

**U. S. DEPARTMENT
OF COMMERCE**

**ENVIRONMENTAL
SCIENCE SERVICES
ADMINISTRATION**

**COAST AND GEODETIC
SURVEY**

Washington Science Center
Rockville, Maryland 20852

**INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
REPORT OF THE
WORKING GROUP MEETING ON
THE INTERNATIONAL ASPECTS OF THE
TSUNAMI WARNING SYSTEM IN THE PACIFIC**

Honolulu, Hawaii, April 27-30, 1965



May 17, 1965

**INTERNATIONAL TSUNAMI INFORMATION CENTER
P. O. BOX 3830
HONOLULU, HAWAII 96812**

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
REPORT OF THE
WORKING GROUP MEETING ON THE INTERNATIONAL ASPECTS
OF THE
TSUNAMI WARNING SYSTEM IN THE PACIFIC
Honolulu, Hawaii, April 27-30, 1965

In accordance with Resolution III-8 of the Intergovernmental Oceanographic Commission, there was convened in Honolulu, Hawaii, a Working Group Meeting on The International Aspects of The Tsunami Warning System in The Pacific. Meetings were arranged by the U. S. Coast and Geodetic Survey on behalf of the Intergovernmental Oceanographic Commission, and held at the East-West Center of the University of Hawaii, April 27 through 30, 1965.

Representatives were present from Canada, Chile, Republic of China, France, Japan, Mexico, New Zealand, Peru, Republic of the Philippines, USA, USSR, Western Samoa, Inter-American Geodetic Survey, Intergovernmental Oceanographic Commission, Tsunami Committee of the International Union of Geodesy and Geophysics, World Meteorological Organization, Ryukyu Islands, and the Trust Territory of the Pacific. A complete list of participants is attached.

Following welcoming addresses by the Governor of Hawaii, the President of the University of Hawaii, the Director of the U. S. Coast and Geodetic Survey, and the Deputy Director of the UNESCO Office of Oceanography, Dr. Harris B. Stewart, Jr., (USA) was elected Chairman, Dr. Kiyoo Wadati (Japan) was elected Vice Chairman, and Mr. Doak C. Cox (IUGG) was appointed Rapporteur. Summaries of the existing tsunami warning systems in their own countries were given by the representatives from Canada, Chile, Republic of China, France (New Caledonia and Tahiti), Japan, Mexico, New Zealand, Peru, Republic of the Philippines, USA, USSR, and Ryukyu Islands, plus summaries of the systems in the Trust Territory of the Pacific Islands, and in the area covered by the operations of the Inter-American Geodetic Survey.

Detailed minutes of these meetings are attached; but, in summary, discussions were held on the tidal monitoring aspects of tsunami warning systems, seismic aspects, and the communications aspects, and these led directly into a discussion of the means whereby improvements at both the national and international levels might be effected. The final morning was devoted to lectures and discussions of tsunami research, both on present research being carried out and on recommendations for future research in this field. The final afternoon, the full meeting reviewed, edited, and approved a set of 17 specific recommendations which it hereby

transmits to the Intergovernmental Oceanographic Commission. Recognizing the importance of having an effective means for warning the residents of low-lying areas of the Pacific of the impending arrival of a destructive tsunami, and further realizing that effective international cooperation and coordination are essential to the operation of any system to provide such warnings, the Working Group on The International Aspects of The Tsunami Warning System in The Pacific strongly urges the adoption of these recommendations.

Three Annexes are appended to this report:

Annex I - List of participants

Annex II - Recommendations

Annex III - Proceedings of the meetings.

May 17, 1965

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION CONFERENCE
ON THE
INTERNATIONAL ASPECTS OF THE TSUNAMI WARNING SYSTEM
APRIL 27-30, 1965
EAST-WEST CENTER, HONOLULU, HAWAII

DELEGATIONSCANADACHILECHINA, REPUBLIC OFFRANCEJAPANPARTICIPANTS

Dr. George L. Pickard
Institute of Oceanography
University of British Columbia
Vancouver 8, Canada

Capt. Guillermo Barros (Chairman)
Director del Instituto Hidrografico
de la Armada
Valparaiso, Chile

Mr. Ricardo Montaner
Jefe, Seccion Mareas y Corrientes
Instituto Hidrografico de la Armada
Valparaiso, Chile

Dr. Kenneth T. C. Cheng
Director, Taiwan Provincial Weather
Bureau
64, Kung Yuen Road
Taipei, Taiwan, Republic of China

Dr. Claude Blot
Institut Francais D'Oceanie
Noumea, Nouvelle Calédonie

Dr. Takuzo Hirono
Japan Meteorological Agency
Otemachi, Chiyoda-ku
Tokyo, Japan

Dr. Ryutaro Takahasi
Chuo University
Bunkyo-ku, Tokyo, Japan

Dr. Kiyoo Wadati (Chairman)
National Scientific and Technological
Center for Disaster Prevention
Bosai Center
6-1 Ginza-Higashi
Chuoku, Tokyo, Japan

MEXICO

Dr. Nicolas Grijalva
Instituto de Geofisica
Universidad de Mexico
Mexico City, Mexico

NEW ZEALAND AND
WESTERN SAMOA

Mr. J. W. Brodie
NZ Oceanographic Institute
Wellington, New Zealand

PERU

RADM Esteban Zimic V.
Director de Hidrografia y Faros
Ministerio de Marina
La Punta (Callao) Peru

PHILIPPINES, REPUBLIC OF

Mr. Jaime J. Tecson
Chief Meteorologist
Philippine Weather Bureau
P. O. Box 2277
Manila, Philippines

UNITED STATES OF AMERICA

Dr. J. Wallace Joyce
Office of International Scientific
Affairs
Department of State
Washington, D. C.

RADM H. Arnold Karo (Chairman)
Director, U. S. Coast and Geodetic
Survey
Department of Commerce
Washington, D. C.

Mr. Leonard M. Murphy
Chief, Seismology Division
U. S. Coast and Geodetic Survey
Washington, D. C.

Dr. John S. Rinehart
Asst. Director for Research and
Development
U. S. Coast and Geodetic Survey
Washington, D. C.

Dr. Harris B. Stewart, Jr.
Deputy Asst. Director for Oceanography
U. S. Coast and Geodetic Survey
Washington, D. C.

Mr. Bernard D. Zetler
Office of Oceanography
U. S. Coast and Geodetic Survey
Washington, D. C.

UNION OF SOVIET
SOCIALIST REPUBLICS

Dr. Uyriy V. Tarbeev (Chairman)
Chief, Section of Hydrometeorological
Guarding of Sea Fleet and Fishing
Industry
Hydrometeorological Service
St. Pavlik Morosov, 12
Moscow

Mr. Mikhail I. Golubnitchy
(Official USSR Translator of Ministry
of Foreign Affairs)

INTER AMERICAN -
GEODETIC SURVEY

Mr. Maurice A. Tewinkel
U. S. Army SOUTHCOM
Inter American Geodetic Survey
Fort Clayton, Canal Zone

INTERGOVERNMENTAL -
OCEANOGRAPHIC COMMISSION

Dr. Richard P. Von Herzen
Deputy Director
Office of Oceanography
IOC-UNESCO
Place de Fontenoy
Paris 7^e France

INTERNATIONAL UNION OF
GEODESY AND GEOPHYSICS,
TSUNAMI COMMITTEE

Mr. J. W. Brodie (Also New Zealand)

Mr. Doak C. Cox
Hawaii Institute of Geophysics
University of Hawaii
Honolulu, Hawaii

Mr. Leonard M. Murphy (Also USA)

Dr. George L. Pickard (Also Canada)

Dr. Ryutaro Takahasi (Also Japan)

Dr. William G. Van Dorn
Scripps Institution of Oceanography
P. O. Box 109
La Jolla, California 92038

Dr. Kiyoo Wadati (Also Japan)

Mr. Bernard D. Zetler (Also USA)

Mr. Leonard M. Murphy (Also USA)

WORLD METEOROLOGICAL
ORGANIZATION

RYUKYU ISLANDS

Mr. Michio Shiroma
Ryukyu Weather Bureau
Ameku, Naha
Okinawa, Ryis

TRUST TERRITORY OF THE
PACIFIC ISLANDS

Mr. John E. Welch
Director of Communications
Trust Territory of the Pacific
Islands
Saipan, Mariana Islands

CONFERENCE SECRETARIAT

Mr. Joel B. Campbell
International Activities Officer
U. S. Coast and Geodetic Survey
Washington, D. C.

OTHER PARTICIPANTS

Dr. W. M. Adams
University of Hawaii
Honolulu, Hawaii

Dr. R. Barkley
U. S. Bureau of Commercial Fisheries
Department of Interior
Honolulu, Hawaii

Mr. Roy L. Belknap
U. S. Weather Bureau
Honolulu, Hawaii

Honorable John A. Burns
Governor of Hawaii
Honolulu, Hawaii

RADM T. J. Fabik
U. S. Coast Guard
Honolulu, Hawaii

LCDR L. T. Gray
U. S. Navy
Pearl Harbor
Honolulu, Hawaii

Dr. Gordon W. Groves
University of Hawaii
Honolulu, Hawaii

Dr. Thomas H. Hamilton
President, University of Hawaii
Honolulu, Hawaii

OTHER PARTICIPANTS (Cont'd.)

Dr. Robert W. Hiatt
Vice-President for Academic Affairs
University of Hawaii
Honolulu, Hawaii

Mr. Edwin Ihli
Federal Aviation Agency
Honolulu, Hawaii

LCDR K. William Jeffers
U. S. Coast and Geodetic Survey
Ewa Beach, Oahu, Hawaii

Mr. John C. Marr
Area Director
U. S. Bureau of Commercial Fisheries
Honolulu, Hawaii

Dr. Gaylord R. Miller
U. S. Coast and Geodetic Survey
Washington, D. C.

Mr. J. W. Osmun
Honolulu Regional Office
U. S. Weather Bureau
Honolulu, Hawaii

Mr. T. J. Sokolowski
U. S. Coast and Geodetic Survey
Ewa Beach, Oahu, Hawaii

Mr. Mark Spaeth
U. S. Coast and Geodetic Survey
Washington, D. C.

LCDR Ray M. Sundean
U. S. Coast and Geodetic Survey
Room 10, Bldg. No. 1, Pearl Harbor
Honolulu, Hawaii

LCDR Floyd J. Tucker, Jr.
U. S. Coast and Geodetic Survey
Ewa Beach, Oahu, Hawaii

Mr. Ronald L. Viets
U. S. Coast and Geodetic Survey
Ewa Beach, Oahu, Hawaii

Col. Glenn M. Vinguist
Defense Communication Agency
Hawaii

OTHER PARTICIPANTS (Cont'd.)

Dr. Martin J. Vitousek
University of Hawaii
Honolulu, Hawaii

Capt. David M. Whipp
Honolulu Field Office
U. S. Coast and Geodetic Survey
Honolulu, Hawaii

RECOMMENDATIONS

The Working Group on the International Aspects of the Tsunami Warning System in the Pacific urges that the Intergovernmental Oceanographic Commission take appropriate steps to insure the implementation of the following recommendations. These are designed to provide for the development of the most expeditious, efficient, and effective methods for providing advance warning of impending tsunamis. It is therefore recommended that:

1) An International Tsunami Information Center be established on a permanent basis to collect and interpret seismic and sea-level data on a real-time basis to act as a source from which national centers may obtain data on which to base their warnings, and further that the United States Government be asked to strengthen its present tsunami warning service based at the Honolulu Observatory to enable it to act in addition as the International Tsunami Information Center, but it is also anticipated that other nations may be prepared to assist in operating this Center, for instance by providing personnel.

2) The Intergovernmental Oceanographic Commission establish an International Coordinating Committee for the Tsunami Warning System in the Pacific to:

- (i) effect liaison among the participating countries at the technical level, particularly with regard to communications,
- (ii) ensure exchange of information on developments of observing methods and of techniques of tsunami forecasting,
- (iii) effect liaison and coordination with the Intergovernmental Oceanographic Commission, World Meteorological Organization, and the International Union of Geodesy and Geophysics -- particularly with its Tsunami Committee, and
- (iv) provide essential secretarial service for the International Tsunami Information Service and for the International Coordinating Committee.

This International Coordinating Committee should meet biennially, and preferably a few months before each meeting of the Intergovernmental Oceanographic Commission, or oftener if required, to review the technical aspects of the System and to prepare recommendations to the Commission regarding improvements in the System which require action by member governments.

3) The Intergovernmental Oceanographic Commission encourage the exchange of scientific and technical personnel among the various national tsunami warning and research centers.

4) The attention of member states be drawn to Resolution III-7 of the Commission which asks member states having surplus tide gauges that they are willing to lend or present to other countries to inform the Secretariat of the Commission so that this information may be promulgated in International Marine Science, and further that seismographs be similarly considered.

5) Further emphasis be placed on the recommendation in Resolution III-8 of the Commission that member states of the Commission in the Pacific area who are not part of the present Tsunami Warning System establish adequate internal communications and responsible administration, establish and operate seismic and tidal stations, and integrate their Systems with that currently in operation. And further that the Commission emphasize to member states the importance of establishing adequate internal national communication networks a) as a prerequisite to joining the Tsunami Warning System and b) so that warnings of tsunamis generated by earthquakes close to their coasts may be initiated from the national center concerned.

6) Emphasis be given to the importance of promptly submitting seismic and tidal records associated with significant tsunamis to World Data Centers A and B so that the information can be used in developing the history of past tsunamis and for research on their nature. It is suggested that the procedure for submission and the provision for additional stations be as specified in the resolution of the IUGG Tsunami Committee, August 1963, and later adopted by the ICG-WDC.

7) An informal tsunami newsletter be prepared by the International Tsunami Information Center for the assistance of tsunami workers and include:

- (i) news of changes in national tsunami warning systems,
- (ii) summarized progress reports on individual tsunami research projects,
- (iii) listings of available tsunami research data such as digitized tide gauge records used in spectral analysis, and

- (iv) bibliographical references to new tsunami research papers. And further, this information be made available for consideration for publication in International Marine Science.

8) The International Coordinating Committee explore the possibility of establishing a standard code for the transmission of seismic and sea-level data.

With regard to sea-level data:

9) In order to have tide gauge data intercomparable among stations, each participating member state be requested to provide to the International Tsunami Information Center:

- (i) a station description of each gauge (including type, size of well, size of orifice, etc.) and of its location,
- (ii) a plotted position on an appropriate large scale chart,
- (iii) several typical tsunami records, if available,
- (iv) results of any power spectrum analysis, if available.

And further, that reports of tidal data for use in the Tsunami Warning System be in the English language and in metric units, using four digits to the nearest centimeter (i.e., 2.85 meters should be reported as 0285).

10) There be a general expansion of the tide station network in the Pacific for the use of the Tsunami Warning System with due consideration also being given to the research uses of sea-level data. Both uses should be considered in site selection.

11) Whenever possible tide gauges that are part of the Tsunami Warning System should be located on the open coast rather than in harbors or behind protective reefs.

With regard to communications:

12) The urgent communications requirements of tsunami data transmission in the Pacific include the requirement for the allocation of radio frequencies which should be made part of the recommendations of the IOC Working Group on Communications.

13) The highest priority be assigned to all messages transmitted as part of and in support of the Tsunami Warning System.

14) The communication links between USA, Japan, and USSR and other areas, such as Latin America be improved. Presently, Japan acts as a relay link between USSR and USA, but in addition the most rapid communications between USSR and USA should be explored.

15) The Intergovernmental Oceanographic Commission take steps to have prepared a summary of the existing international communication links which could serve the Tsunami Warning System.

With regard to seismic data:

16) Any country not participating in the system but having suitable seismic stations whose data could be very useful for determining the elements of any strong earthquake be asked to cooperate by sending its seismic data to the appropriate center as part of the System.

With regard to research and development:

17) The Commission draw the attention of member states to the urgent need for additional support for tsunami research and equipment development.

Cooperative tsunami research efforts among scientists of all countries should be encouraged.

Areas of necessary research include:

- (i) methods of describing ground motion from seismic and barometric evidence, and development of techniques for rapid analysis of such motion,
- (ii) the mode of transfer of energy from the earth to the water,
- (iii) tsunami period and amplitude measurements in the deep sea,
- (iv) study of one-and two-dimensional propagation of tsunami waves over irregular topography,
- (v) study of the transformation of tsunami waves produced by near-shore topographic features,
- (vi) study of tsunami runup,

- (vii) additional bathymetric surveys to facilitate study of propagation, transformation, and run-up of tsunami waves,
- (viii) assessment of tsunami characteristics in terms of earthquake characteristics,
- (ix) development of improved equipment and techniques required for telemetering seismic and sea-level data; eventual automation of sea-level recording; rapid low-magnification seismic recording, deep-sea tsunami detection, etc. Equipment standardization and intercalibration should be encouraged, and
- (x) development and use of modeling techniques for tsunami studies.

Honolulu, Hawaii
April 30, 1965

PROCEEDINGS

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORKING GROUP MEETING ON THE

INTERNATIONAL ASPECTS OF THE TSUNAMI WARNING SYSTEM IN THE PACIFIC

27 - 30 April 1965

East-West Center, University of Hawaii
Honolulu, Hawaii

Morning session, Tuesday, 27 April

Welcoming addresses

The initial session was opened by Dr. Harris B. Stewart, Jr., U.S. Coast and Geodetic Survey at 10:00.

John A. Burns, Governor of Hawaii, welcomed the participants to Hawaii, expressing hopes for accomplishment of the purposes of the conference.

Dr. Thomas A. Hamilton, President of the University of Hawaii, remarked on the importance of the conference topic to Hawaii. He invited participants to visit all parts of the University of Hawaii, including the Hawaii Institute of Geophysics.

Admiral H. Arnold Karo, Director of the U.S. Coast and Geodetic Survey, welcomed the delegates on behalf of the USA Government. He pointed out limitations in the existing tsunami warning system, stressing the problems connected with locally generated tsunamis and the need for rapid communication.

Dr. R. P. Von Herzen, Deputy Director, Office of Oceanography, UNESCO, welcomed participants on behalf of the Intergovernmental Oceanographic Commission. He stressed the size and importance of the Pacific and the limitations of understanding of characteristics of tsunamis. The existing tsunami warning systems, largely national in character and functioning internationally primarily through the USA system by bilateral agreements, have saved many lives. It is hoped that the conference will formulate recommendations for forwarding to the IOC.

Organization of the Conference

Upon nomination by Admiral Zimic and second by Dr. Cheng, Dr. Stewart was chosen chairman of the conference. By nomination of Admiral Karo and second by Dr. Brodie, Dr. Wadati was chosen vice-Chairman. With the approval of the conference, Dr. Stewart appointed Messrs. Cox, Brodie, Zimic, and Tarbeyev as rapporteur and assistant rapporteurs, respectively.

Mr. Joel Campbell of the U.S. Coast and Geodetic Survey discussed arrangements and logistics of the conference, and announced the addition of a visit to the Hilo tsunami hydraulic model to the program on Friday morning.

Mr. Doak Cox of the University of Hawaii, announced an informal post-conference trip to the Island of Hawaii, with priority for non-U.S. participants.

Dr. Stewart discussed the agenda of the Conference, as proposed in advance, and this was approved by the Conference.

Summary of existing warning systems

Canada

The Canadian warning system was discussed by Dr. G. L. Pickard. Warnings are received from the Honolulu Observatory via U.S. Navy Communications Unit in Seattle by the Royal Canadian Navy Communication Station at Victoria B.C. These are passed:

- 1) to the Dominion Astrophysical Observatory, Victoria B.C., which observes seismographs and reports back to Honolulu via the same channels;
- 2) to the Tofino, B.C., tide station where the tide record is read. Deviations from normal are reported by the same route to Honolulu;
- 3) to the British Columbia Civil Defense Coordinator who passes all alerts and warnings to the Royal Canadian Mounted Police, for transmittal to coastal communities, low lying areas are evacuated in the occasion of warnings.

Chile

The Chile system was described by Capt. Guillermo Barros. An internal system was first established in 1964, but Chile became a participant in the international system in 1958. The system is described in a pamphlet issued as instruction to persons working in the system. For improvements the Chile system needs additional seismographic and mareographic equipment as well as improved international cooperation. In response to a question, Capt. Barros said the Navy telegraph system is used for internal communication.

Republic of China

The warning system in Taiwan was described by Dr. K.T.C. Cheng. Tsunami messages are received from Honolulu by the Taiwan Defense Command. Messages can be received from Honolulu in 30 minutes and

transmitted by radio network to all parts of the country in 15 minutes. A network of 15 seismic stations has been formed. Five tide stations are observed, but there are as yet no special communications with them. A more efficient system is to be planned. In response to questions Dr. Cheng indicated that there are no special provisions for warning of locally generated tsunamis. There was general discussion of the problem of local tsunamis.

France - New Caledonia and Tahiti

The French system in the Pacific was described by Dr. Claude Blot. In the seismic phase in Tahiti the occurrence of a T-phase with an earthquake is especially watched. Messages from Honolulu are used. Messages cannot, at present, be sent from Tahiti to other French territories at night. In Tahiti a question has arisen whether the messages contain earthquake or tsunami information. Discussion indicated that the first message generally concerned earthquake information, and a later message either confirmed tsunami generation or indicated no tsunami had been generated. Dr. Blot said that New Caledonia shorelines were well protected by barrier reefs, and there was no history of tsunami effects.

Japan

The Japanese tsunami warning system was summarized by Dr. Takuzo Hirono from a pamphlet on the system prepared by the Japan Meteorological Agency. The system, which was established in 1952, involves a forecast phase handled by the JMA, dissemination phase handled by several organizations, and a terminal (evacuation) phase handled by local governments. In the forecast phase both seismic and mareographic stations are involved, interlinked by JMA communications with 5 district centers which serve 17 coastal divisions. Personnel are always on duty at the district centers. Tsunamis from farther away than 600 mi. are handled by the JMA headquarters in Tokyo.

Altogether there are 109 seismic stations involved, with 66 specially designated as "tsunami stations", and 14 specially designated as "distant tsunami stations". Forty-eight tide gages are involved, from which 10 records are telemetered to weather stations. Reports from tide stations include measurements of heights of peaks and troughs every hour or two. The functions of a center are to determine earthquake epicenters (by S-P), estimate magnitude of an accompanying tsunami from a forecast chart, and selection and dispatch of an appropriate tsunami message.

For distant tsunamis, the JMA national center determines the epicenter itself and also establishes contact with Honolulu for the exchange of seismic and wave data. Since 1963, USSR tsunami warnings have also been received, in the English language broadcasts from Khaharovsk. It is hoped that these may be supplemented by

actual seismic and tide data. From local and distant data the epicentral location and magnitude are determined. Forecasts include arrival time of tsunami (from refraction diagrams), rough estimates of wave heights, reports of actual waves at foreign countries and in Japan, and preparative measures. Times given include an estimate of the lag of maximum waves behind the first arrivals. Any warnings issued in Japan are also transmitted to Honolulu, Naha, and the USSR, and also to Hong Kong if that is likely to be affected.

In answer to a question, Dr. Hirono commented that the predicted height of tsunamis was rough only. In answer to another question, Mr. Spaeth reported that military radio teletype was used between Honolulu and Japan, and the teletype to JMA, and that transmission times ranged from 20 to 90 minutes.

Afternoon Session, Tuesday, 27 April

Mexico

Dr. N. Grijalva, Mexico, discussed tsunami interests in Mexico, which has no warning system, as yet. Although tsunamis have been recorded at the 7 Pacific tide stations, they have been a problem so far only at Ensenada, which gets warnings via San Diego. However, theoretical studies of numerical forecasting possibilities are in progress at the Institute of Geophysics, University of Mexico.

New Zealand

Dr. J. W. Brodie discussed the warning system of New Zealand, which is affected by tsunamis from the northern Pacific and especially the eastern Pacific. Distant tsunami information is received only from Honolulu. Messages are received by the Civil Aviation Agency Communications Center and passed to an assessment group of seismologists and oceanographers of the Department of Scientific and Industrial Research as well as to the Ministry of Civil Defense. Police and harbor authorities are alerted. If sea level changes of practical importance seem possible, a stand-by notice is sent to these authorities and to local Civil Defense organizations, using teletype and telephone. Arrival times are estimated from travel charts and tables. Heights are estimated, based on an empirical relation to heights at Canton and Suva. If a substantial tsunami is anticipated, warnings are broadcast through the national system to the public as well as to local authorities. Warnings are given locally by siren. Cancellations are originated by the assessment group and transmitted through the same channels. Few local tsunamis have been observed, and only one, which originated from an M=5 shallow earthquake on the upper continental slope has caused damage. Reports of local tsunamis are made through the same assessment group.

Peru

A description of the warning system in Peru was given by Admiral E.V. Zimic who referred to the division of responsibility between two organizations; (1) the Geophysical Institute of Peru, which handles seismic investigation, and (2) the Navy Hydrographic Department, which handles mareographic investigations. The communication system consists of messages originating in Honolulu directed to the Geophysical Institute of Peru by the NASA system, the U.S. Military Communication system, or telegraph. Tide stations are located at about 200-mile intervals along the coast, but only one is used as a center for tsunami warnings. In a tsunami alert, communications are transferred to the Navy Hydrographic Department, which warns certain authorities in several coastal points. About 3 hours are required to pass messages to all points. Incidentally, the Spanish term "maremoto" leads to such alarms that the term "tsunami" is now used in its place.

Philippine Islands

Mr. J. J. Tecson discussed the warning system in the Philippines. Messages from Honolulu are received at the Civil Aviation Administration and delivered by special messenger to the Weather Bureau forecast office, from which they are passed by radio or telephone to the Geophysical Observatory and Directorate of the Weather Bureau. If warnings are received from Honolulu, or if the Geophysical Observatory deems that, as a precautionary measure, warnings be issued, they are transmitted further by radio, telegraph and telephone for country-wide dissemination, specifically to the areas to be affected. Flow diagrams of original messages from the Honolulu Observatory to the Philippine Weather Bureau and of the revised messages from the Bureau's Geophysical Observatory to the other government agencies and ultimately to the general public are submitted.

Mr. Spaeth indicated that Honolulu receives seismic information from the Philippine Bureau of Coast and Geodetic Survey. In reply to a question, Mr. Tecson indicated that the communications used for dissemination of a warning are the same as used for typhoon warnings.

United States of America

Mr. L.M. Murphy discussed the USA tsunami warning system. Interest in Tsunami warnings rose in 1946, and the USC&GS assumed responsibility, securing the support needed from other agencies. By 1948, a system was essentially completed to serve Hawaii and other Pacific Islands, using 4 seismic and 9 mareographic stations. The growth of the system since to serve other areas including Alaska and the Western Pacific has led to the involvement now of 15 seismic and 30 tide stations. Each country added has been asked to provide its own adequate warning facilities to cope with locally generated

tsunamis. There has been improvement in instrumentation. The calibration of the visual seismic recorders has been improved. Remote recording has been provided at some tide stations. Research is in progress and planned. A research group in oceanography soon to be located in Honolulu will be followed by a group in seismology. Seismic work now in progress relates to correlation of magnitude and focal depth with tsunami generation and its geographic area of generation. No major submarine earthquake has happened since the system began without issuance of a warning in sufficient time, never less time than 1/2 hour and sometimes 2-3 hours in advance in Hawaii, with more time generally in other areas. Undoubtedly many lives have been saved.

The 1964 Alaska quake indicated that the eastern Pacific is not free from tsunami damage, and highlighted the two-fold nature of the problem: warnings of tsunamis of distant origin, for which the Honolulu Observatory capabilities are adequate; and warnings of locally generated tsunamis, for which the Honolulu Observatory cannot be adequate.

Thanks are due to: a) the Coast and Geodetic Survey Honolulu Observatory staff; b) University of Hawaii; c) Civil Defense Agencies; d) Weather Bureau; e) Federal Aviation Agency, Coast Guard, Defense Communications Agency, and National Aeronautics and Space Agency; f) foreign countries; and g) IUGG, WMO, and IOC.

The system is really international in character now, serving 9 countries. Others are invited to participate.

Literature available consists of a new tsunami brochure, a booklet of travel-time charts, the Communication Plan of the system, and an FAA Communication Plan, all of which were provided to each attendee.

Union of Soviet Socialist Republics

The USSR tsunami warning system was summarized by Dr. U. V. Tarbeyev. It is more completely described in a booklet, a copy of which (in Russian) was provided to the Chairman. Tsunamis are important in two regions: Kurile-Kamchatka, and Sakhalin. The Kurile-Kamchatka earthquakes lead to the worst tsunamis. The warning system involves essentially two organizations, the Academy of Science for seismic aspects and the Hydro-Meteorological Service for mareographic aspects. In the Kurile-Kamchatka area are two special tsunami stations. At each station are specialists from each of the organizations. In this area there are lags of only 15-20 minutes between earthquake occurrences and tsunami arrival, so very rapid analysis is required. At present, warnings can be issued in 12 to 15 minutes after a quake. These warnings include estimates of the heights of waves. Warnings are issued via the Ministry for Communications except in the immediate vicinity of the stations. The system works satisfactorily, although some difficulties

arise due to the separate administrations involved. For outside information and cooperation the JMA is thanked and also the USC&GS.

In response to a question, Dr. Tarbeyev indicated that height estimation was only very rough and the wave heights sometimes exceeded 10m., that 3 tide stations are available for international data exchange but that others in the Kurile-Kamchatka line would have to be improved, and that the warning centers do not collect damage statistics.

The chairman, after consultation with the chairman of the USA delegation, indicated that the USC&GS would arrange for translation of the USSR warning system booklet.

Ryukyus

Mr. Michio Shiroma said that the Weather Bureau in Okinawa receives tsunami information from the Japan Meteorological Agency, for its own evaluation. The Weather Bureau has one tide gage and two seismic stations of its own. No tsunami of importance has been locally generated in recent years. In reply to a question, he said there were four main weather stations in the Ryukyus.

Trust Territory of the Pacific

Mr. J.E. Welch described the 3×10^6 mi² area of the Trust Territory, saying that no seismographs nor tide stations were operated by its administration. However, the Territory has extensive communication facilities and could establish stations if needed. Warnings are now received from Honolulu via Guam and transmitted to the populace if considered of importance. However, the coral reefs are effective in protection.

Inter-American Geodetic Survey

Mr. M.A. Tewinkel described the interest of the IAGS, which is a U.S. agency with headquarters in the Panama Canal Zone with a mission to help Latin American countries in geodesy, cartography, and natural resource inventory. IAGS has been interested in tide observation since 1946, originally as a means for datum plane determination, and more recently in connection with cartography and natural resource studies. Of 35 mareographic stations on the Latin American Pacific Coast, only 2 are satisfactory for tsunami monitoring. There exists good government communications systems with Latin American countries and a direct route from Honolulu to the Canal Zone. The tsunami warning system can be improved by coordinated use of the existing communication system, and IAGS will continue its interest and assistance.

The Chairman indicated that Nicaragua and Guatemala had been invited to participate in the conference but could not send delegates. There was discussion of the generation of tsunamis off the Latin American coast from which it appeared that none of importance were generated off Central America.

Miscellaneous

Certain corrections were made to the preliminary list of participants.

Dr. Takahasi submitted a discussion of the views of Japan concerning the existing warning system, which was indicated by Dr. Wadati as being provided to serve as the basis for discussion. For reference, was submitted also a description of a seismic code. Discussion of seismic monitoring stations was then begun.

Seismic Monitoring Stations

Mr. Murphy discussed the need to decrease the time involved in seismic analysis. At the Honolulu Observatory, the distance of a quake is determined from the S-P time on a visual recorder. However, 45 to 90 minutes are required to get other P arrival times from stations around the Pacific. A quadripartite net is planned on Oahu using 4 vertical seismographs at 15-20 mile separation, telemetering to the Honolulu Observatory for central film recording. A scheme has been worked out for determination, in about 10 min. of the azimuth of a quake to 2° or 3°, depending on P arrivals at this net. A Press-Ewing 3-component visual recording seismograph is already giving azimuths to 5° or 6°. Magnitude determination will be simplified by a direct scaling scheme. Three tripartite net recorders are planned in Alaska, each consisting of a 3-component seismograph station with two outlying telemetering vertical instruments. One will be on Adak, one in Anchorage, and one at Sitka. A magnetic and seismological observatory is being established near Newport, Washington, with a nearby seismic station at Baker, Oregon. The Baker station is proposed as a tripartite station.

Mr. Sokolowski stated a need for more seismic stations in the eastern part of South America to give epicentral location control in the western part.

In response to a question from Dr. Tarbeyev as to the relative roles of seismic and mareographic information in the USC&GS system, Mr. Murphy indicated that the seismic information is used normally to establish epicentral location, land vs ocean, whereas the actual warnings are based on mareographic information. Discussion brought out the fact that an earthquake had to have a magnitude of about 7-1/4 before it would be accompanied by a destructive tsunami, but that not all oceanic earthquakes of M 7-1/4 were accompanied by

tsunamis. Mr. Murphy indicated that Dr. T. Algermissen of the Coast and Geodetic Survey is investigating a possible correlation between fault-plane solutions and Tsunami generation. Depth of focus is also important. Quakes of 300 km depth are seldom, if ever, accompanied by tsunamis, 70-80 km rarely, 20-40 km commonly.

In response to a question from Dr. Tarbeyev as to the relative importance of improvement in speed of communications, Mr. Murphy stated that this is of primary concern in the international aspects rather than in the US area. He mentioned the future possibility of transmission of digitized seismic data to Honolulu for rapid computer fault-plane solution.

Dr. Tarbeyev mentioned the occasion of the February 4, 1965, earthquake as one indicating a need for speedier transmission of error-free data.

Admiral Karo pointed out that warnings of wave generation were not generally coincident with seismic notices.

Morning session, Wednesday, 28 April

There were a few announcements by the Chairman, who indicated the need later in the session to form small working groups for formulation of recommendations. There being no further discussion of seismic monitoring stations, the meeting advanced to the next topic.

Tidal monitoring stations

Mr. Zetler referred to the array of tide stations used in the USC&GS warning system. He described the standard tide gage, the bubbler tide gage recording air pressure in a system in balance with the water, the tsunami detector giving an alarm in the case of a tsunami larger than the normal tide, and a remote recording system being installed at some stations. Under consideration is direct radio telemetering from Aleutian stations to Anchorage. Also to be used is the SELCAL alarm device, which can be automatically triggered by a radio inquiry. Under investigation are a deep-sea differential pressure recording device, and a Vibratron-type deep-sea device. In the future, all tide gages are to be of digital type; however, the sampling time intervals will not be suitable for use in tsunami problems. Additional travel time charts are still being prepared by hand, but computer programming is being prepared. Some ocean areas need additional tide gages reporting: the Kuril-Kamchatka area, the Southeast Pacific, and the vicinities of Iwo Jima and Koror. Improved implementation of data exchange agreements to supply tsunami data is needed. The availability of digital data should be made generally known.

Dr. Pickard added that seismic data is also called for in the international data exchange program. Mr. Tewinkel asked whether the automatic digitizing equipment could be operated on an analog recording gage. This is not certain.

Dr. Wadati stressed the desirability of prompt reports from tide stations, including amplitudes of tsunami waves. Mr. Zetler pointed out that the not-unreasonable objective should be direct telemetering to Honolulu. There was discussion of the need for radio frequencies assigned to oceanographic telemetering and of the justification that the priority of tsunami messages gave. There was further discussion of the use of Vibratron equipment in mid-ocean in tsunami recording. Dr. Takahasi amplified the international agreement for tsunami data exchange. In reply to a question, Mr. Zetler and Dr. Miller amplified the discussion of the tsunami propagation computer program being prepared. Initially, it will handle the refractive problem only, but diffraction, reflection, scattering, and decay can be added later. The hydrodynamic model used is a linear one.

Mr. Tewinkel indicated that IAGS has been asked to assist in establishing a tide station on Juan Fernandez Island. He also discussed the need for tide stations on the island of Chiloe, which is tilting. Improvements of facilities in South America and at Easter Island, and the addition of stations in Central America are needed.

Dr. Hirono described the ordinary tide gages used in Japan and also a submerged bellows type of moderate sensitivity used for telemetering by wire or radio which gives water heights at intervals adjustable so as to be shorter at tsunami warning periods. Dr. Wadati pointed out the utility of storm surge instrumentation.

Dr. Tarbeyev indicated that the USSR used several systems for tsunami recording: a) a float-well connected with the sea by a pipe, as much as 300-400 m length; b) a scheme for recording only sea heights at dangerous levels; c) a device for recording hydrostatic pressure changes. He recommended international standardization.

The diameter and length of the horizontal pipe in the USSR gages, for example, is not standardized. It is also necessary to know something about the local conditions where mareographic devices are installed. A considerable enlargement of the number of USSR stations is planned.

Mr. Zetler discussed difficulty of complete standardization but stressed need for information on type of equipment. Dr. Miller stressed the need for flat response in the tsunami frequency range and the need for proper maintenance in maintaining this. Dr. Takahasi stressed need for having the response characteristics of the gages. Mr. Cox spoke of the non-linear character of the response of most tide

gages, and also stressed the importance of installation with the most open exposure possible. Dr. Tarbeyeve clarified the nature and character of installation of the USSR gages. Dr. Von Herzen referred to tide gages possibly available from Canada.

The C&GS remote recording equipment was demonstrated by Mr. Sundean.

Afternoon session, Wednesday, 28 April

Communications

Lieutenant Commander F. J. Tucker discussed the communications scheme used in the USA tsunami warning system. This scheme involves especially Federal Aviation Agency and Defense Communications Agency communications systems, which it reaches by teletype. Messages are precut except for specific data. The system is described in detail in the "Communications Plan". In Hawaii, the Civil Defense Agency is contacted by telephone. In emergencies, long-distance telephone can be used to a few areas.

Dr. Tarbeyeve asked about the time elapsing between an earthquake and issuance of an alarm, pointing out the necessity in the USSR for issuance of warnings within 15-20 min. of a quake. Mr. Tucker said that at Honolulu this depended on the location of the quake. There was a general discussion of the distinction between general advisory announcements and actual warnings. It was recognized that the U.S. system cannot at present serve areas close to earthquake epicenters. Captain Barros pointed out the need for early warnings in Chile as indicating the need for the Hydrographic Bureau to have some control over the seismic stations. Admiral Karo stressed the need for public education and initiative so that there would be immediate response to a violent earthquake in shoreline communities even without a formal warning.

Dr. Tarbeyeve raised the question of the best measures of improving communications between Honolulu and the USSR. The possible supplementary use of the meteorological direct line between Moscow and Washington and the improvement of the operation of the present tie via Tokyo could be investigated. There was extensive discussion of these possibilities, following which, upon the suggestion of Dr. Wadati, a small working group was formed to study the question and report later. The Chairman appointed the heads of the Japan, USA, and USSR delegations to this group.

There then followed discussion of the areas in which communications give the most problems. These were identified as the Aleutians, the southwest Pacific, and the southeast Pacific. Use of an oceanographic satellite was suggested, but it was pointed out that the oceanographic satellite was intended for observation, not communication. Mr. Tewinkel suggested some alternate communications routes in Latin

America, including one involving English translation. Mr. Cox pointed out the need not only for common language but for common units.

Improvements to the Warning System

Dr. Wadati stressed the desirability for any country having seismic data of use in the warning system to send in this data, even if this were not prescribed. Mr. Tucker commented on the need for high priority for the transmission of such data.

Dr. Tarbeyev pointed out that communications are the weakest part of the system, but that the communications phase could not be considered separate from seismographic, mareographic, and analytic phases, and that both improvements of existing communications' routes and substitute of new communication routes should be studied. Admiral Karo pointed out that even though the USSR, USA, and Japan might form the nucleus of an international system, the fullest cooperation was required from all countries involved. Dr. Wadati reviewed the necessity for the existence of national warning systems to take care of local tsunamis.

Following a break, Mr. Murphy reported the conclusions of the working group on USA-USSR-Japan communications. Although the World Meteorological Organization hot line was proposed as a communications route, there are definite difficulties with it. The group recommends the use of the existing Sakhalin-Tokyo communications link and the existing Honolulu-Tokyo link. Both USSR and Japan personnel will investigate possible improvements in the former. The possibility of a direct radio link between Honolulu and the USSR was also mentioned. No recommendation was made but the possibility should be investigated after the meeting. Dr. Wadati confirmed the report and added that the USSR-Japan communications link should carry seismic and mareographic data, not just warnings. Dr. Tarbeyev confirmed the report and added the possible advantage of reference to an inter-agency arrangement previously worked out. There was discussion of the fact that the Japanese proposal submitted incorporated this arrangement, and that recommendations from this meeting should not be confined to just the three countries.

Mr. Murphy pointed out the need for low-magnification seismographs for the determination (in the case of large earthquakes) of focal depth by the P phase, of distance by the S phase, and of magnitude. Although the spread of seismograph stations is adequate for the problem of warning Hawaii, the warning of additional areas would require additional seismographic coverage. He repeated the need for inland seismic stations in South America. Dr. Stewart asked whether the USA could help provide such stations and Mr. Murphy said yes.

Dr. Stewart stated that amateur radio operators had offered to assist in emergency with the transmission of warning system messages. Admiral Karo commented on the need for a diagram of communication links available. Mr. Viets expressed a belief that the use of special radio frequencies for tsunami communication was not practical, but that frequencies now in use would be satisfactory if there were authority to break in with high priority information.

Mr. Zetler indicated that the situation regarding tide gages was similar to that regarding seismic stations - that more would have to be added to service new areas added to the warning system. He suggested a general recommendation to this effect.

Dr. Stewart asked whether exchange of personnel would be helpful. Mr. Cox discussed the advantages of Honolulu for persons interested in either the practical aspects of the warning system or the research aspects of tsunamis, and said that such persons would be welcome at the University. He asked whether such persons would be welcome at other Centers.

In reply to a question, Dr. Grijalva indicated the definite interest of Mexico in joining the warning system. Dr. Von Herzen discussed the availability of mareographic data from Antarctica and also discussed the possible availability of tide gages from Canada.

Morning session, Thursday, 29 April

The session was begun by the showing of two highly informative reels of 8 mm. movie film of the 1960 Chile Tsunami in Japan, provided by the Japan delegates.

Dr. Stewart discussed further the need for preparation of recommendations. He proposed the establishment of a drafting group with the following membership:

Dr. Pickard, Dr. Barros, Dr. Cheng, Dr. Blot, Dr. Wadati, Dr. Takahasi, Dr. Hirono, Dr. Grijalva, Dr. Brodie (Chairman), Admiral Zimic, Mr. Tecson, Mr. Murphy, Mr. Zetler, Dr. Tarbeyev, Dr. Von Herzen (ex officio), Mr. Tewinkel.

A summary of possible improvements on the Tsunami Warning System, prepared by the Chairman from the discussions to date, was made available to the drafting group.

Dr. Wadati discussed Japan's proposal for the establishment of a Tsunami Information Center, and for the establishment of a coordinating committee under the IOC. Mr. Cox spoke in favor of both the committee and the center. Dr. Tarbeyev inquired as to the tasks, permanence, frequency of meetings, and site of the committee. The functions were stated to be liaison with the participating countries, exchange of results of studies, assistance in improvement of instrumentation, liaison with scientific groups, and secretarial work of the system. The committee was conceived to be a permanent one, meeting once every two years. The Tsunami Information Center,

it was clarified, was intended to serve the needs for rapid receipt, analysis and provision of information on the time of possible tsunamis, but that some function of providing information on research results, etc., might be added. In response to a question from the Chairman, it was made clear that the Tsunami Information Center should serve much the same function as the Honolulu Observatory in the collection of data in the event of a tsunami, and that its results should be available to all interested countries. Mr. Spaeth mentioned the delays that might ensue at the Honolulu Observatory in low priority requests due to its workload of high priority requests. The possible assumption of the extra duties by the Honolulu Observatory was discussed. Mr. Cox suggested that meetings of the Committee more often than once in two years would be useful. Admiral Karo suggested that the Committee meet whenever necessary, but at least every two years just before IOC meetings.

The Chairman then declared a recess to allow the drafting groups to meet.

The afternoon was spent on a tour of the Honolulu Observatory. The drafting group met from 7-10 p.m. to prepare a draft of the recommendations to the IOC.

Morning session, Friday, 30 April

Minutes through the Wednesday morning session were discussed and corrected. Final lists of participants were distributed. The progress of preparation of recommendations to the IOC was reviewed.

Tsunami Research

Dr. Takahasi discussed briefly the research interests of the Japanese Organization for Tsunami Investigation and also of the US-Japan Science Cooperation Project, as expanded in a document submitted. He indicated that the near solution of the generation problem was valid only in the case of very simple sources. Propagation studies are in progress and promising. Nearshore and runup studies are of great importance because of the great practical importance of nearshore complications. Model experimentation is needed, including frictional consideration.

Dr. Grijalva described research in progress in Mexico, dealing with the propagation of tsunamis. Numerical analysis is made of the propagation of waves across a 2500 x 5000 km area including a shelf and a trench. The boundaries still create problems.

Dr. Miller pointed out that waves generated in very shallow water have, for the same initial wave length, a lower frequency than those generated in deep water. Dr. Miller is working on a ray-tracing program, using a 1° grid of depths. Munk and Snodgrass are working on a deep-sea tide gage. A study of edge waves will be

commenced. Mareographic records of tsunamis are being digitized. Records of 50 hrs duration are being treated with .01 hr intervals.

Dr. Van Dorn discussed the possibility of forecasting tsunamis by measuring barometric pressure changes. The variation in relation of seismic magnitude to tsunami wave amplitude is well known. The tsunami magnitude depends on horizontal size, vertical height, speed, and direction of crustal displacement. Until now, many detection stations, preferably in or near deep water, have been needed for wave evaluation. Dr. Van Dorn distinguished between non-dispersive, dispersive, and mixed tsunamis, caused respectively by large, small, and intermediate size sources. He pointed out that the non-dispersive and mixed tsunami cause the highest runups and the most destruction. The large-dimension crustal displacements associated with non-dispersive tsunami generally also cause long-period atmospheric pressure waves, which can be recorded at great distances. Distant microbarographic stations may therefore be used for tsunami forecasting. The barographic pressure waves travel much faster than the tsunami waves and can be measured on land with simple equipment. However, epicenters on land and water must be distinguished. Good phase resolution is needed to distinguish the signal from the noise.

Dr. Van Dorn also discussed research problems in which international cooperation was needed. Although wave form and size may soon be calculable in the ocean, nearshore and runup effects cannot be calculated and hydraulic modeling will probably be necessary, on a very large scale, larger than that of the Hilo Harbor model. He proposed an international research center.

Mr. Cox announced the establishment, in Honolulu, of a new Joint Tsunami Research Effort by the U. S. Coast and Geodetic Survey and the University of Hawaii, intended to promote international research. Dr. Miller of the Coast and Geodetic Survey will join the Hawaii Institute of Geophysics tsunami research staff this summer to implement this effort. He also announced the installation early this week off Kona, Hawaii, of a deep-ocean tsunami gage, which was described by Dr. Vitousek, the developer, as a Vibrotron-type gage, installed at 1600 m. depth and telemetering through an 8-mile cable to shore.

Admiral Karo expressed the expectation that the new UH-USC&GS joint endeavor will help to meet the well-recognized international need for research. In this organization there are provisions for visiting staff members to encourage the widest possible international cooperation.

The Chairman pointed out that one of the draft resolutions prepared for discussion dealt with the need for research.

Dr. Tarbeyev pointed out the need for the simultaneous conduct of research on the theoretical aspects with research having practical aspects. He introduced three papers having to do, respectively, with the 1951 Kamchatka tsunami, the effects of other large tsunamis, and the distortion of tsunami waves in shoaling waters.

Afternoon session, Friday, 30 April

Press conference

The Chairman reviewed the intent and auspices of the conference, indicated that draft resolutions have been prepared after committee discussion and reviewed the research discussion and draft recommendations. Discussion indicated that the recommendations could be released this afternoon and considered by the IOC in November. Other questions discussed concerned the pilot-model of the deep ocean gage, the number and location of additional stations in the tsunami net, in part in connection with the cooperation of additional countries, and practical results of immediate possibilities of implementation.

Recommendations

Dr. Brodie referred to the full Conference the draft recommendations, which were then discussed and adopted as indicated in the attached version, with the following supplementary commentary:

- Rec. No. 2. It was agreed to leave financing of the proposed International Coordinating Committee up to the IOC.
- Rec. No. 7-iv The bibliographic references referred to are intended for rapid distribution and do not supplant the need for continuation of annotated bibliographies.
- Rec. No. 9) In the eventuality that the Coordinating Committee cannot be established, it is left to the IOC to determine where to centralize the data collection.

Conclusion

The Chairman expressed his thanks to the Japanese delegation, especially for its careful preparation for the conference; to the Secretary and the University of Hawaii for services and facilities, to the Honolulu Observatory and Look Laboratory for their hospitality, and to Mr. Campbell for his many services.

The Secretary called for thanks to the Chairman for his capable services. These were given with acclaim, and reinforced especially by the vice-Chairman.

Captain Barros read a thoughtful and well-phrased statement of thanks to the USC&GS Organizing Committee, the University of Hawaii, UNESCO, and other groups involved, commenting on the additions to understanding that would be provided through the conference to circum-Pacific countries.

Dr. Takahasi expressed the thanks of the IUGG.

Dr. Von Herzen expressed the thanks of the IOC.

Dr. Tarbeyev joined in these and noted that not only were solutions presented to immediate problems, but ways of meeting future problems.

The Chairman again expressed his thanks and declared the meeting at an end.

Documents distributed to participants
at the Tsunami Warning System Conference

Note: This list includes only documents pertaining to the Conference (not those pertaining to field trips or periferal to the purpose of the conference), and only those distributed generally to participants.

Tsunami! The story of the Seismic Sea-Wave Warning System. U. S. Coast and Geodetic Survey 1965.

Present and future research on tsunami, by Ryutaro Takahasi
/Apr. 1965

Tsunami warning service in Japan. Japan Meteorological Agency,
Apr. 1965.

Tsunami travel time charts for use in the Seismic Sea Wave Warning System. U. S. Coast and Geodetic Survey, Apr. 1965.

Communication plan for seismic sea wave warning system and dissemination of Civil Defense Agency disaster warnings.
U. S. Federal Aviation Agency, Mar. 1965.

Communications in the trust territory of the Pacific Islands, by John E. Welch, April 1965.

View of Japan concerning existing warning system. /Japan delegates to conference Apr. 1965.

Instrucciones generales sobre el sistema nacional de alarma de mavemotos. Chile Inst. Hidrogr. de la Armada. Publ. 3.014. 1965.

An international tsunami warning system for the Pacific, by L. M. Murphy /April 1965

Summary of the existing warning system in the Republic of the Philippines, Philippines Weather Bureau, April 1965.

Tsunami travel times in the Pacific. New Zealand Oceanogr. Inst. 1963.

Tsunami forecasting by Doak C. Cox, Hawaii Inst. Geophy., HIG 64-15. August 1964.