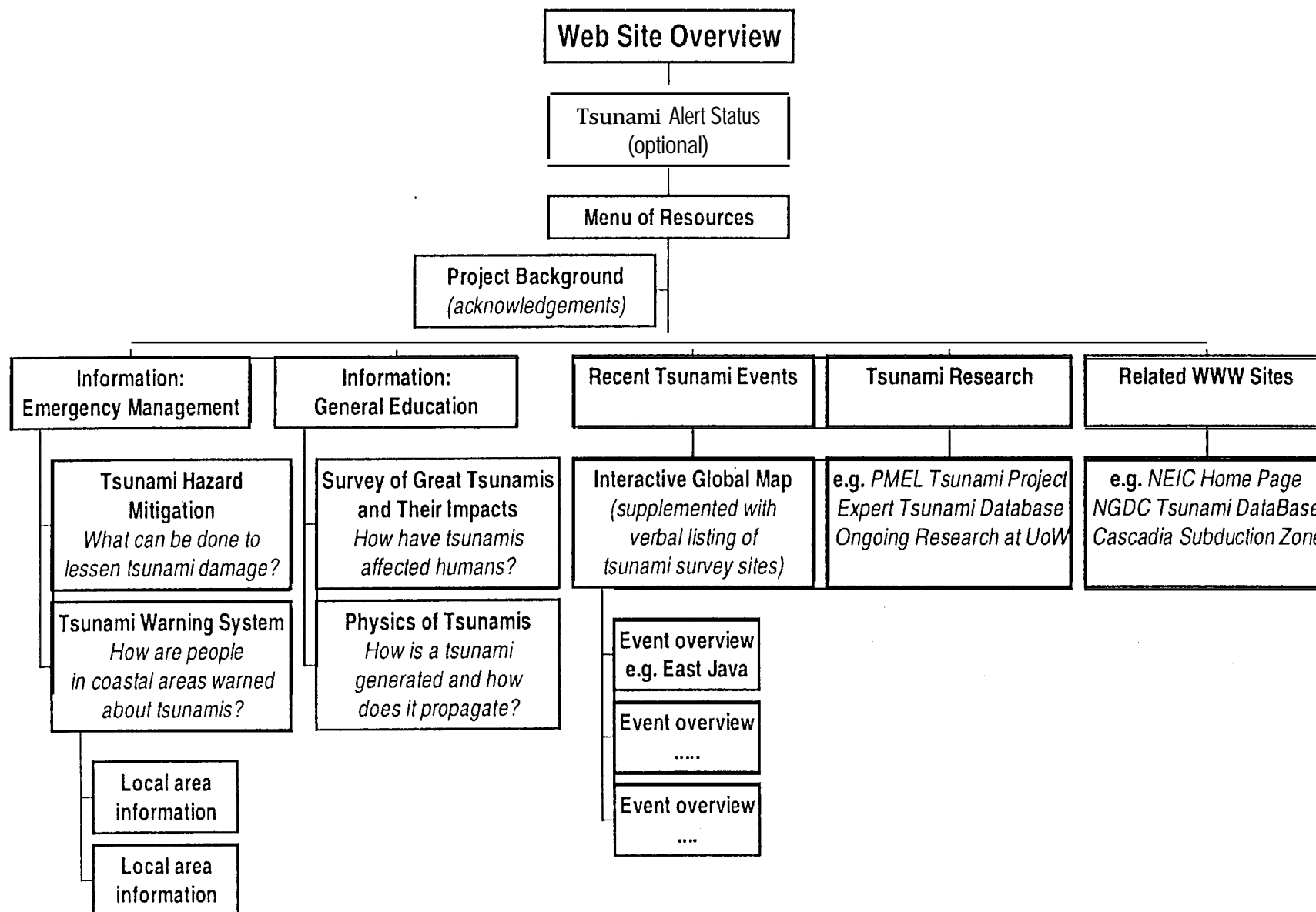
Models are useful for inundation mapping, real-time, wave-height prediction, source studies and training.

- (a) Continued develop work is needed on all types of models;
- (b) Continued use of the TIME project model for training should be supported (Addressed in 3.2).

4. MITIGATION

- (a) New and improved historical databases are needed in most areas (Addressed in 7.3);
- (b) Additions to the databases and the continued development of the expert tsunami database is supported (Addressed in 3.3).

Prototype for Tsunami WWW Browser



ANNEX XI

Tsunami World Wide Web (WWW) Browser

Motivation:

Access to written, visual and audio tsunami information over the Internet for

- R e s e a r c h
- Emergency Management
- Public Education

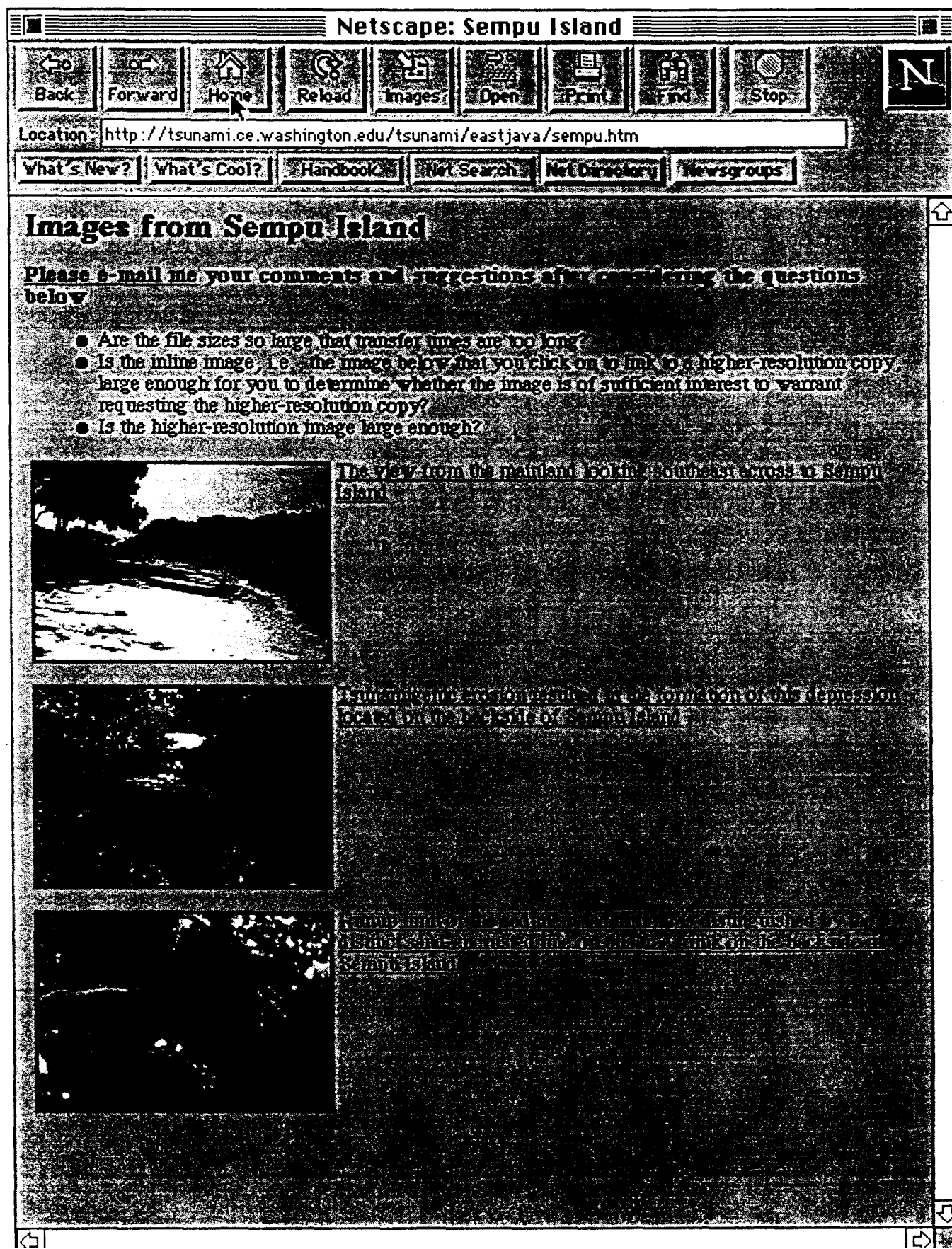
Organization:

- Administered at an international level
- Contributions maintained by individual investigators
- Physical location of information resources transparent to end users

Requirements:

- Non-platform specific
- Efficient information retrieval
- Minimal download time (with options for more data for high tech users)
- Minimum user system requirement:
2400 Band Modem. Black and White monitor, text based access software





Netscape: Recent Tsunami Events

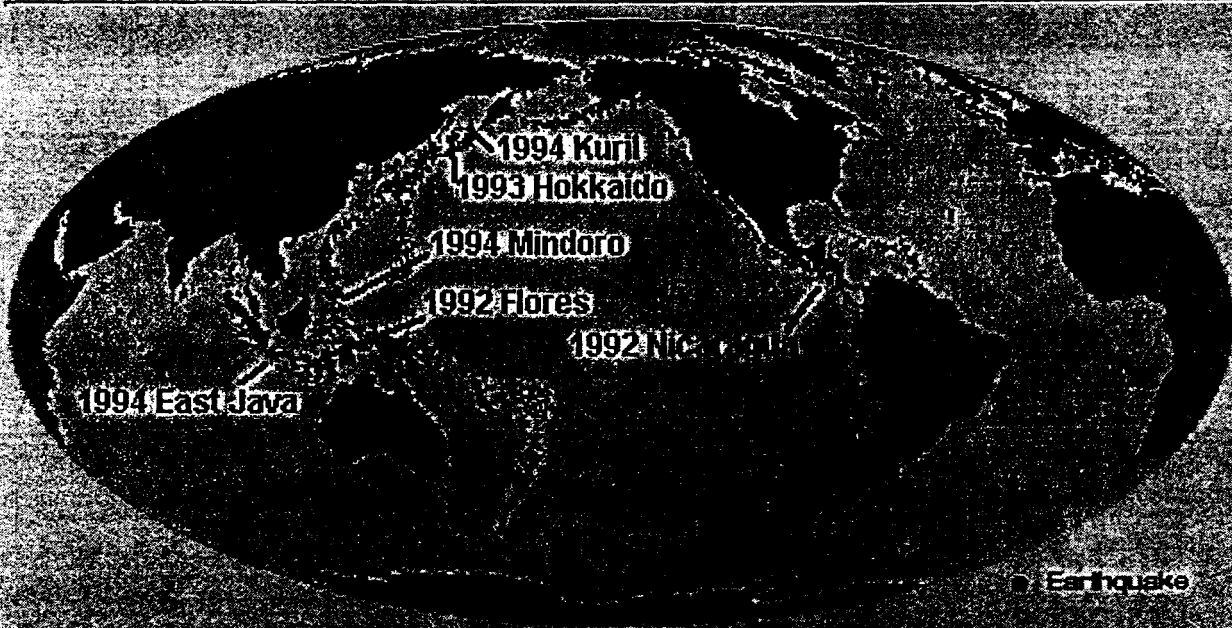
Back Forward Home Reload Images Open Print Find Stop

Location: <http://tsunami.ce.washington.edu/tsunami/events.htm>

What's New? What's Cool? Handbook Net Search Net Directory Newsgroups

Recent Tsunami Events

To obtain more information about a particular event, click on the text in the map below or choose an item from the event list.



1994 Kuril
1993 Hokkaido
1994 Mindoro
1992 Flores
1992 Nicaragua
1994 East Java
Earthquake

Events

- 1994 Mindoro
- 1994 Kuril
- 1994 East Java
- 1993 Hokkaido
- 1992 Flores
- 1992 Nicaragua

ANNEX XII

LIST OF ACRONYMS

ATWS	Australian Tsunami Warning System
CEC	Commission of the European Communities
CICESE	Centro de Investigación Científica y de Educación Superior de Ensenada (Mexico)
CMA	China Meteorological Administration
ECHO	European Community Humanitarian Office
ETDB	Expert Tsunami Data Base
GITEC	Genesis & Impact of Tsunamis on European Coasts
GTS	Global Telecommunication System
ICG/ITSU	International Co-ordination Group for the Tsunami Warning System in the Pacific
IDNDR	International Decade for Natural Disaster Reduction
IOC	Intergovernmental Oceanographic Commission
ITIC	International Tsunami Information Centre
IUGG	International Union of Geodesy & Geophysics
JICA	Japan International Co-operation Agency
JMA	Japan Meteorological Agency
NGWLMS	Next Generation Water-Level Measurement System
NOAA	National Oceanic & Atmospheric Administration (USA)
PMEL	Pacific Marine Environmental Laboratory
PTWC	Pacific Tsunami Warning Centre
PTWS	Pacific Tsunami Warning System
TBB	Tsunami Bulletin Board
TEMA	Training Education & Mutual Assistance in Marine Sciences (IOC)
TWS	Tsunami Warning System
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific & Cultural Organization
WDC	World Data Centre
WMO	World Meteorological Organization
WWW	World Wide Web